Wildlife Ecology
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Lecture –18
Community Organization

[FL] We move forward with our discussion on Community Ecology.

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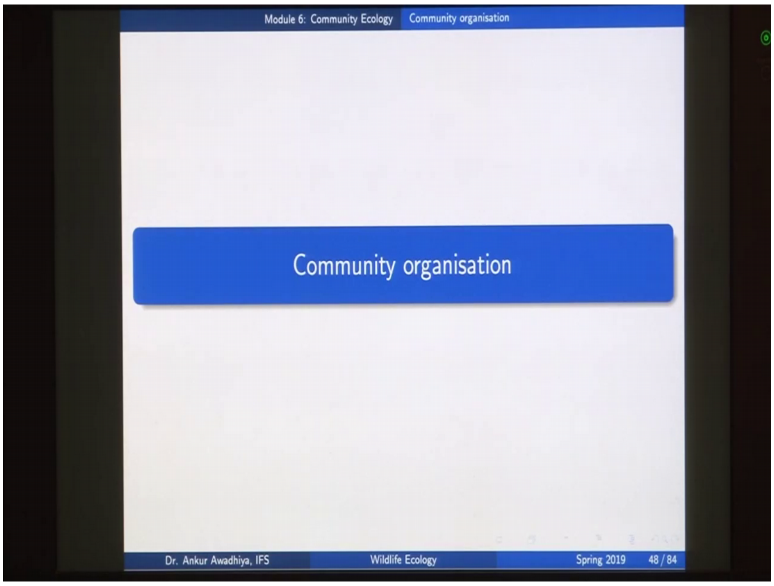

And, today we will have a look at Community Organization and how communities change in response to external forces.

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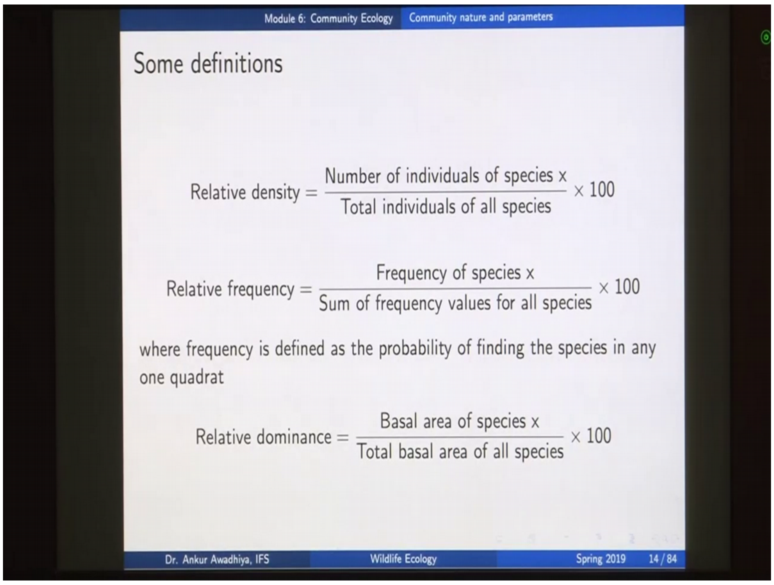

So, we had defined these 3 terms earlier, relative densities, relative frequency and relative dominance. So, to recap relative density is the number of individuals of a particular species divided by the total number of individuals of all the species multiplied by 100 percent.

So, this is telling us the number of individuals of any species, as a fraction of the total number of individuals of all the species that are there in this particular community. We had also defined relative frequency; as the frequency of finding the particular species in this case a species x, in any portrait divided by the sum of the frequencies or values of all the different species.

And, we had also defined relative dominance in terms of the basal area of the species or this definition of relative dominance is primarily used in the case of trees, but in the case of other species when we are talking about say herbs or shrubs, we can make use of other definitions of relative dominance.

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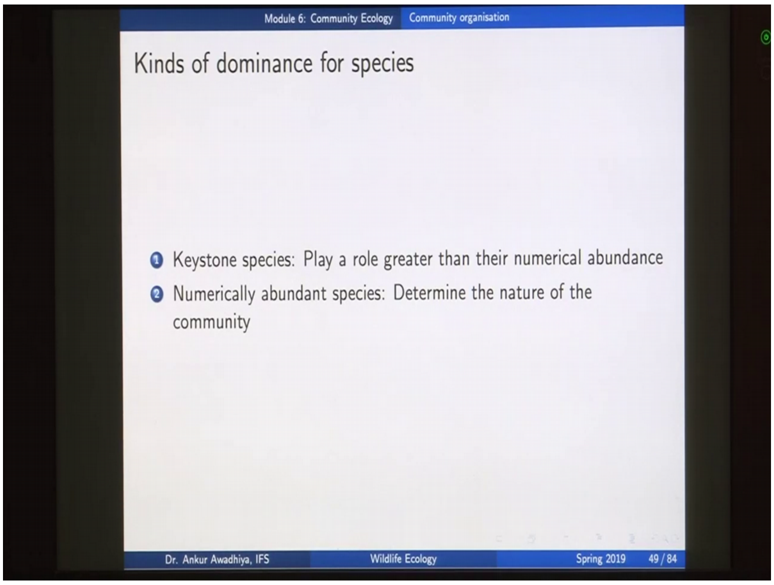

So, a more generalized definition of relative dominance is in terms of the importance of the species for that particular community. So, we can define dominance in 2 terms. The first is in terms of keystone species, which play a role that is much greater than their numerical abundance. So, if we have a keystone species such as a ficus species in a particular forest ecosystem will say that, the fighter's species is a dominant species because it is a keystone species.

It is supporting a number of other species, which are found in that community plus a number of parts of this particular tree the ficus trees are edible, their fruits are edible, their leaves are edible, even their flowers are edible. So, in that case even in the case of very pinch periods like, extreme dry seasons they act as a food source. So, they are essentially they are providing for the whole of the community.

So, we say that the ficus trees are dominant species for that particular community. Secondly, we can define dominance in terms of the numerical abundance of the species. So, if there is a species that is numerically very abundant or a species that is having a high relative density.

