Wildlife Ecology
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Lecture – 20
Why are things where they are?

[FL]. Today we move forward with our discussion on biogeography and look in detail at why things are where they are?

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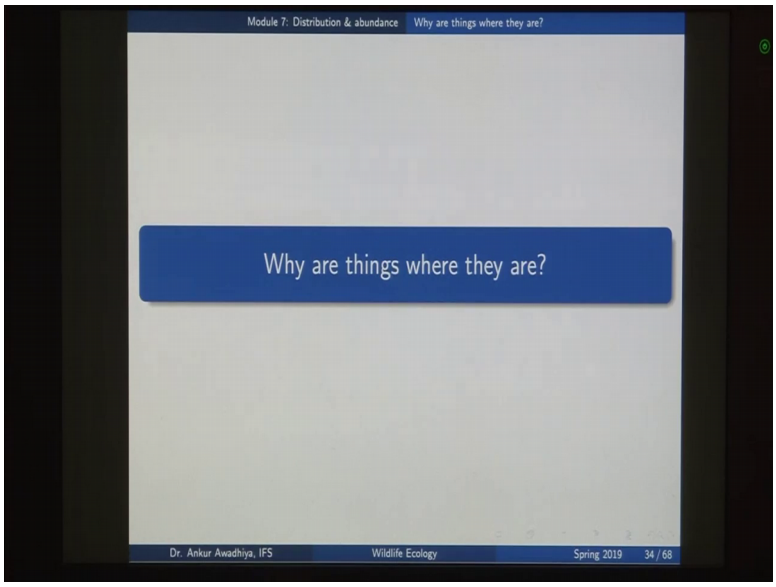

So, in the last lecture we began by looking at the definition of biogeography, so it is a discipline of ecology that asks the questions what species are found where? So, in different areas of the earth what different species are seen in those areas. Then it ask the second question why are those species found only in those areas? So, if we see if we say that lions are found in Gujarat why are lions found in Gujarat, what is there in Gujarat that lions are finding it a hospitable place. Then it ask the third question what are the other factors that are not permitting lions to live somewhere else?

So, for instance why do not we have lions in the Sundarbans or why do not we have lions in Jammu and Kashmir; is there something that is related to the characteristics of the lion or the characteristics of the area that is different physical or chemical constituents that are there in that area that is not suitable for a lion to live there. And, if you go for a very simplistic analysis we can ask this question why does a fish live in water, why does not a

fish live in the land or why does not a fish fly? So, what is there in water that is making it a suitable habitat for the fish, what is there on the land that makes it an unsuitable habitat for the fish. So, these are the three questions that biogeography asks. 1: what species are found there, 2: why are they found there and 3: why are they not found somewhere else? Now when you ask this question why things where they are?

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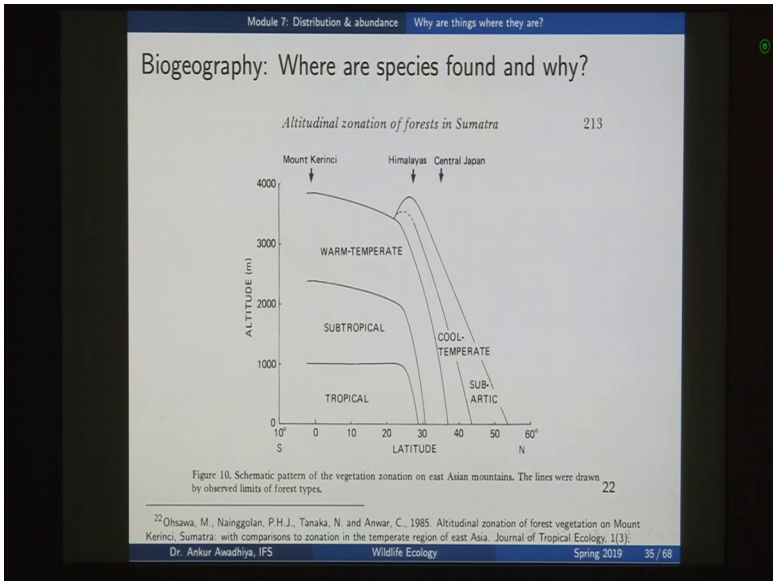

We looked at this particular diagram, now in this particular diagram we said that here we are putting up the altitude of the location and here we are putting up the latitude of the location. Now we see we say that these kinds of habitats a subarctic forest or a cool temperate forest these are typically found at higher latitudes, but then if we have a mountain that is very tall and it is very near to the equator then we also see the subarctic or the cool temperate forest near the equator.

So, essentially it is not related to where exactly these kinds of forests are found, it has got more to do with what kinds of characteristics are available for these forests. So, if you can make so like typically you will not find a subarctic forest near the equator, but then if you make the conditions such that you have a low temperature or maybe the kinds of wind speeds that we find in the subarctic forest.

If you make these sorts of conditions available near the equator you will start finding a subarctic forest near the equator as well and this is a fact that we regularly make use of when we are doing the conservation of different species using ex-situ conservation. So,

for instance we know that polar bears live in Arctic and Subarctic areas, they live in very cold areas, but then we can also have a polar bear in New Delhi. How? If we can create a condition, if we can create a chamber that is cold enough for a polar bear, if we can give it a big sheet of ice to live on then the polar bear will not know whether it is living in the Arctic or whether it is living in New Delhi.

So, this is a fact that we regularly make use of, if you want to have a botanical garden somewhere and you want to have say species from Africa. So, you can just bring those seeds from Africa, you can give or you can create those sorts of conditions in your botanical garden that those species can grow there. So, typically in the case of many botanical gardens we go for in for areas that have an altitudinal variation.

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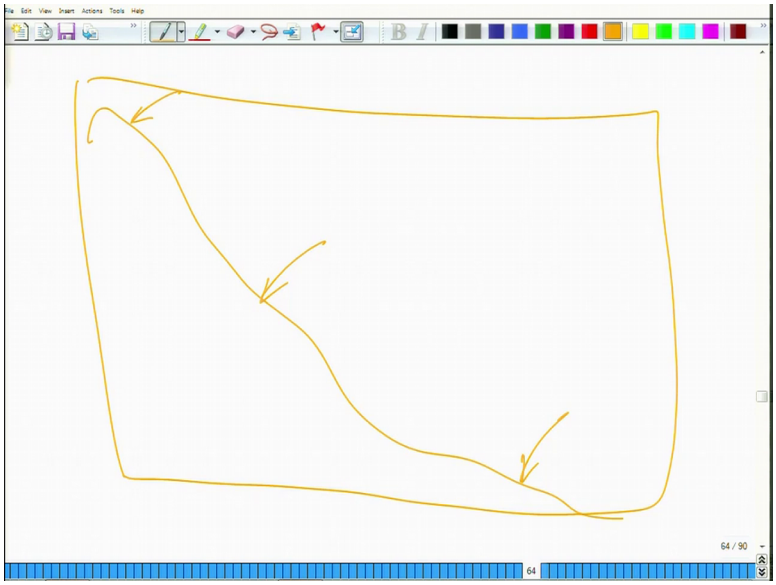

So, if you have say a forest that is there near a hill, so now, the climate here will be cooler, the climate here will be more moderate, in the climate here will be warmer. Now, if you select such an area to construct say a botanical garden. So, in the cooler areas you can bring the seeds of those species that are found in cooler areas, in the warmer areas you can bring the seeds of species that have found in the warmer areas. And then in this small area that you have designated as a botanical garden you can have multiple different kinds of species.

Now here again we have to ask the same question, what are the conditions that are making those species live in those areas? So, that we can copy paste those conditions

into our areas, but then this also brings us a second question. Now, let us say that we have a hill in India and we have a hill in say South America and both of these hills have similar soil types and they have say similar climates, but then again we do not find all the species of South America in our hills in India.

Now what is causing certain species to be found then in South America, but not in India? So, when we are talking about say the cat families why is puma found in south America, but it is not found in India even though we might be having several areas that have very similar kinds of climates and vegetation. So, this is also another question that we are going to look forward when we are studying biogeography.

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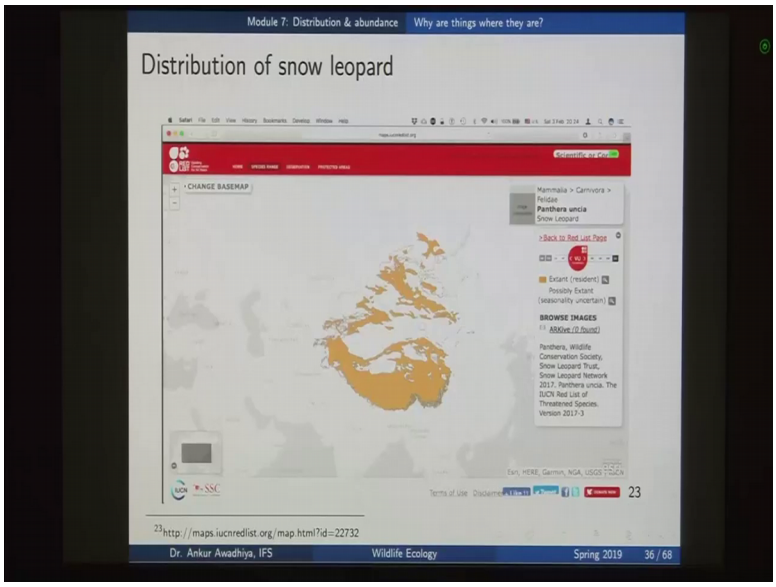

So, to summarize my geography if we look at any distribution if say the distribution of snow leopard, the first question would be various snow leopard found? The second question is why is it found in these areas? The third question is why is it not found in these areas? And then the fourth question is if suppose we look at another location at the same latitude and having the, and having very similar conditions so if snow leopard is found here why is it not found here? Now this place might also be having a very similar climate. So, what are the factors that are limiting the distribution of this species, only to the areas where it is currently found and you can do this for n number of species.

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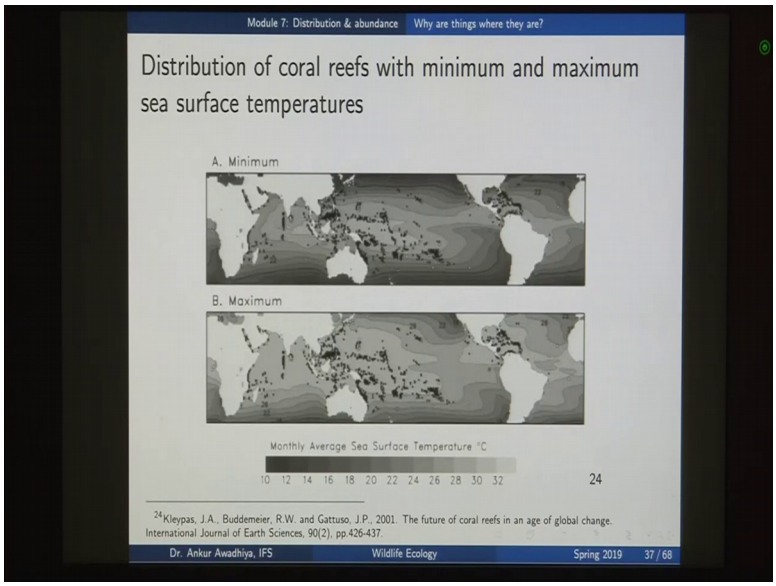

And we saw that we can look at island biogeography, we can look at continental biogeography, we can even look at oceanic biogeography. So, this was another case that we looked at in the last lecture, that if we have coral reefs that are found in these areas why are they only found in these areas? Now, if you look at the distribution of coral reefs in greater detail you would find that there are a number of conditions that make their survival possible in these areas, they cannot live in very cold waters, they cannot live in very warm waters.