Then, we can say that that particular species is also dominant in that community, because of it is numerical abundance it is able to regulate the characteristics of the community. And, a good example is the sal trees in a sal forest so, because we have so, many number of sal trees the environmental conditions or the habitat conditions for all different species in the sal forest community are determined by the sal trees. Because, they are very tall (Refer Time: 03:26) and they have a canopy. So, there they do not permit enough amount of sunlight to reach to the ground. And, at the same time they also result in a very high amount of moisture that is present in the whole of the community.

So, just because of their vast numbers the whole of the community is characterized by the properties of the sal trees. So, in this case we can also say that the sal trees are dominant species in the case of the sal community.

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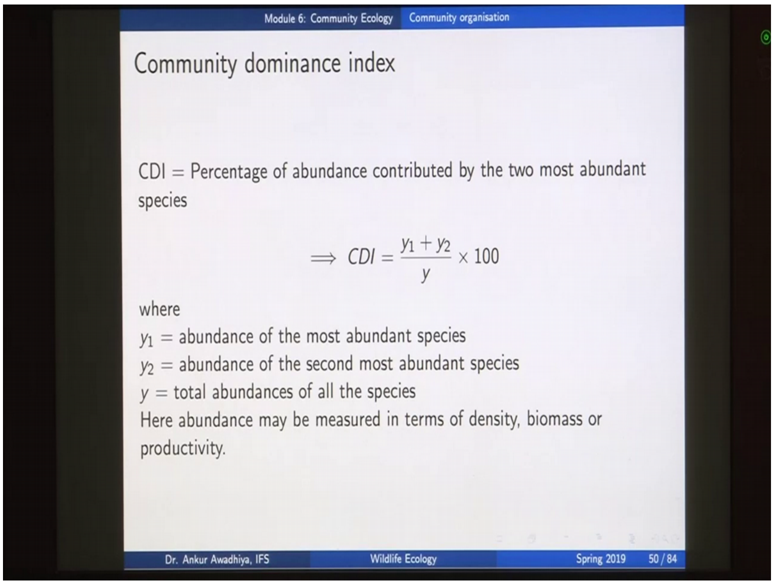

And, for any community we can define a term which is known as a community dominance index. Now, community dominance index is the percentage of abundance that is contributed by the 2 most abundant species. So, earlier we were talking about the relative abundance of any 1 species. Now, we are talking about the relative abundance of 2 species.

So, CDI or the Community Dominance Index is defined as y 1 plus y 2 divided by y in 2 100 percent. So, y 1 is the abundance of the most abundant species, y 2 is the abundance of the second most abundant species and y is the total abundance of all the species. And, here abundance may be measured in terms of density biomass or productivity.

Now, why are we doing that? Now, if we are talking about the abundance of 1 species, we are looking at the abundance of that particular species in the community, but it is often seen that there are a number of other species that are associated with the most dominant species.

So, for instance in the case of a sal forest, you will normally find (Refer Time: 05:15) where there is sal. So, in that case we say that (Refer Time: 05:19) is a dependent species or it is a sal associated species. And, when we are talking about the dominance value in any particular community, we should incorporate the abundances of both these species, because they are always occurring together. So, sal is the most abundant species (Refer Time: 05:39) is maybe the second most abundant species.

So, we add both of these to determine the community dominance index, whether this community is dominated by a few species of whether this community is not dominated by just a couple of species, but nearly every species has an equal amount of (Refer Time: 05:58) that is the question, that, we are asking. Is this community turning towards say a monoculture or a biculture when you see only 2 species everywhere or is this community a more diffused community, where you have a more number of different species that are found in all the regions.

So, CDI is y 1 plus y 2 divided by y into 100 percent. Now, the question is there a relationship between the community dominance index and the biodiversity of an area.

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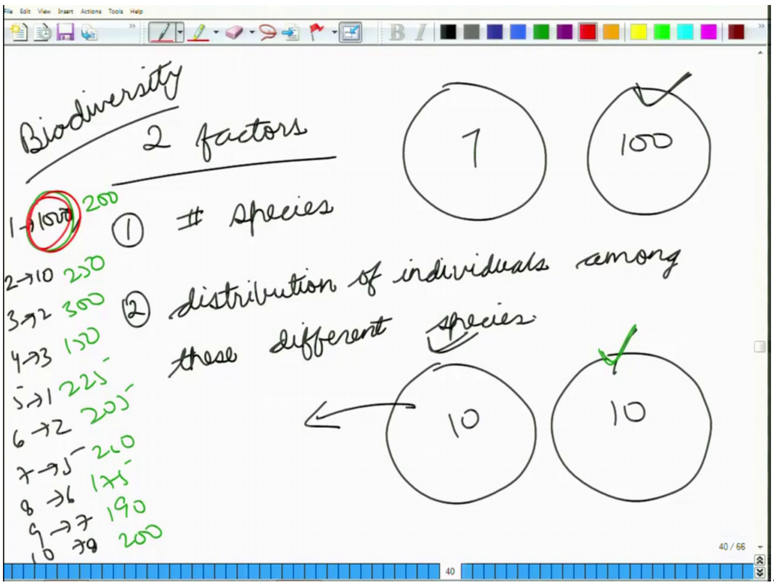

Now in our lecture on biodiversity we had seen that biodiversity is dependent on 2 factors. Now, the first factor is the number of species that is found in the area and the second one is the distribution of individuals among these different species.

So, essentially what we had said was if you have 2 communities and there is one community that has say 7 species and there is another community that has 100 species. So, we will say that this community is much more bio diverse as compared to the first community. So, here we are talking about bio diversity. So, we will say that the second community is much more diverse, but then if we have 2 communities.

And the first community has 10 individuals, the second one also has 10 individuals, but then in the first case you have the individuals such that, in the case of 1 2 3 4 5 6 7 8 9 10. The first one has say 1000, the second one has say 10, then you have 2 3 1 2 5 6 7 8. Now, in this case this community is having this particular species that is species 1, in so, much abundance that if you go anywhere you will only find species 1.

Whereas, in the case of the second community, we have a situation where let us say we have 200 250 300 150 225 205 200 and 10 let us say 175 190 and 200. If, this is the number of individuals that we have in of different species in, the second community then wherever you go you will find a representation of all these different species because all of them have a roughly equal numerical abundance.

So, if you have a situation where there is one community that is where there is one species that is dominant. So, the more is the amount of dominance or the more is the amount of the relative abundance the lesser is the biodiversity. Now, when we are talking about the community dominance index, we take not just the most abundant species, but also the second most abundant species. Now, in this case what we are saying is that suppose the first species had 1000 individuals and the second one the second most abundant had say 800 individuals.

So, here we have 1800 individuals that are there in just 2 species in all the other species have very less number of individuals. So, here again we will say that the amount of biodiversity in this community is less. Why, because if you go anywhere you will find either individuals of species 1 or you will find individuals of species 2.

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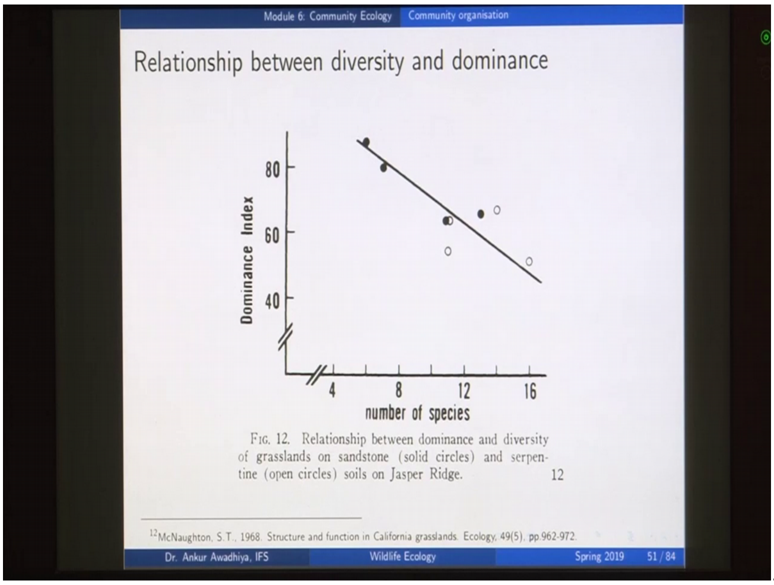

So, the more is the amount of dominance the lesser is the biodiversity. Also the more is the number of species the lesser would be the dominance index, because when you have more number of species, then it is also possible that the numerical abundance of the top 2 species will be lesser because you have individuals from so, many different species. So, this is roughly the relationship that we expect.

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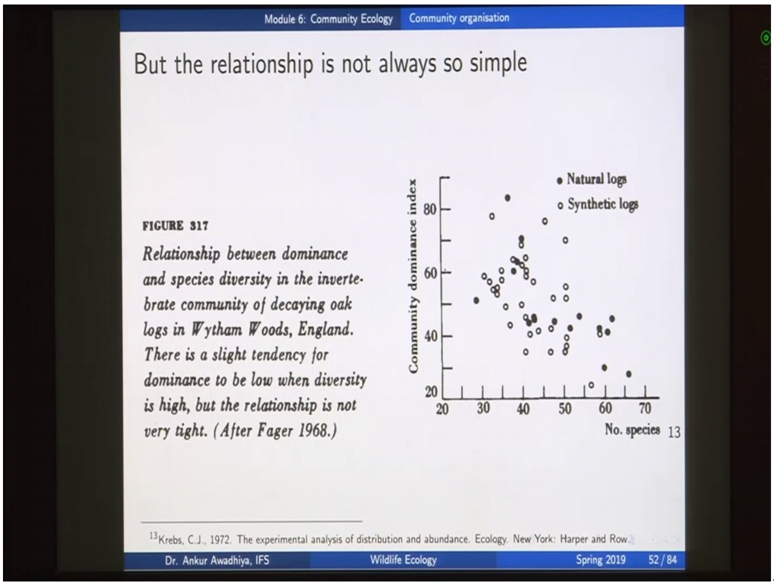

But, then this relationship is not that simple if, we actually look at the field values. So, here we are looking at the relationship between dominance and species diversity in the invertebrate community of decaying oak logs in a place called Wytham Woods in England. And, there is a slight tendency for dominance to be lower in diversity is high, but the relationship is not very tight.

So, here you have the community dominance index on this side you have the number of species. Now, we can say that you can try to put a curve like this, but then because here you have so, much amount of variation. So, it is also possible that we might try to put a curve not like this, but say like this that is also possible. So, the relationship is not very tight in this case or in terms of mathematics we will say that the r square value is not very high or the amount of correlation between both of these variables is not very high.

So, roughly we can say that if you have more number of species the community dominance index reduces, but then this is not a very hard and fast relationship, the level of correlation that you have between both of these variables, the number of species and the community dominance index the correlation is very less. But, then there is one correlation that is much more prominent, which is the relationship between dominance and productivity.

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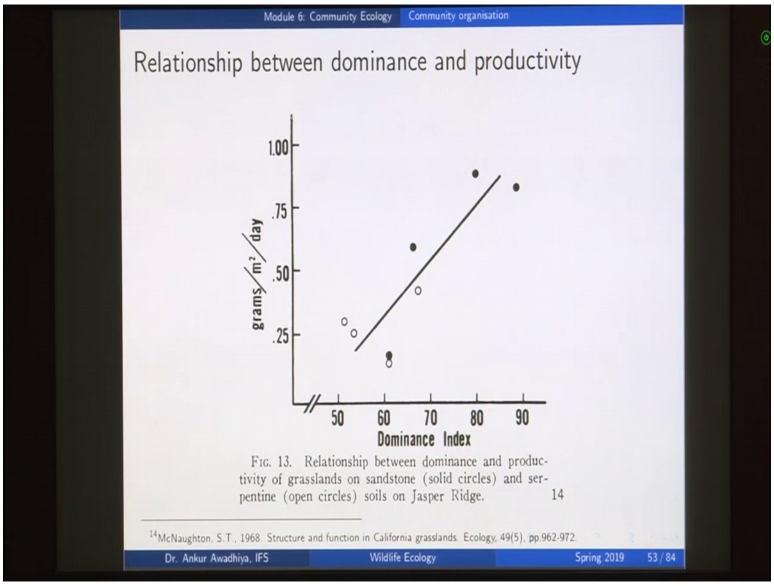

Now, here we are looking at the relationship between dominance and productivity of grasslands on sandstone and serpentine soils in on jasper ridge. So, in this case here you have the dominance index here you have the productivity. Productivities in terms of grams per square meter per day, that is the amount of production that is going on in this area.