So, this is typically the area where there will be found where the water is having a good enough temperature for them to be found. Then they have some specific nutritional requirements and also some other requirements such as the condition that they cannot live in areas that are extremely polluted or in areas that have a high sediment load. So, for instance if we look at this area which is near (Refer Time: 07:47) ones.

So, here we have the Ganges river and the Brahmaputra river both of these are falling into the Bay of Bengal in this area, but then because they are carrying a huge amount of sediment load so we will not find a coral reef in this area. So, again we are looking at those factors that are causing coral reefs to be found here and are causing the coral reefs not to be found in this area. So, this is all what it biogeography is all about and the observations have come from a very long period of time.

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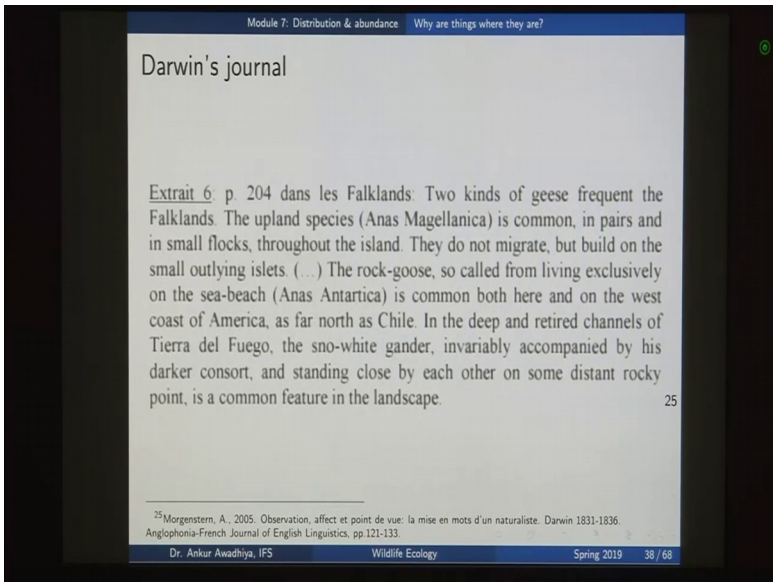

So, even if we look at Darwin's journals, now Charles Darwin as we had seen in one of the earlier lectures. So, Charles Darwin happened to be a naturalist who went around the world in a ship called the Beagle and when Charles Darwin was visiting the Falkland Islands so there he made this journal entry. Two kinds of geese frequent the Falkland's, the upland species Anas Megellanica is common in pairs and in the small flock throughout the island, they do not migrate, but build on the small outlying islands islets.

The rock goose, so called from living exclusively on the sea beach Anas Antarctica, is common both here and on the west coast of America as far north as Chile. In the deep and retired channels of Tierra del Fuego, the sno-white gander invariably accompanied by his darker consort and standing close by each other on the same distant rocky point is a common feature in the landscape.

So, this natural list when he was going around South America and when he visited the Falkland islands he made this observation that there are two species of geese. Now geese as we know are birds and now even in the geese of these birds we are think that there are two different species and these two species are found in different areas. So, the upland species is found throughout the island of Falkland's they do not migrate, but they build on small outlying island islets.

Now, there is another goose that is the rock goose which lives exclusively on the sea beaches. So, it does not go it does not venture inside and it is common both here and on

the west coast of America as far north as Chile. So, here he is making the observation that there are two species of geese, now we can say that gees when we refer to gees as a species of bird or as a kind of bird.

Now these both gees would be having similar requirements, they would be feeding on similar kinds of food, they would be having similar kinds of wings. They would be having similar size and shape of the body, there are only some minor differences because of which we are saying that these are two different species of geese.

So, they are not able to interbreed amongst each other, but then they requirements are more or less the similar. But, even in those species that are very similar to each other we are observing that they have very specialized requirements or very specialized area that they are inhabiting. So, then the question arises why are they only in those areas and not in the other areas?

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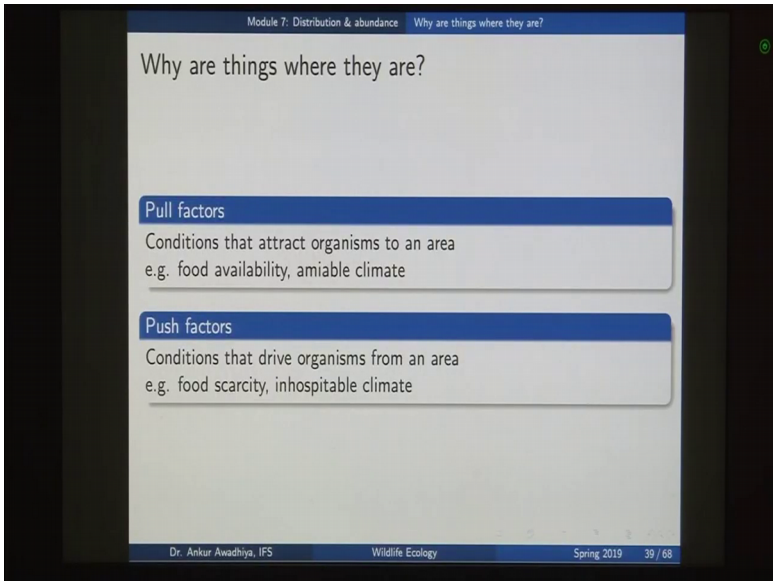

So, this brings us to the push and pull factors, so when we are asking the question why are things where they are we need to talk about the pull factors in the push factors. The pull factors are conditions that attract the organisms to an area. So, for example, food availability, amiable climate so if you have plentiful amount of food there is a good climate you want to live in that area.

The other factors who go by the name of push factors or can drive organisms away from an area example food scarcity or inhospitable climate. So, these are in general the push and the pull factors.

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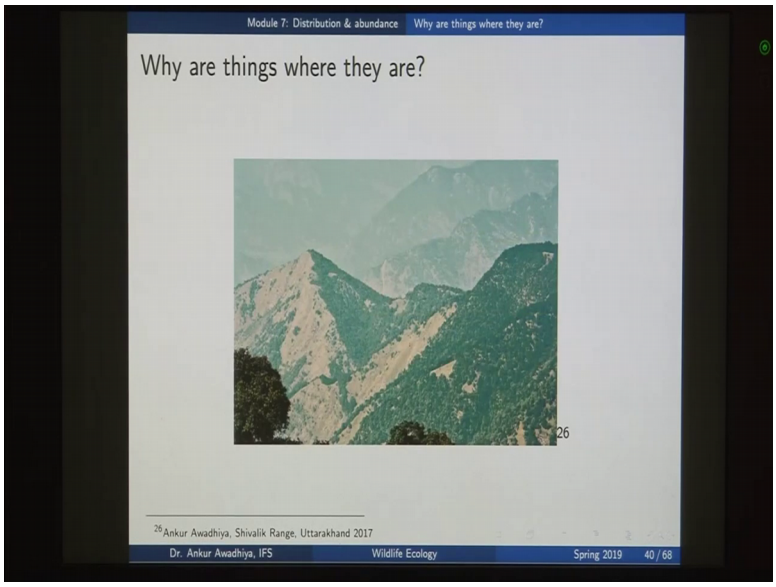

So, here if you look at this image so this is again an image from Uttarakhand and here we are observing, that we have these hills and on these hills there is vegetation on these slopes and there is no vegetation on this particular slope. Now, the question is why do we have vegetation on the slope and why do not we have vegetation on the other slope, what can be the push factor, what can be the pull factor? So, here again we can say that because this area is getting more amount of sunlight so probably this area is drier or probably the slope here is greater than the slope here.

So, if you have of a mountain phase that has a greater slope, so in that case soil will not be able to accumulate in that area. So, the depth of soil will be less, now if there is a less depth of soil so the roots cannot penetrate deep, they cannot hold on to that area and at the same time they will not be able to get sufficient amount of nutrients.

So, that could be some push factors that are keeping plants away from these slopes. Now what are the pull factors that are bringing plants here? So, probably because this area is a depression area so it might be retaining much more amount of moisture, it is also having a slope in a way that it is getting less amount of sunlight. So, probably that is also another reason by the losses of water is less.

And also because the slope here is less so probably more amount of soil is able to accumulate here. So, here we can see that even in the case of a single hill there can be a vast variety of differences in the microhabitats of two different areas on the same hill that might be responsible for a plant to leave in certain area and to not leave in certain other areas. But then push and pull factors are not the only things that govern where a species is found and why is it found there?

So, for instance we were talking about the availability of puma in the hills of South America, but not in India. Now it is also possible that if you bring puma from South America and you allow it to settle in India, then probably it would be able to survive here, probably it would out compete some other species and make a niche for itself.

So, it will occupy some of the initials that are available or say create a niche for itself. But then you do not have puma in here in India, not because they because India is providing some sorts of pull facts push factors, but because puma has not been brought to this area because puma is very far away from India, there are oceans that are separating the continents of Asia and the South America. So, probably that is one reason why puma is not found in India.

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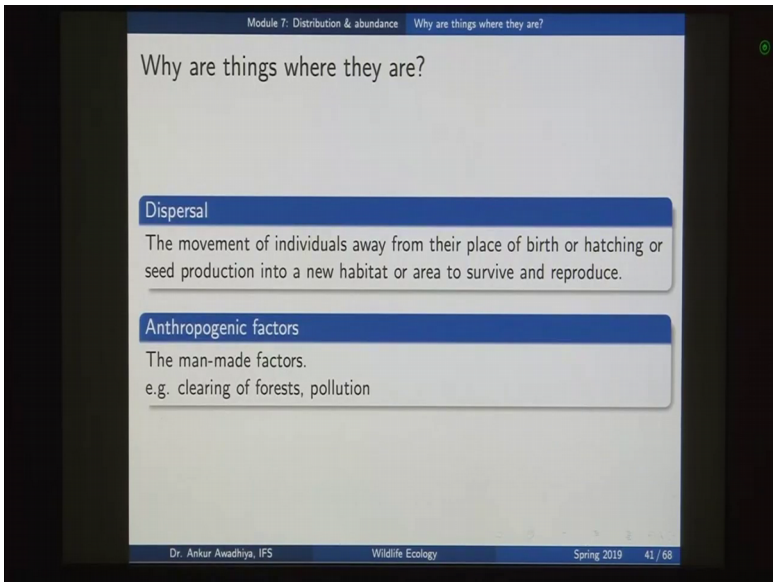

So, apart from the push and the full pull factors the next factors that we need to look at are the dispersal factors, what are the ways in which the organisms are able to move from one area to another area. So, dispersal is the moment of individuals away from their

place of birth or hatching or seed production into a new habitat or area to survive and to reproduce. So, this is the movement of individuals from one place to another place, now why would there be a moment of organisms?

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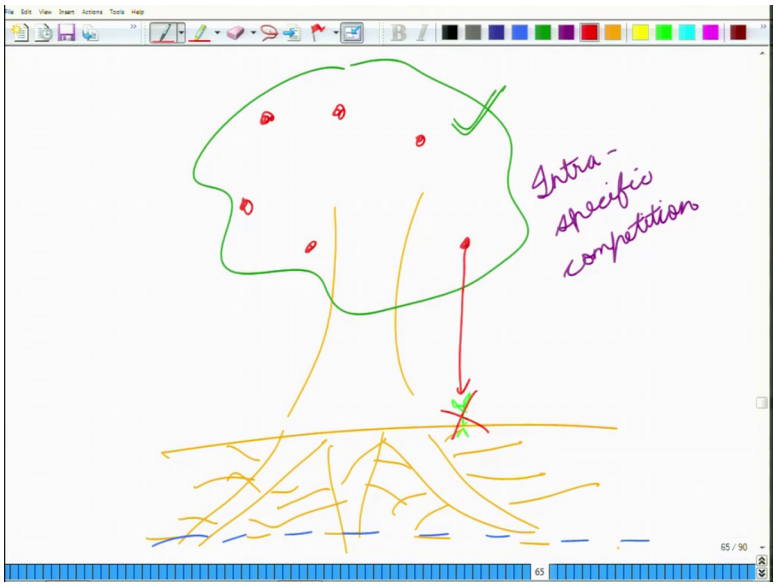

Let us consider this particular tree so here we have a tree and this tree bears fruits and inside the fruit so you have the seeds. Now let us suppose that this fruit fell down here and then later on it gave rise to sidling, so here we now have a seedling that is coming up. Now this is a seedling of the same species as that of the tree, but then in the case of the tree we would have roots down here and because this tree is very old so these root should also be very extensive.

So, maybe they are able to tap the groundwater so they are able to tap the groundwater and they are also able to tap various minerals throughout the soil. So, because they are already a very extensive network of roots, so they are better able to get water, they are better able to get the nutrients. On the other hand the roots of this plant are very small and so they are neither able to reach to the groundwater table nor are they able to very reach to the nutrients so extensively as the larger plant.

Now in this case what is happening is a case of intra specific competition, there is competition for water, there is competition for nutrients, there is competition for sunlight and so many things. Now in the case of this intra specific competition we can say that in

a number of situations, because this tree is much more older it has got a much better network so it will be able to out compete its own sapling and the sapling would die out.

Now, if the sapling dies out then evolutionarily we would say that the plant is not having that good a fitness because fitness not only means that you produce more number of office springs. But, also that your office springs should be able to live and grow to their maturity and produce their own office springs.

So, in this case if the plant adopted a strategy that all of its seeds just fell down below it so all of most of those seedlings would die off or else they would be competing with the mother plant itself. So, in this case this is not the best of the strategies, now let us think about another strategy; another strategy could be a strategy of dispersion.

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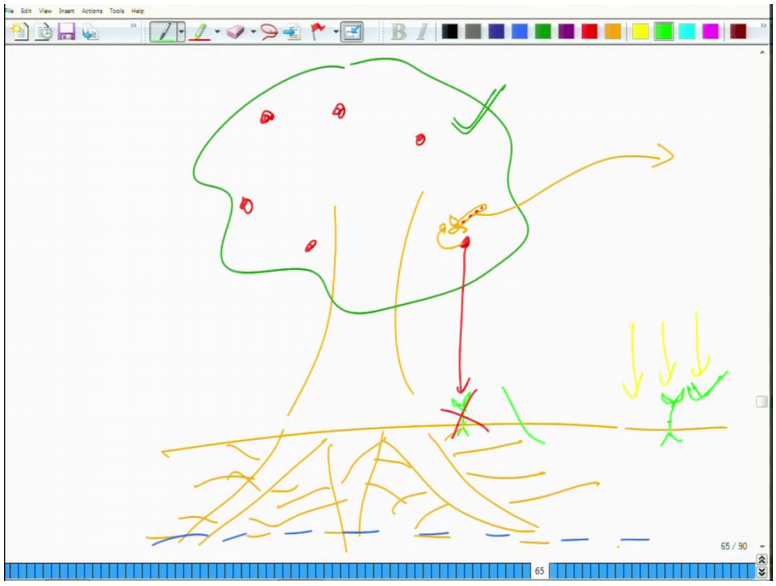

So, probably the fruits are such that a bird comes here there is a bird that is coming here and this bird eats up the fruit and then this bird goes to some other area and there the through its intestines the seed of the fruit moves and then it gets dropped somewhere else so probably as seed fell down here. Now in this case this again would give rise to a plant a sapling, but then in this case because this is far away from the mother tree so there is less amount of competition that this seedling will have to suffer from.

So, probably now it is not always possible that your seedlings will always have less amount of competition because it is also possible that your bird went and sat on some

other tree and then, but the seeds their visits droppings. But, then it is also possible by chance that your seeds fall into an area where there is less amount of competition where there is a canopy opening for instance.

So, if there is a an opening in the canopy so some amount of sunlight is able to reach down and reach to this particular sapling or probably if there is this canopy opening, so there are less number of trees around. And, so its roots are also not suffering from that amount of competition from the neighbors and in that case this plant would be able to survive.

And when it survives when it grows up then we would say that the fitness of the mother tree was greater than that of another tree, that was only having this is strategy that all the seeds come down because when all the seeds fall down then there is a very big chance that all of them are going to die. Whereas, if there are some seeds at least that fall to some other area or are able to move from their area then there is a better chance that they are going to survive, which makes dispersal a very important component of ecology.

So, you will observe that most of the species would want to disperse, so most of the office springs would want to disperse from that area consider tigers. Now if there is a tigress that has given birth to say three cubs, now when these cubs are say around three or four years of age in that case the male cubs will start moving away, they will go away to some other area and they will establish their own territory because in that process, one they will not be posing a competition to their own mother, two the mother will not be posing a competition to their own kids and three the chances of inbreeding become less or consider a plant such as the coconut.

Now why does a coconut have such a big shell? The coconut has this big shell so that when it falls to water and there as there is ample amount of air that is trapped inside so this whole fruit and the seeds are able to move away. So, every plant or every organism wants its individuals or its office spring to move away to move at least slightly away. So, that there is less amount of competition and less amount of inbreeding and the process by which these office springs are moving away is known as dispersal.

So, it is the movement of individuals away from their place of birth or hatching or seed production into a new habitat or area to survive and reproduce and this is one strategy that increases the fitness of the species. Now there could be some other factors apart

from dispersal and apart from the push and pull factors which might be responsible for why certain species are found where they are found and those are the anthropogenic factors or the man made factors. Now, manmade factors include things like clearing of forests or pollution, now a good example is this clearing of forest.

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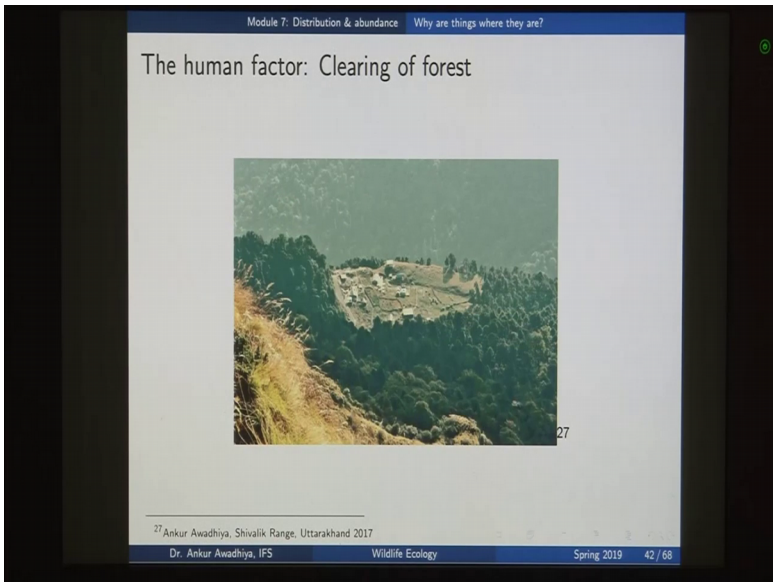

Now, here if we ask the question why do we have trees here, but we do not see a tree here. Now this area is no different from this area, so this area also has all the pull factors that this area has, this area has none of the push factors that, this area has and the because these areas are so well connected. So, it is very much likely that the seeds from here are able to disperse to this area, but still we are seeing that this area is not supporting these trees. Now here comes the impact of humans, so this is a man made factor, this is a man made clearing of the forest for their own purposes.

So, today if we are talking about biogeography we not only have to look at the natural factors, but also the man made factors. So, if we ask the question that if we are considering a river say if he considered the river Yamuna, so why are there certain patches in the Yamuna river that do not have many species of fishes? The answer is because of the of the man made factor because that particular stretch of Yamuna is so polluted that species cannot that fishes cannot live in that area or if you ask the question why do we not see forest in near industrial areas or especially those industrial areas that give out quite a lot amount of sulfur dioxide.

So, for instance if there is in ore processing industry that is releasing a plentiful amount of sulfur dioxide why do not we see plants nearby it, now that again is a man made factor because of acid rain the plants are dying out. So, today when we are talking about biogeography we not only need to take into consideration the natural factors, the bush and the pull factors, the dispersal factors, but also the man made factors that might be responsible for a species being found in an area or not being found in an area.

So, for instance if you ask the question why are lions not found in India or say why are why are lions not found in Madhya Pradesh or why are cheetahs not found in India? The answer is manmade factor because the lions of Madhya Pradesh or the cheetahs of India were hunted down long back, but then again there was a human intervention that led to the wiping up of these particular spices in those particular areas.