And, we can see that if they if you have a lower dominance index, the productivity is in is roughly low and if you have a higher dominance index the productivity is roughly high. Now why is that? So, because here we can look at the organization of the community in terms of why a certain species is dominant in a community, any species will be dominant when it is able to compete better than the other species.

So, probably a species that that is more dominant is able to say they produce faster or maybe it is able to take much more amount of sunlight and convert it into biomass. So, it is efficiency is much greater. So, if you have a community where some species are dominant. So, they are typically those species that have a very high level of productivity. And, in those communities where you do not have a level of a very high level of dominance, then most of the species that they are either all very low productivity species, or else they are also on these species are spending quite a lot of energy in competing with each other.

Because, none of them is having a very high level of competence or competition as compared to the other species. So, in this case those communities which have some dominant species, they will be able to have a much higher level of productivity as compared to those communities that do not have a species that is dominant.

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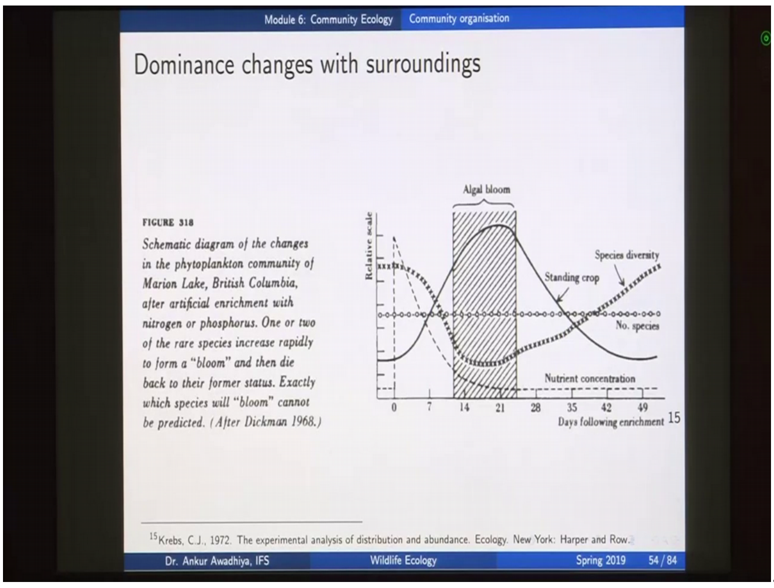

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And, this dominance also changes with the surroundings; it also changes with the biotic and abiotic conditions that are brought about in the community. Now, in this image we are looking at the changes in the phytoplankton community of a particular lake in British Columbia, after artificial enrichment with nitrogen or phosphorus 1 or 2 of the rare species increase rapidly to form a “bloom” and then die back to their former status. Exactly which species will “bloom” cannot be predicted.

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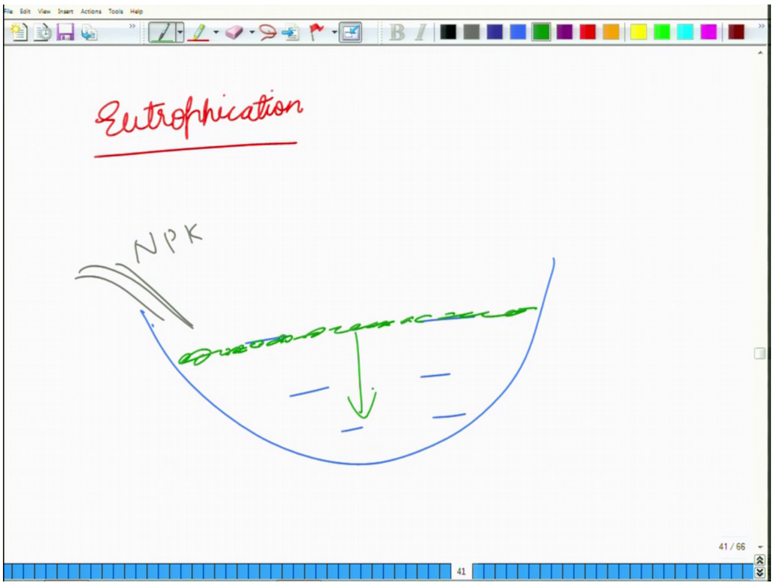

Now, what was done in this case was that we have already talked about eutrophication. Now, in the case of eutrophication, we have a situation in which you have a water body and in this water body there is some discharge of nutrients into it. So, suppose you add N P and K inside so, nitrogen phosphorus and potassium.

So, there will be some algal species that will form a very big bloom that will cover the whole of the surface, because they are now getting very ample amount of nutrients and once there is this algal bloom. So, after a while the this whole lake will be dead because all of these algae after a while will start dying and when they die they will start sinking to the bottom.

And, when they are decomposed so, all the oxygen that is there in the water is taken away.

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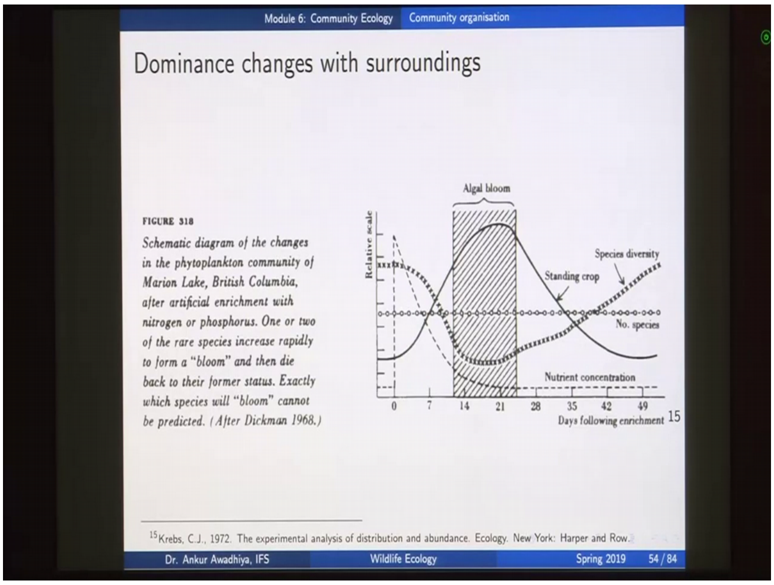

Now, in this particular experiment the scientists tried to artificially do eutrophication in a controlled manner. So, here on the x axis we have the days following the enrichment. So, on this day 0 you added the nutrients, which nutrients were added nitrogen or phosphorus.

So, here you have the nutrient that was added and this curve this dashed line is showing you nutrient concentration that is there in the water. So, when you put the nutrients. So, this is the 0 level. So, before day 0 you have this line this dashed line, then you spread it with nutrients. And, after a while then the concentration of the nutrients it starts to come down. Now, why does any nutrient come down in concentration after a while, because as we have seen in the case of nutrient cycles, if you have nitrogen in the form of nitrates.

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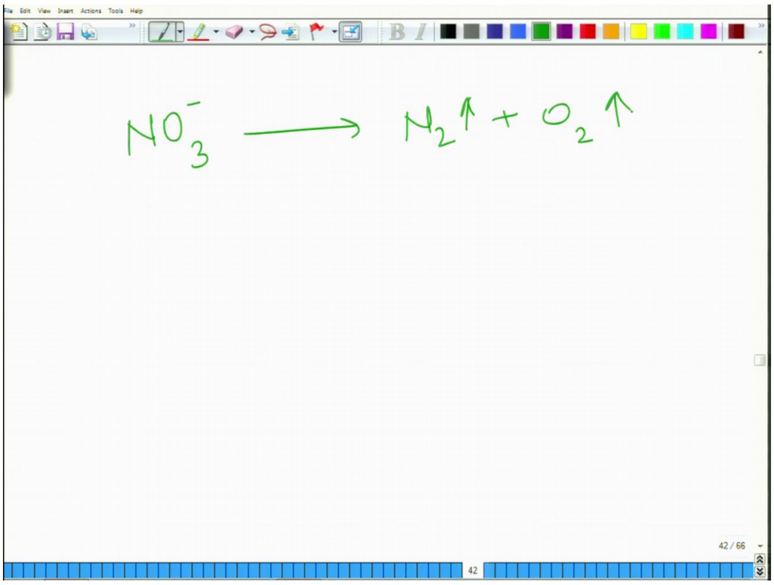

So, there will be some organisms that will be denitrifying organisms. And, in that case they will convert this, these nitrates into nitrogen and oxygen and both of which will be later on released from the water. Or in case you are adding the second nutrient if you are adding phosphorus into the lake what happens is, you have this lake in which you added the phosphorus let us just talk about phosphorus here.

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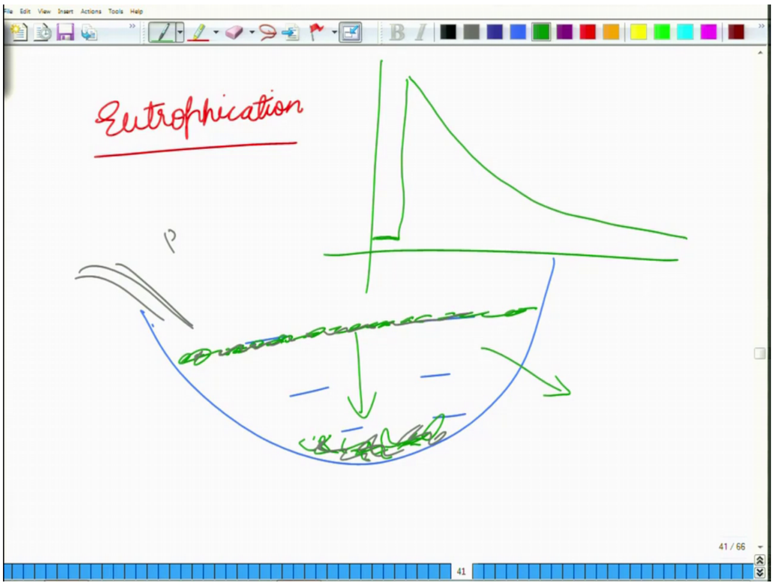

So, the phosphorus and was used up by all of these algae and then later on when these algae die off. So, their bodies have come to the bottom of the lake and with them the phosphorus has also come to the bottom of the lake. And, it typically takes a very long period of time for this phosphorous to get released back into the water. So, if you look at the concentration of phosphorus in this water after the y it will start declining.

So, if we plot the concentration. So, if that was if this was the normal concentration. In this case the concentration was spite and then it will start decaying and it will reach to the normal levels after some days. So, this is what we are seeing. So, it increased and then it started decreasing.

Now, if we look at the number of species in this particular lake the number of species all throughout it remains constant, because in this particular chart experiment there was no extinction of species that occurred. So, none of the species was completely a decimated from this community, but if we look at those species diversity. So, if this was the species diversity shown by these crosses the species diversity reduced considerably and then it started to increase.

Now, why do you have a situation of reduced species diversity, because as we have seen earlier if we have so, in this case you have these 2 communities, in the case of the first community you have 10 into 10 a species, in the case of the second community you also have 10 a species, but then if the number of individuals that are found in different species if that changes that can reduce the level of diversity.

So, what happened in this particular case was that we started with same.

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So, let us say that this is the species and say we had this 6 species in the water. Now, the earlier numbers were say also we are looking at the abundance shape per 100 ml of water. So, let us say that earlier we had 20 25 22 24 23 and 18 number of individuals. Now, once you have spiked it with the nutrients. So, let us say after spike.

So, once you added these nutrients there were some species that were able to prolifically use these nutrients. So, suppose that was the second species in this case after this pie here you have 20 22 24 23 and 18, but in place of being 25, let us say that it increased to 10,000. Now, why did this happen? Because, when you have a lake that does not have ample concentration of nutrients so, all these 6 species are competing against each other, there is not a plentiful amount of nutrient that is of level.