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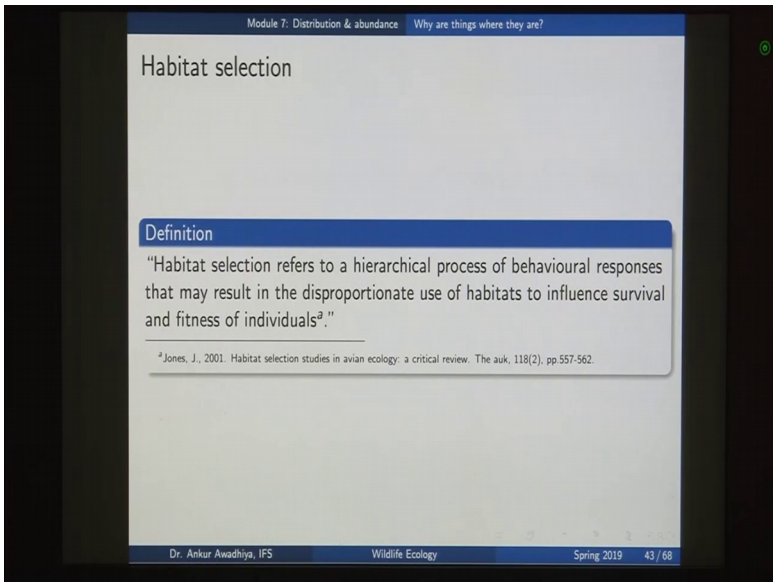

Now, another factor that might play a role in biogeography is known as habitat selection. Now habitat selection refers to a hierarchical process of behavioral responses that may result in disproportionate use of habitats to influence survival and fitness of individuals. Now what we are asking here is suppose you have two areas and both of these areas have equal amount of push and pull factors for a particular species.

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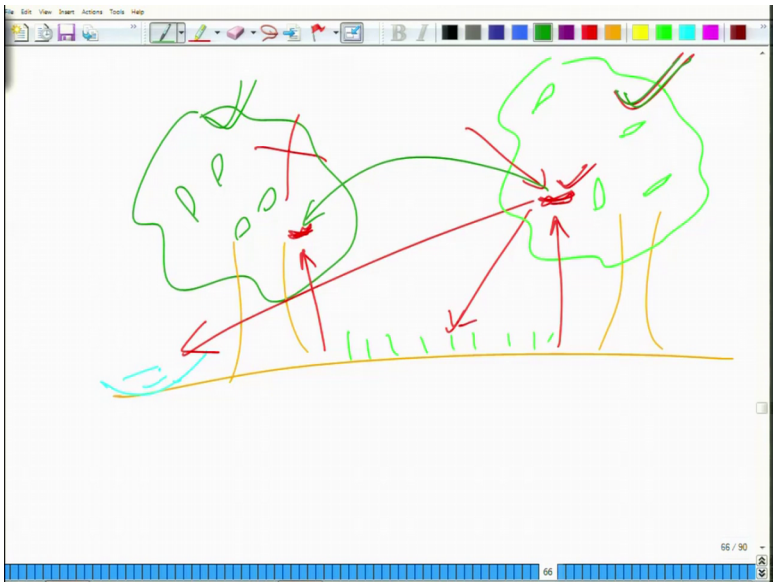

So, for instance you have this forest and in this forest you have two trees. So, this is the first tree and it is short like this so this is the first tree and then there is a tree of another species. Now both of these trees look similar there is only some slight difference in the chemical constituents that are found in the leaves, but then if you have a bird that makes its nest on this tree and there is a bird that makes a nest on this tree.

And if you look at the survival of the office springs you figure out that probably the both of these nests have statistically equally equal probability that the chicks are going to survive because this tree the first tree is also providing a place to the bird that it is able to nest at a higher place. So, that it is away from a number of predators and then this is also in an area where you have plentiful food sources and this is also in an area where the bird has access to water say nearby.

So, you have a nearby pool of water and the same factors are also available in the second tree. So, in this tree as well because these both of these trees are so close by here also if the bird makes a nest, it will be at an elevated location so predators will not be able to find it the bird can access all the food that is nearby and the water that is nearby.

So, in this situation we might see that there is hardly any push or pull factor that is different between both of these trees, but then it is also possible that because of some behavioral selection that the bird prefers this tree and does not prefer this tree. Now those behavioral selections may come because of some amount of learning or maybe because

of the exposure of the bird. So, probably if this bird was born in this nest so it knows that these particular leaves are good for making a nest and so it makes a nest here.

Whereas, if you had shifted this bird here so it would have known these leaves and it would have known that these leaves are also good for making the nests and in that case it would have preferred this tree, but because that did not happen then we can say that the bird is choosing this nest. So, these kinds of factors in which the bird is not going after a push or a pull factor, but then there is a behavioral choice that the bird is making is known as habitats selection.

So, it is a hierarchical process of behavioral responses, here we are talking about the psychology of the bird or the behavioral responses of the bird to different stimuli that may result in the disproportionate use of habitats to influence survival and fitness of individuals. So, there is a disproportionate use of a particular species of tree and not other species of tree.

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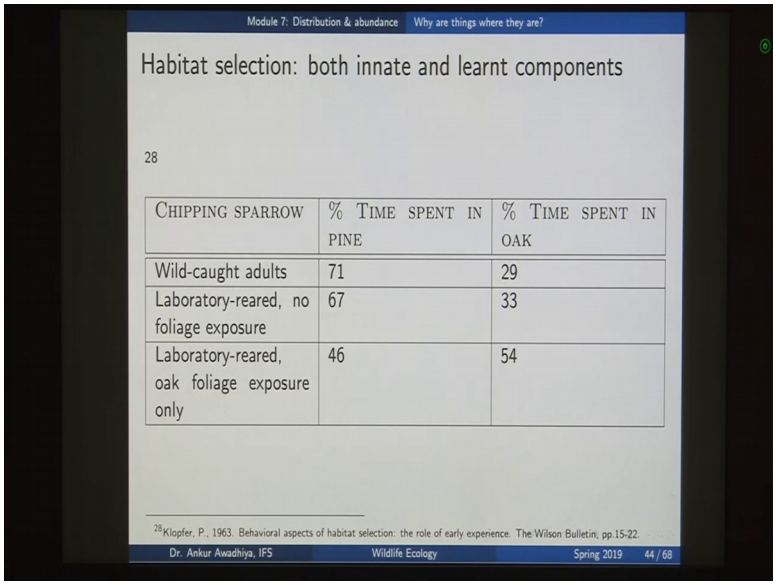

And this can be because of both innate responses that is the responses that are that come from birth and they could also involved the learnt components, that the bird is learning after it is born. So, there was this experiment that was done in which a species of bird which is known as chipping sparrow it was studied and then the scientist wanted to see how much time it spends on two different species of trees, so there are these two species of trees pine and oak.

Now if you catch these birds out from the wild, so they have lived all their life in the wild and you and you catch these birds and then you reared them in an aviary.

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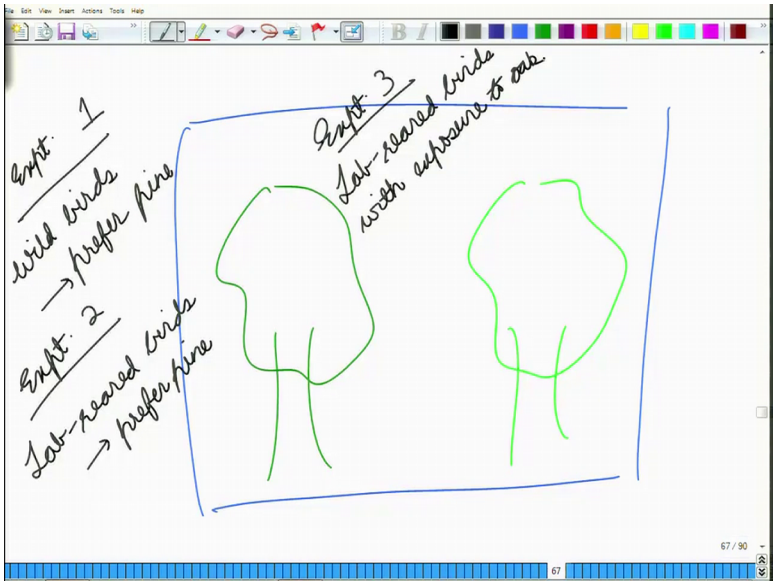

So, in this aviary you have say a large size open air aviary and here so this areas completely covered with say your nets and in an inside you have these two kinds of trees one is a pine tree and one is an oak tree and then you catch these birds from the wild and you have released these birds into these aviaries. So, how much time do they spend on a pine tree how much time do they spend on the oak tree was the question. Now if you catch these birds from the wild you find that these birds spent as much as 71 percent of their time on pine and only 29 percent of their time on the oak trees, so essentially the birds preferred the pine tree.

Now if you rear these birds in the laboratory so essentially you catch hold of the eggs or probably you catch hold off the chicks before their eyes are open you bring them into the laboratory and they are not exposed to anything else. So, they are just kept in the laboratory and once they have been reared like this then you leave them out into the same aviary. So, the first case was so let us say that, so here we have case one and you have wild birds and they prefer pine, that was the first experiment or let us say experiment one so they prefer pine.

Now there was the second experiment; experiment two, now in the second experiment the scientist just caught hold of the birds before their eyes were open or they caught hold

of some eggs before the birds had been has, they allowed these eggs to hatch in the laboratory or they allowed these chicks to open their eyes in the laboratory and then these chicks when they became slightly older then they were released in the same aviaries.

And here what we are observing is that if there is no foliage exposure to these laboratory treated birds, then the percentage of time they spent in pine was 67 percent which is very close to 71 percent and the percentage of time that they spend on the oak tree was only 33 percent which is very close to what we see in the wild behavior. So, in this case what we can conclude is that if the birds have not learnt anything new then it is probably in their genes, it is probably coming from the birth that they should prefer living in the pine trees and not prefer living on the oak trees or not prefer spending more time on the oak trees.

So, this was the second experiment and so you have lab reared birds and they also prefer pine, but then we have a twist we have a third experiment. Now in this third experiment the eggs were caught or the birds were caught before their eyes were opened and then they were reared in the laboratory, but then the scientist also put oak leaves nearby, when this bird opens its eyes it sees that there are oak leaves nearby. So, you have lab reared birds with exposure to oak and what happens in that case. So, here you have laboratory reared birds and oak foliage expose your only they were not exposed to pine they were only exposed to oak.

Now after these birds have become older so then you release them in the same aviary what happens to the behavior now? Now they spend 46 percent of their time in pine and 54 percent of their time in oak. Now, if we say that a bird that is spending more than 50 percent of its time on a particular species we say that it is preferring that species. So, in that case we would say that in these two situations the birds are preferring pine, but now they are preferring oak. So, here we say that in the 3rd experiment they prefer oak.

Now this preference or this habitat selection by this way we can say that it has got both in born components, the innate components. Because, if the bird has not been exposed to anything new then it would prefer the pine tree we have these innate components, but also there are some learnt components if the bird has been exposed to the oak leaves it would learns that oak is a preferred species. So, this is about habitat selection it has both

innate components and the learnt components. So, we look at a number of variables that can govern where by a species is found in a certain area or not found in a certain area.