So, none of the species can become dominant. So, all of these are competing for the same scarce resources, but then once you have given the resources so, again if you remember the lyrics law of the minimum. So, those are those species that were constrained by the nutrient availability, they were able to come out of the, that particular threshold and they were able to proliferate very rapidly. Because, see in this particular example suppose this was a species that was limited because of the nutrients. Let us say this was a species that was limited by the PH of the water.

So, probably it required a more basic PH, but the PH was more acidic or maybe this again was another species that required an even more acidic PH, but then it was again limited. Because the PH was not that much acidic, or probably there was some other species that was limited because of the light, that could be there in this area. Or some other species that was limited by the temperature, or there was some other species that again required another range of temperature, there was some species that wanted a more higher temperature there was another species that wanted a lower temperature.

Now, suppose we played with these parameters suppose we played with the PH. So, in that case this species would have proliferated much better or say this species would have proliferated much better, but then because of all of these species this one was the one that was actually limited by the nutrients that were available. So, it was tolerant of the PH it was tolerant of the temperatures, it was tolerant of the light the only thing that it needed was the nutrients.

So, once you put in the nutrients. So, other species are not able to overcome their limitations, but this species is able to overcome it is limitations and from 25, it becomes 10000s. Now, once that happens, what do we say about the diversity or the biodiversity that is there in this community. In this particular community, that is in the earlier situation we had all the individuals that are roughly the same.

So, in this case every species has roughly the equal of more or less equal number of individuals. So, in that case the level of biodiversity is high. In this particular case after the spike this species became so large, that it now looks more or less like a monoculture. So, there are so, many individuals of this particular species that now if you take out any sample, you will only find individuals of this species and others will be just overwhelmed because of these numbers.

So, because of these reasons the biodiversity so, you have the same number of species, but the species diversity it reduces. Now, it reduces and then it starts to increase again why, because you had this peak and your species to work was able to use this peak of nutrients, but then later on when they speak again subsides. So, again you are getting to a situation where the amount of nutrients in the water is less.

So, in that case it is coming back to the status quo. So, you started with this relative scale. So, it started here and it came back to here. So, this value and this value are roughly the same, but then what happened to the standing crop in that time, standing crop is the amount of biomass that is present in the lake.

Now, in this case the standing crop it increased exponentially, then it reached a peak and then it decreased. Now, why did that happen this is because of the second species which was using these nutrients and it led to an algal bloom in this area? Now, when that happened? So, this peak coincides with the time where you had the algal bloom. So, this is how dominance changes with the surroundings. Earlier when you did not have this spike of the nutrients in this particular condition, in the earlier situation there was no species that was very much dominant if you had to find out the community dominance index.

So, the 2 most abundant species are these 2. So, this is roughly length, this is 15 49 divided by 5 6 7 8 9 10 14 22 and in 2 4 6 8 10 12 13. So, this is the community dominance index would be 49 by third-one 32 in 200 percent. So, which is roughly we can see that this is around 50, this is see around 150. So, this will become close to around 33 percent.

So, this is the amount of community dominance index that we had in the lake before hand, but then after the spike you have this value that is 10,000 and the second most diverse most abundant is 24. So, you have divided by and now this bottom value will also be very close to 10000, but let us do the computation 8 9 10 14 317 and then you have 2 4 6 8 9 10 into 100 percent. And, this is very much close to 100 percent.

So, the community dominance index it shifted from 33 percent to 100 percent just because of some changes that came up in the surroundings. So, the dominance changes with the changes in the surroundings, but then in this particular case we can also see, that the community even though it suffered with these changes, even though it suffered with this algal bloom, but then the later on values of everything are the same as that of the initial values.

So, if you look at the number of species it does not change, if we look at the species diversity here suppose this was 100 percent. So, here I mean it comes back to the same level. If, you look at the standing crop it also comes back to the same level, if you look at the amount of nutrients that also comes back to the same level.

So, this is what we mean when we said that a community shows some amount of homeostasis or self-regulation. So, even though this community was given some changes it was able to self-regulate and it was able to bring everything back to the normal state.

So, it at the very end it had the same level of biodiversity, it had the same standing crop, it had the same number of species, it as if nothing had happened. So, how is any community able to bring itself back to the normal well it is able to bring it itself back to the normal, because we have this concept of stability of different communities.

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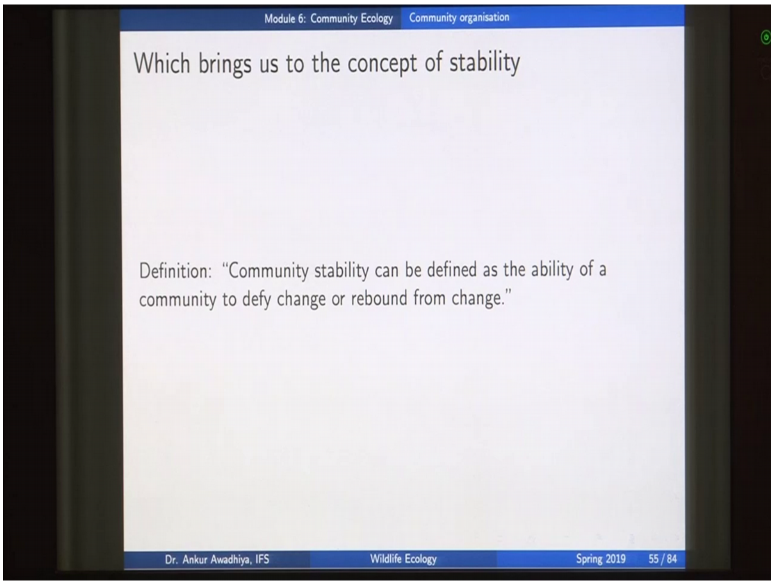

So, community stability is defined as the ability of a community to defy change or to rebound from change. So, there can be certain situations in which there is a community that is define the change, what do you mean by defining a change, that is if there is a change a communities able to resist the change or in certain situations if it suffers from a change, then it is able to rebound from the change.

Now, how do you defy a change? A very good example of defying a change is the case of buffers.