So, there can be push factors, there can be pull factors, there can be anthropogenic factors, there could be factors of dispersal the species is not found somewhere probably because it has not raised it so far and there can also be factors of habitat selection. Now how do we decide which of these factors are at play at for any particular instance? But for any particular species why is a which of these factors is playing a role. So, we can dissect out the roles of all these different factors by doing what are known as transplant experiments.

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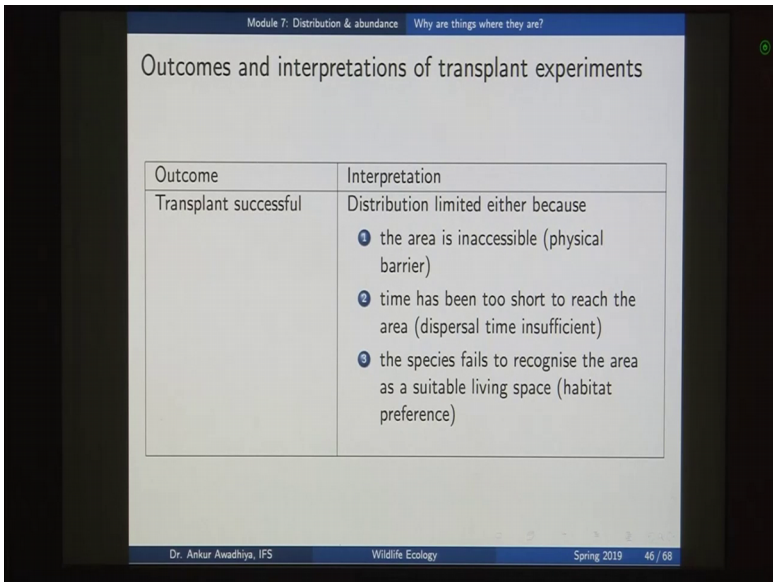

Now, what happens in a transplant experiment? Suppose this green area is showing you the area where a particular species is found. So, let us say that there is a particular plant species that is found in the green area and is not found outside. Now, what we do in the transplant experiments is that we take certain plants from this area and we transplant them to the other areas.

So, there are three experiments here the first experiment is that you have transplanted it from this green area into the yellow area and you observe that when you transplant these plants to the yellow area the plants are able to leaven in that area ok, but then when you are transplanting it to some other area see to the red area then the transplant dies out and

then the there is a third experiment which you call as the control experiment in which you transplant a plant from the green area to the green area itself.

Now why is a control experiment necessary because it is also possible that in the process of transplantation the plants are dying out because probably you were not able to separate out the roots properly over probably your procedure was such that way while you were transplanting these plants the plants dried out. And, so they died out of trying or maybe because they got exposed to certain test or maybe because they got broken or maybe there was an extreme of temperature which these plants got exposed to so which is why we perform these control experiments.

Now if the control experiment tells you that the plants are not dying because of your procedure. So, there has to be some other reason what can that reason be? In the yellow areas because the plants are able to survive so then we can say that the reason that the plants are not found in the yellow area is probably it does not have to do much with the push in the pull factors involved. Because if you transplant a plant there then this plant is able to live in that area, but then this plant is not naturally found in the yellow area probably because the plant has not yet reached into that area.

So, probably in the process of dispersion the process of dispersion takes its own time and the time has not been sufficient enough to permit the plant to move from the green area to the yellow area, but then with time if the plant is able to reach into the yellow area then it will survive in that area, now that is the first kind of inference that we can draw. The second kind of inference is when you transplanted a plant from the green area to the red area and the transplant died out.

So, probably there was something in the environment in the green area that is not suitable to the for the survival of the plants. So, probably this red area is having some push factor or probably it is lacking some pull factor because of which the plant is dying out. So, these are the kinds of inferences that we can draw using the transplant experiments. So, we can ask this question whether a species is not found in an area because of dispersal factors or because of push or pull factors. So, what are the kinds of outcomes that we will see. If the transplant is successful so you have a transplant from a green area to the yellow area and in this case the distribution is limited either because the area is inaccessible.

So, there is a physical barrier why pumas are not found in India? Because there is a physical barrier in the form of oceans, but if you transplant pumas from South America into India they will be able to survive here or the time has been too short to reach that area that is the dispersal time is insufficient, so here we could ask the question that there is some plant that is growing in Gujarat which is a weed and it has not yet reached Madhya Pradesh but then at in time it will be able to reach Madhya Pradesh.

So, if it reaches Madhya Pradesh then we will see that it is now naturally found there, but just because this process of dispersal takes its own time and the time has been short. So, the so the plant has not yet moved to Madhya Pradesh and which is why it is not found in Madhya Pradesh or the third reason can be that the species fails to recognize the area as a suitable living space because of habitat preference.

So, this is common in the case of birds, so birds so there could be a bird species that that is normally found in a particular lake so it is a migratory bird and it always lands in that particular lake it does not land in any other particular lake. But, then it is possible that both these lakes are having the same kinds of constituents the same biotic and biotic constituent but then just because of habitat selection, because the bird has not been exposed to the other lake, so which is why the bird is not found in that lake. So, that is the third reason, so if you have a transplant successful then distribution is limited either because of a barrier or because of time or because of behavioral selections.

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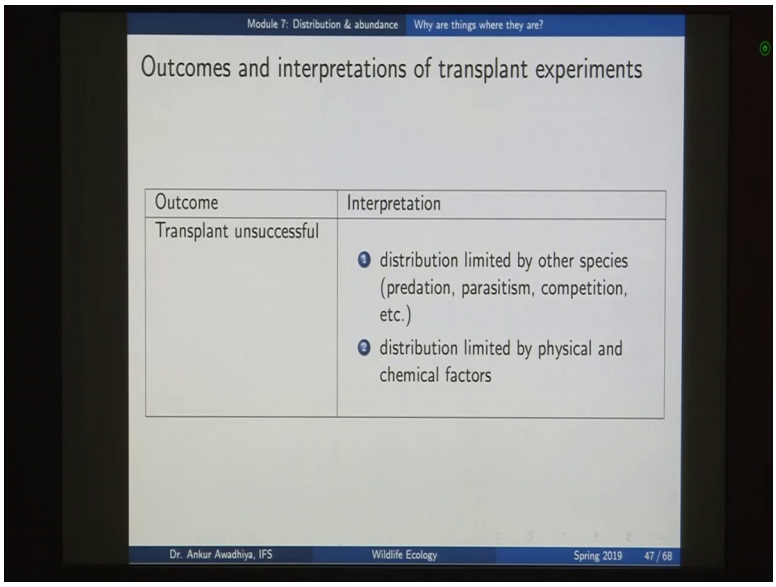

But then if your transplant is unsuccessful as in the case of over transplant from the green region to the red region then probably you have a distribution that is limited by physical or chemical factors or a distribution that is limited by some biological factor. So, you can have situation that the other region does not have fertility or it does not have some specific micronutrients that this species needs or that area is too hot or too cold or too dry or too wet so or may be too windy. So, these are the kinds of physical factors and chemical factors or they can be say some other species that are found in that area that are out competing this particular species.

So, there is competition or maybe there are some predators found in that area that eat away these plants or maybe there is some pathogen that is found in that area and the local species of that area have become resistant to that pathogen, but then because this transplant that you are taking from the green area it does not have those resistance genes so it dies out. So, these are the kinds of inferences that we can make out of the transplant experiments. Now when we talk about these physical chemical and biological factors we need to take into account the lyrics law of the minimum.

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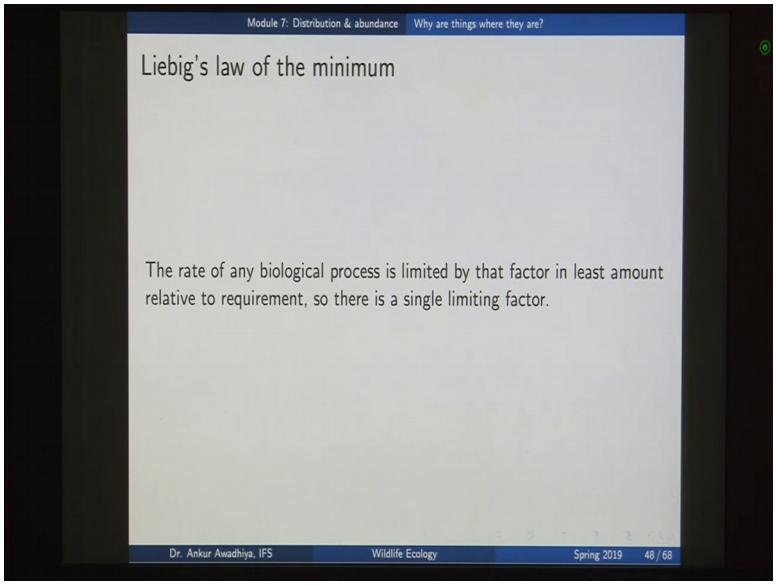

Now, this is a law which states that the rate of any biological process is limited by that factor in least amount relative to requirement so that there is a single limiting factor. So, basically what we are asking here is when we want to decide between different physical chemical and biological factors that which factor is actually responsible for the limitation

of or for the presence or absence of a species from a certain area when we have this law which says that suppose a plant has these requirements.

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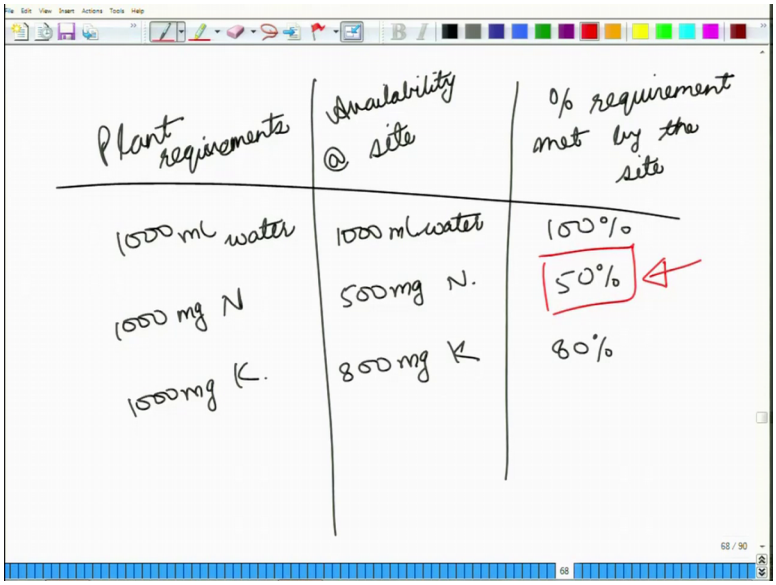

So, suppose every day this plant needs 1000 ml of water and say it needs 1000 milligram of nitrogen and say 1000 milligram of potassium just to keep things simple so we are keeping 1000 everywhere. Now the availability at the site is that, this site is able to give say 1000 milliliter of water, this site is able to give say 500 milligrams of nitrogen. So, it is not able to give all the amount of nitrogen that is required by the plant and maybe this site is able to give 800 milligrams of potassium. So, then Liebig's of the minimum will ask what is the factor that is present in the least amount relative to the requirement.

So, let us ask this question percentage requirement met by the site and this case because the plant requires 100 ml of water and it is getting 100 ml of water, so 100 percent of the requirement is being met. On the other hand for the case of nitrogen only 50 pursuant of requirement is being met and in the case of potassium we have 80 percent of requirement that is being met. Now Liebig's law of the minimum see is that the rate of any biological process in this case we are asking the question what is limiting the rate of growth of this particular plant? So, the rate of any biological process is limited by that factor in least amount relative to requirement so that there is a single limiting factor. In this case we can see that the most limiting factor is this factor which is only available in 50 percent to the requirements.

So, we will see that in this case the plant growth is limited by the availability of nitrogen in this particular area. Now how does this help us because if we know the requirements if we know, how much amount is being available is being made available by the site so how much percentage of requirements are being met. So, if we add this particular factor if we add nitrogen to this particular soil, so the rate of tan growth would increase.

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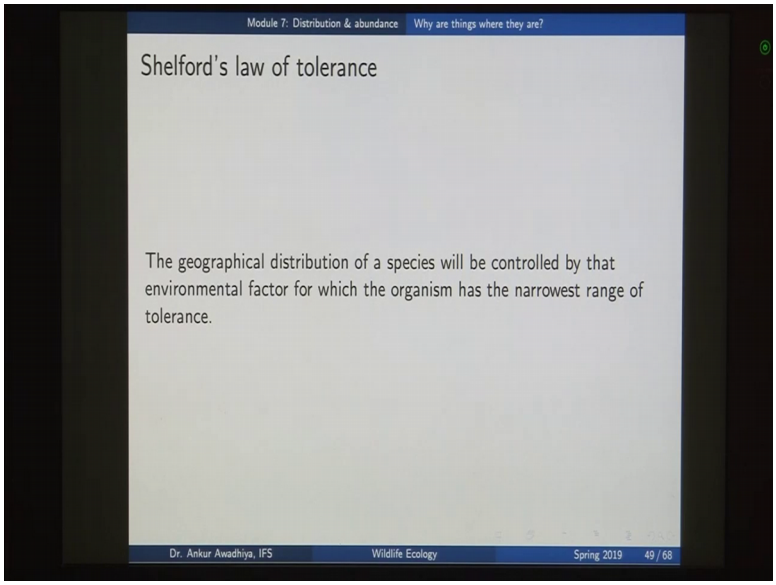

The second law when we talk about biogeography is the Shelford's law of tolerance. The geographical distribution of a species will be controlled by that environmental factor for which the organism has been narrowest range of tolerance, what is that mean?

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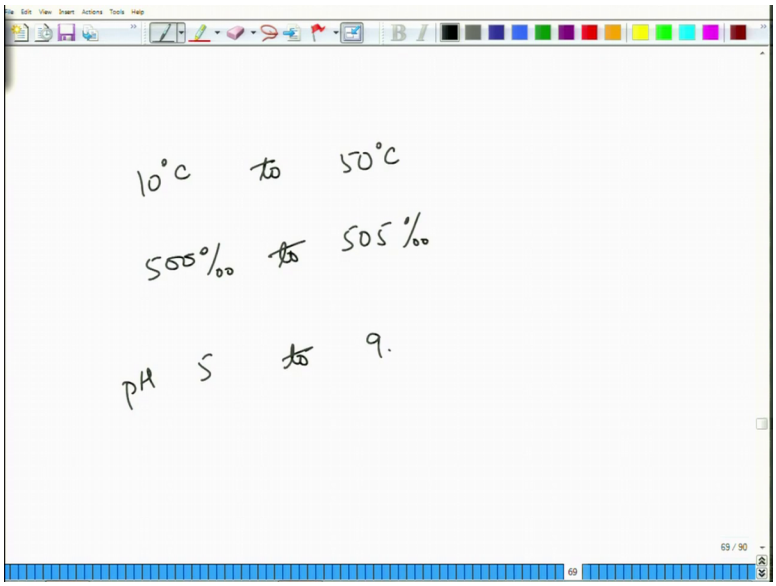

Suppose there is an organism, so this organism can say tolerate temperatures from 10 degrees Celsius to 50 degree Celsius. Then this organism can tolerate that is say 500 parts per million or parts per 1000 to say five 505 parts per 1000 and then this organism is able to tolerate say the necks against pH, so a pH from say 5 to a pH of 9. Now in this case what Shelford's law of tolerance says is the geographical distribution of the species will be controlled by that environmental factor for which the organism has the narrowest range of tolerance. Now, in this case the range of tolerance for temperature is high it is from 10 degrees to 50 degrees the range of the range of tolerance for pH also is high from pH 5 which is an acidic pH to a pH of 9 which is an alkaline pH. But, then if we look at the salinity we can say that this organism has the lowest tolerance for salinity.

If it becomes less than 500 the organism dies, if it becomes more than 505 the organism dies. So, in this case Shelford's law of tolerance would say that the geographical distribution of the species will be controlled by the salinity because, it is for the salinity that the organism is having the lowest amount of tolerance and this would also depend on what are the variabilities that are available in the environment. So, for instance if you have a situation in which all the areas of the earth have a salinity between 500 and 505.

So, in that case this particular factor will become immaterial and in that case the organism will be limited by the next limiting factor. So, Shelford's law of tolerances that the geographical distribution of a species is controlled by that environmental factor for

which the organism has the narrowest range of tolerance, if the environmental factor is able to is such that it is able to cater to that requirement, then probably it will move to the next level of environmental factors.

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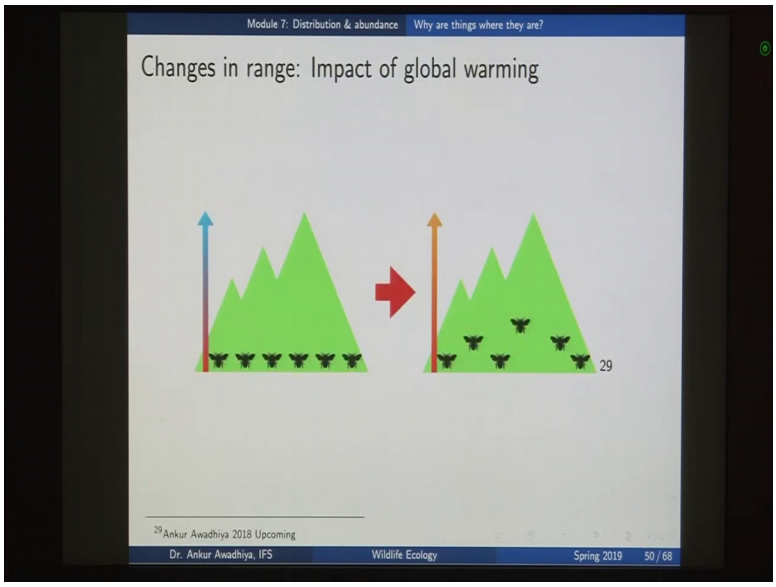

Now this is becoming the important these days because of the changes that we are observing. Now once it changes that of global warming, now if you have heating up of many areas of the earth there is an increase in the temperatures then that would mean that certain areas that were so far good habitats for certain species might cease to be good habitats for those particular species. Because, the species is not able to tolerate the higher temperatures that are available or otherwise if there is a species that is not able to tolerate a lower temperature. And, now with increasing temperatures that area also is start to get a higher temperature, so the organism will be able to live in that area.

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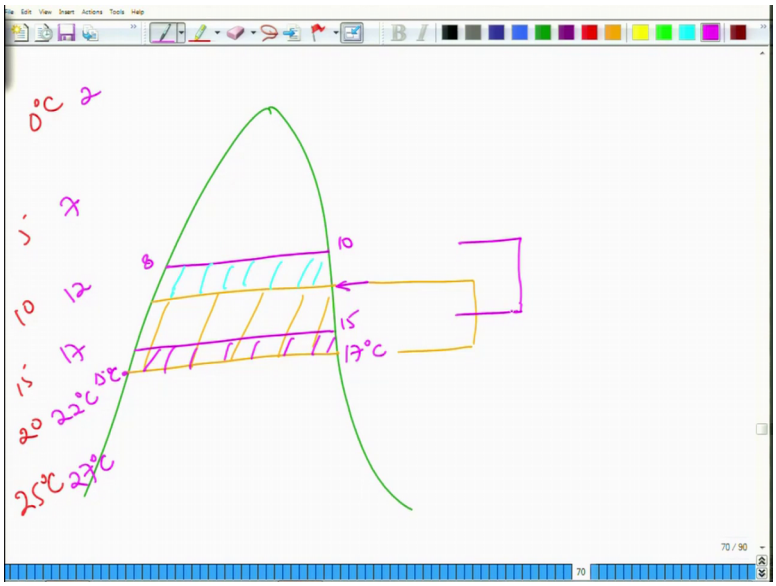

So, essentially let us say that there is this hill and we have a temperature range. So, let us say that here you have see 25 degrees Celsius and here you have 0 degrees Celsius. So, 25 then you have 20 15 10 5 and 0 degrees Celsius so there is this lapse rate, so as you move up the temperature reduces. Now let us say that there is one particular species that can live between these temperatures between 10 and 15 degrees Celsius. So, this is the normal distribution of this particular species this is the natural distribution of this particular species.

Now, suppose global warming happens and when global warming happens say every position increases in its temperature by say 5 degrees. So, this poor area or let us say it increases by say 2 degrees. So, in place of 25 degree Celsius this is becomes 27, this is becomes 22, this becomes 17, this becomes 12, this becomes 7 and this becomes 2. Now, this point that earlier had a temperature of 10 degrees now has a temperature of 12 degrees and this point that earlier had a temperature of 8 degrees now it has a temperature of 10 degrees. So, if we talk about this particular area this was earlier not a suitable habitat for this particular species because it was too cold for the species.

But now with increasing temperature it has become warmer and so now, the species can live in this area. Now, similarly this point this was earlier 15 degrees Celsius, now it has become 17 degrees Celsius. So, now, this is species will find living in this area very difficult because this species can only tolerate temperatures still 15 degrees and so now,

till the distribution is going to change. Earlier we had a distribution that was this distribution and now that the distribution has changed to this distribution and this is something that we are now observing in a number of situations.

So, for instance for a number of insects that were earlier found in the lower areas of the hills they are now starting to rise up.