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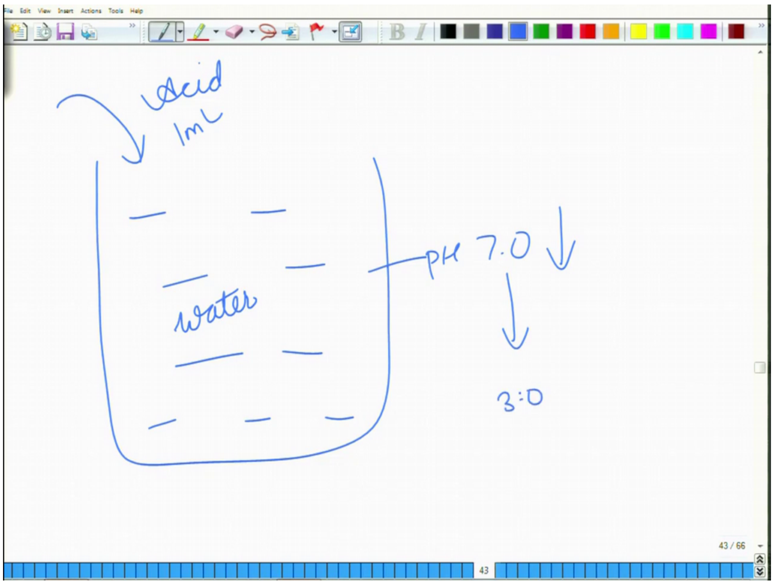

So, suppose you have a beaker and you have say water in it and the PH of the water is 7. And, now if you add acid into this water. Now, as soon as you start adding acid the PH starts decreasing.

So, this is an example of a system that is not able to resist a change.

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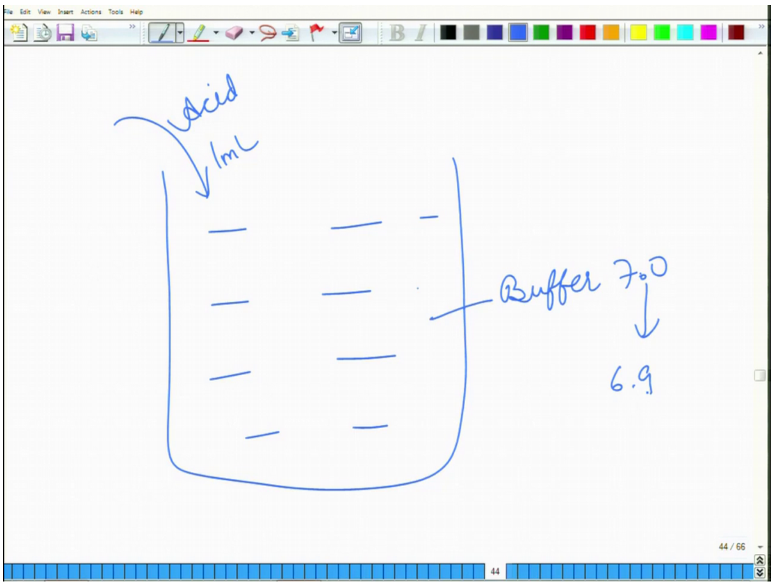

But, then if we have another beaker. And, in this beaker suppose you have a buffer and the PH of the buffer is again 7.0. Now, you add the acid. So, because you have a buffered solution so, the PH will go down, but it will not go down at that faster rate. So, suppose in this case when you had the water inside and you added say 1 milliliter of an acid and the PH moved from say 7 to 3.

In this case here again you added 1 ml of the acid, but the PH change from 7 to 6.9. So, this would be an example of a system, that is the resisting the change. Now a good example in the case of our communities would be that if you have a system in which say you have again a lake ecosystem or a lake community.

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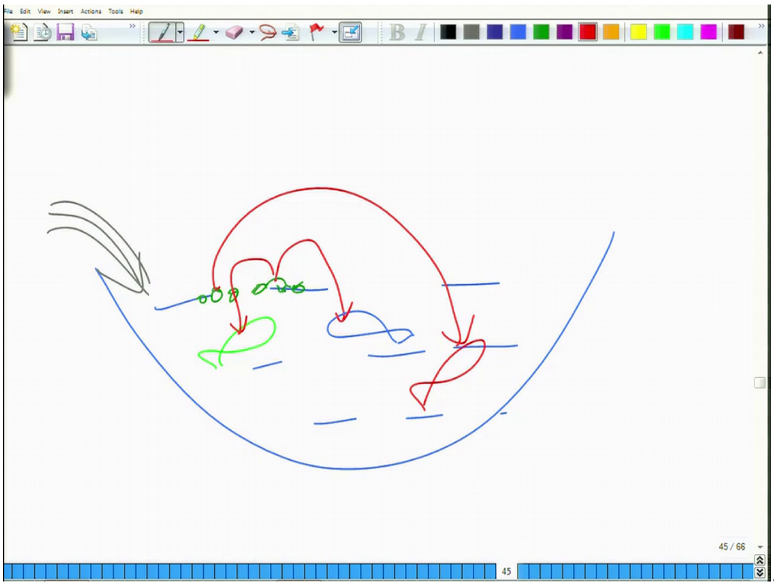

And, here you are adding your nutrients inside. And, once these nutrients come in you have an algal bloom, but then before this algal bloom can happen. Suppose there are some fish species inside this water and these fish species they eat up the algae that are being formed. So, in that case this system is resisting the change, because you are putting in an external disturbance which is trying to increase the algal population, but then your system is such that you are maintained maintaining our homeostasis because your fishes are eating up that algae.

So, in that case the there cannot be an algal bloom, but then this amount of resistance will be limited. Because, it will depend on the amount of changes that you are bringing in and in the rate at which you are bringing in the changes. So, for instance when we were talking about this particular lake, in place of giving it this spike suppose we gave it a spike that was only this much.

So, in that case probably the algae that were that started to proliferate they could have been eaten up by the fishes and then probably we would not have seen an algal bloom. Or in other case in place of giving it a very sharp spike, suppose we gave it the same amount of nutrients, but then probably we gave these nutrients in a span of say 30 days, what would happen in that scenario?