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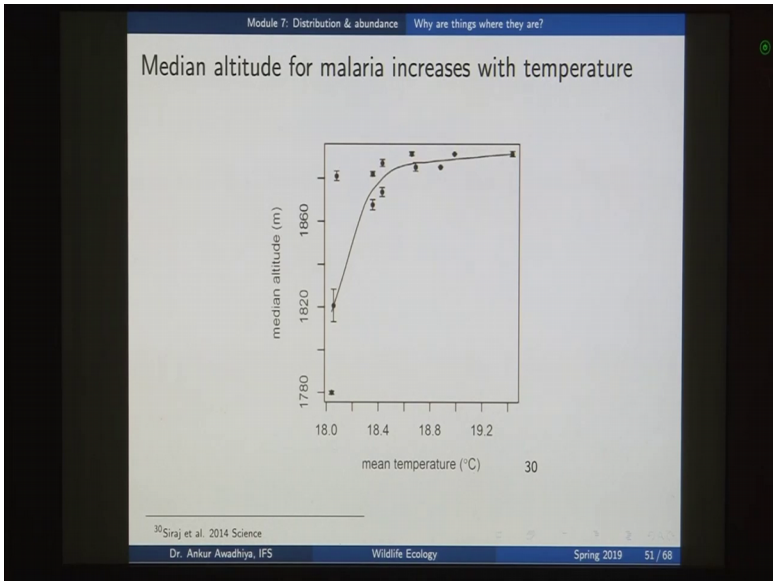

This is another such result, so here we have in have different temperatures and here we have the median altitudes. Now if you have 18 degrees Celsius then your malaria vectors or the incidence of malaria will be found till a height of 1820 meters above sea level, but then if you have a higher temperatures in 19.2 degrees then your malarial incident will be found at a much higher altitude where it was not found earlier. So, this is something that we are observing in a day to day manner and this is not just important for the understanding of bio geography or ecology, but it also has a number of practical applications such as the spread of diseases or extinction of species or changes in the ranges of different species.

And this is one result that we are getting out of the Shelford of tolerance only those species that were so far limited by temperatures will be shifting because of these temperature changes of course, if you have global warming you will also have other impacts there will be changes in the amount of precipitation, in that area there will be changes in the wind speeds in that area. And, so those species that are limited by those

factors will also now change their ranges or they will start becoming extinct in different areas.

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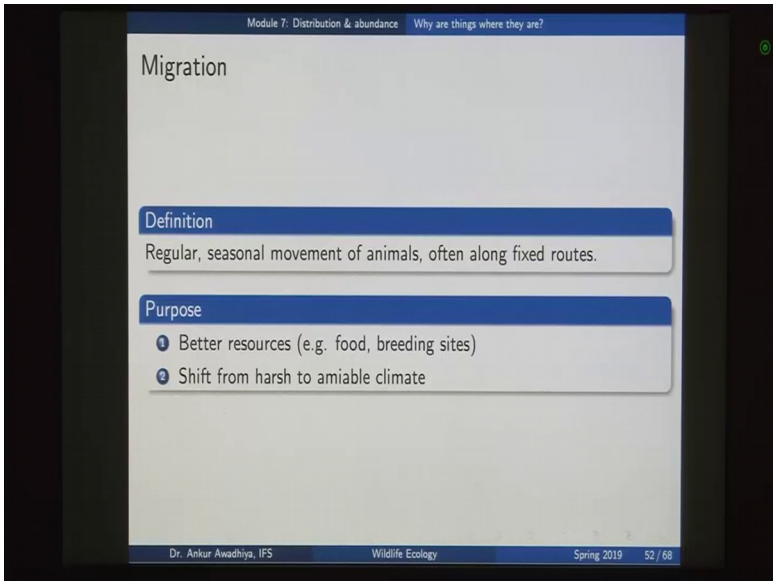

Now, apart from dispersion there is also another factor that we need to differentiate. So, there is dispersion and the other factor is migration, now migration is defined as regular seasonal movement of animals often across fixed routes and the purpose is to have better resources and to shift from harsh to amiable climate. So, if you have certain birds and there are a number of migratory birds that are found in India.

So, they might spend some part of their life in say China or Russia with climate is much cooler and then during the winter seasons when the climate shifts from cool to cold, so in that case these birds start migrate they start migrating and then they come to India, because when these areas in Russia are very cold in those cases the areas in India are probably cooled and so, the birds find it much better to live in these areas and then with the advent of the summer season, when the Indian climates will become very hot. So, they will start migrating and they will move back to Russia where the climate is much cooler.

So, it is a regular and seasonal moment it is regular and seasonal because it is regular because you will find these migrations every year. So, on a yearly basis you will find these migrations, these are seasonal because you will find these migrations in the summer season you will find these migrations in the winter season and they are often

along fixed routes so this year the bird follows a route the next year the birds will also follow the same route more or less.

And there are two purposes one is to shift from a harsh climate to a more amiable climate and second is to make use of better resources such as food or breeding sites. So, probably during the breeding season when the animals require much greater supply of nutrients so in those seasons they would prefer to live in those areas that can provide those better nutrients.

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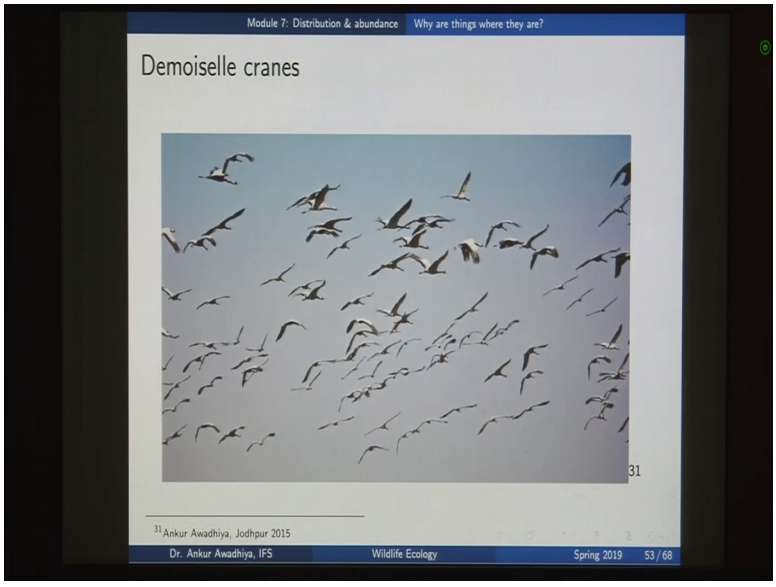

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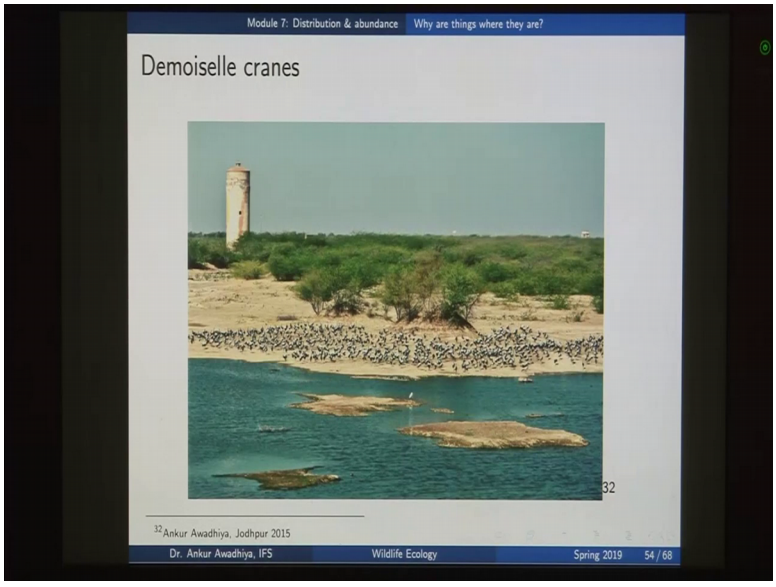

Here are some other examples that the demoiselle cranes are also migratory species that we find in large numbers in Rajasthan.

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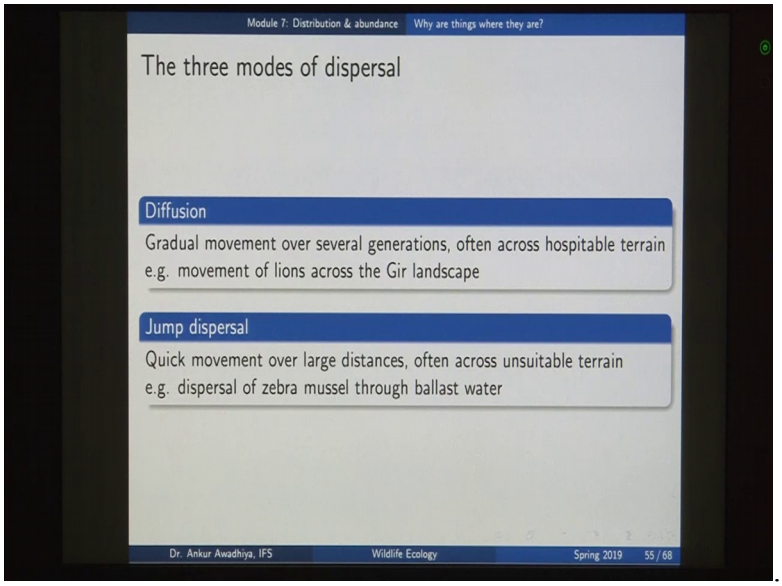

And this was migration; migration is different from dispersal because in the case of migration the animals are moving two and four. In the case of dispersal the animals are moving from their place of birth to other locations, so, this is how we differentiate between migration and dispersal. Now migration might not be that important of factor when we are talking about biogeography, but then dispersal is a very important factor because it governs whether a species is found in that area or not.

So, if a species have been able to move to an area through the process of dispersion so it will be found in that area. Now there are different modes of dispersal the first mode is called diffusion. Now, diffusion is gradual movement over several generations often across hospitable terrain, example the movement of gate lions across the gate landscape.

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So, in this case what we are saying is that in the case of Gujarat, you have these lions that are found in this particular area which is Gir and now these lions are moving to other areas. Now, when these loins are moving to other areas the areas that are in between so, if this lion is moving from here to here all the areas in between they are also hospitable areas. So, the lions can live anywhere, but then because this movement is slow it takes place across several generations so we call it diffusion.

The second mode of dispersal is called jump dispersal, now jump dispersal is quick movement over large distances often across unsuitable terrain example is dispersal of zebra mussel through ballast water. Now in the case of these lions in the process of diffusion they were moving through a hospitable climate.

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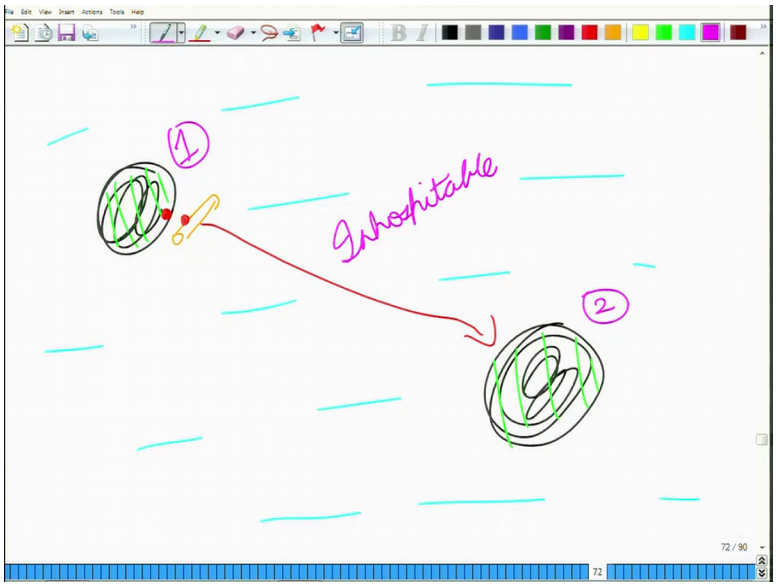

But then let us consider two islands so here you have one island and here you have another island and there is a species that is that is a terrestrial species, so this is species is found in this island. So, if this species needs to disperse out how can it reach to the second island, probably it can jump on top of a piece of log and then when this piece of log is able to move with the waves or with the water to the second island, then probably this species will be able to move to the to the second island. But, here the important part is that this island is hospitable for this species this island is hospitable for the species, but then all the all the areas in between they are inhospitable.

Because if the species falls into the ocean then probably this species will does going to die, because it is a terrestrial species. So, a dispersal that is from this location; location 1 to the second location; location 2 which will happen very fast because, it will probably happen in a period; period of a few days and it is happening across an in hospitable terrain so this kind of a dispersal is known as a jump dispersal.

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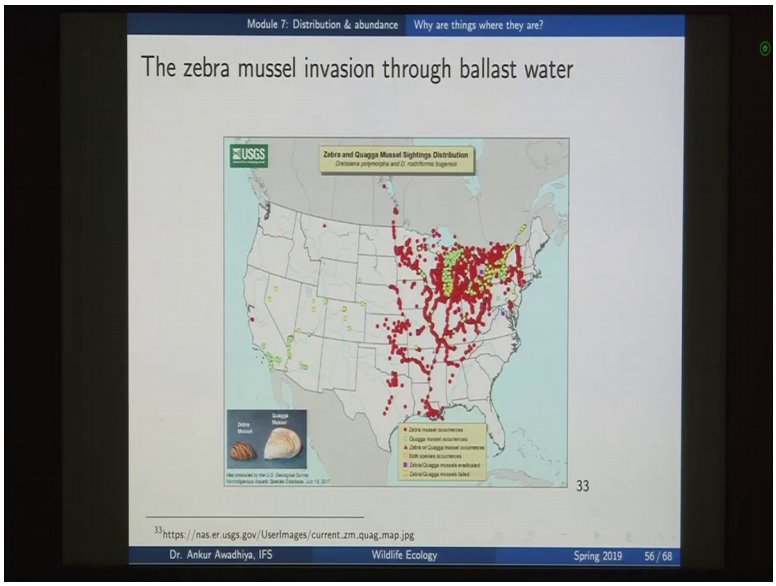

And a jump dispersal is often seen in the case of a number of waterways. So if you have a ship that is moving from one place to another place, so there can be a number of animals that stick themselves to the surface of the ship or they get inside the ship along with the blast waters, and when the ship has moved to the second location then these animals are able to come out or maybe with the release of the ballast water these animals are able to reach to the second area.

And zebra mussels are a very common example, other good examples are the spread of rats to a number of islands so when sailors were moving from one place to another in their ships rats came in and those rats were able to disperse from one place to another that is also a good example of jump dispersal.

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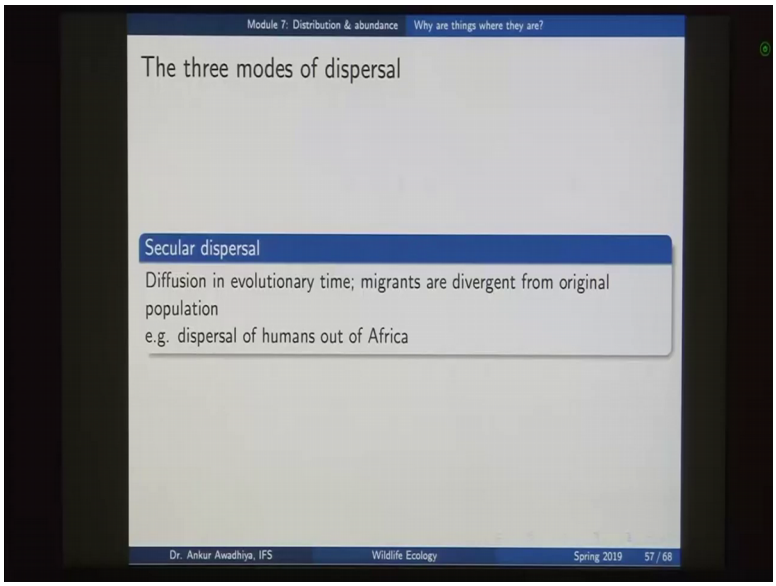

Another mode of dispersal is known as a circular dispersal, now this is diffusion in an evolutionary time. So, it takes a very long period of time several generations and this is so long that it is happening in evolutionary time. So, by the time the migrants are able to reach to the second place they have already changed a lot and a good example if the dispersal of humans out of Africa.

So, the humans moved from Africa through Middle Eastern countries to say India, now all during this movement which occurred across several generations the population that reached to India was very different from the population that remained in Africa because it happened over a long evolutionary period. So, such kinds of diffusions or dispersions are known as secular dispersals now there is one more point that we need to discuss and that is allelopathy.

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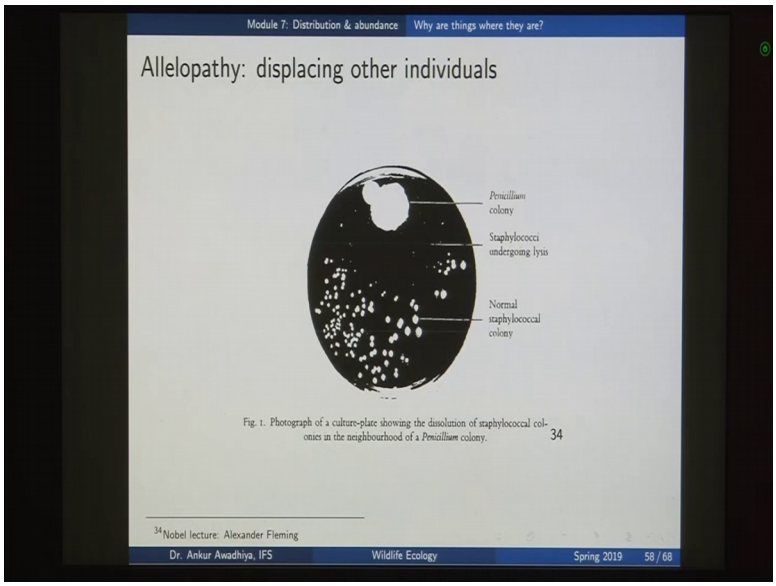

Now, allelopathy is a process it is another push factor that we observe in a number of circumstances in which there are some organisms that actively try to kill or hinder the growth of other organisms. So, examples include things like antibiotics, so there is this fungal colony and this fungal colony is giving out antibiotics which is killing off the bacteria in the surrounding or we can observe it in a number of forest.

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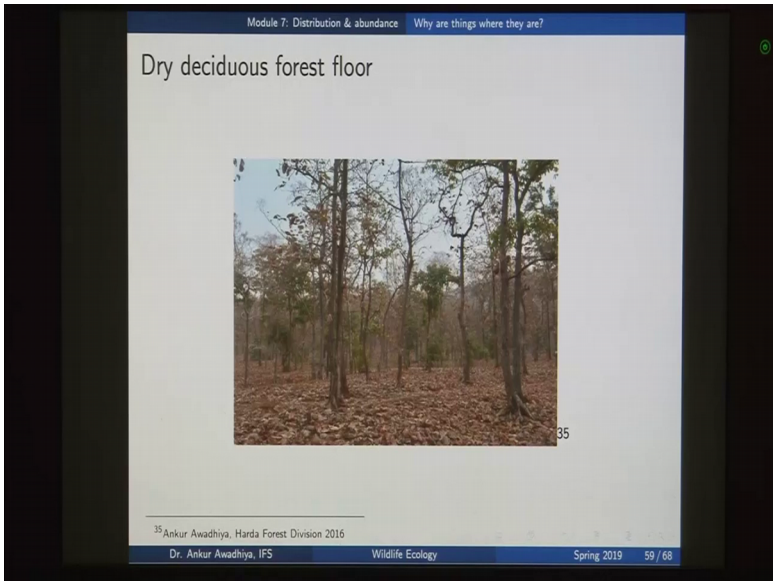

And in this forest I would like these are our teak forests so teak forests are giving out some chemicals in the soil that are not allowing other plants to grow.

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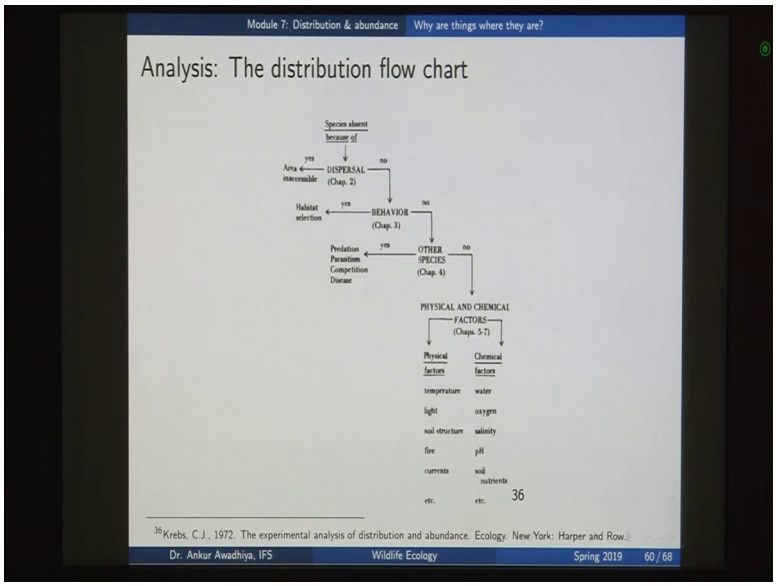

So, these are also another sort of push factors that might play a role in governing the distribution of animals and the abundance of animals or organisms in different areas. So, to sum up we can use this chart or species can may be absent because of dispersal, so, if this is the reason then the cause is probably that the area is inaccessible. If it is not absent because, of dispersal that it might be absent because of a behavioral cause because of habitat selection.

If that is not the cause it could be because of some other species, predation, parasitism, computation, diseases, if it is not because of that then probably there are some physical and chemical factors such as temperature, light, availability of water oxygen and so on. So, using all of these factors we can come to a conclusion about all different species why species are found in some particular areas and why they are not found in the other areas, so, that is all for today.

Thank you for your attention [FL].