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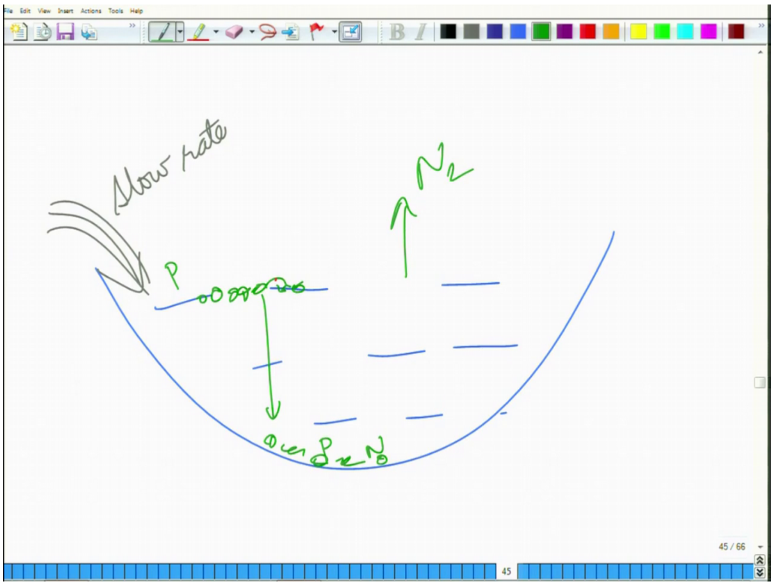

So, we are not talking about the fish that I eating up these algae, but let us say that we are giving in the nutrients at a very slow rate, what happens when you have a very slow rate. So, you have some algae that were able to proliferate, but then after a while they start dying and so, these algae's they come down to the bottom of the lake, with that the phosphorous that was there in the water that also came down. So, the phosphorous that was there on the top it has come down.

And, when they are when they have started to degrade the nitrogen that was there it was released out by the denitrifying bacteria that are present in this community. So, again you have added very small amount of these nutrients, again there was a small algal bloom and then again the phosphorous went down the nitrogen what lost. So, if you are giving these changes at a very slow speed.

So, if the quantum of changes is less or if these changes are coming at a very slow speed, in that case the system is able to resist the change. Because, you are giving it these nutrients, but this system is able to push those nutrients down or it is able to push those nutrients away. So, that there is no change in the community.

So, that is the resistance to change. And, so, that is defined the change or the ability to rebound from the change. So, in our example of this lake the community did suffer from a change, it did suffer from a decline in species diversity, it did suffer from an extensive increase in the standing crop, but then it was able to rebound back. So, it was able to bring all these values back to the normal.

So, the ability of a community to defy a change to resist a change or to rebound back from the change is known as community stability. And, community stability is a very integral part of this study of ecology, because we are pushing different communities through different changes, because of our anthropogenic influences, we are putting quite a lot of waste materials into our water bodies into the environment and that is all changing different communities.

Now, it becomes important to know how it is the amount of change that different communities can tolerate. And, whether the communities will be able to come back to normal or not and, if we know the variables that govern the amount of resilience or the amount of resistance in any particular community we can play with those variables, we can make our communities much more stronger so, that they are able to resist changes in a much better way or maybe much more resilient. So, that even though these changes have occurred they are able to come back very quickly. So, that is why a study of stability of community stability becomes very important these days.

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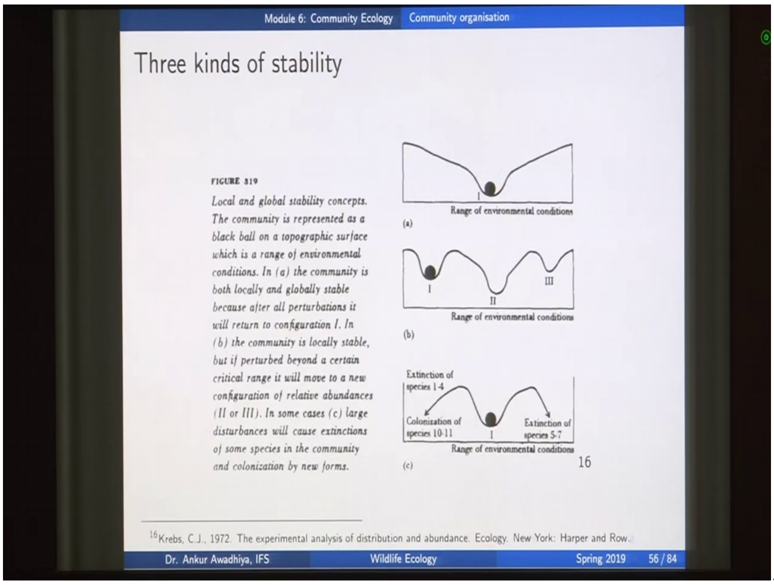

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Now, stability is divided into 3 different kinds. So, we can talk about global stability and we can talk about local stability. Now, we can understand it by the example of this ball that is there on the surface. Now, if you have a ball here and you take this ball up here and then you release it. So, with gravity this ball will come down and it will be here, you take it here to the other direction and here again it will come down. Now, this is an example of a global stability. So, in the context of a community this is a community that is in such a state that whenever you take this community to some level of disturbance it is always able to come back.

And, it will always come back to the same initial state, because this is a global stability. Now, in this second example is an example of local stability. Now, in this case you have a ball here, if you push it to this direction it will again come down here. If you push it to this legend it will again come down here, but then if you push it too far if you maybe bring this ball to this particular point.

Now, it will not come to this point, but then it will start rolling in this direction and it will come here. Now, in the context of a community this is an example of a local stability. Now, in the case of a local stability, if there are small changes in the community the community will be able to bring things back to the normal.

But, if there are larger changes in the community, then the community will change and maybe become a very different community. And, a good example is when we are talking about the successions. Now, in the case of any of an ecological succession, the community is shifting from one local stability to another local stability. So, a grassland is a stable community, if you if you put some amount of changes in the grassland, it will come back to it is own state, but then if you bring about a large change then maybe it would convert itself into a shrubland or maybe it would come convert itself into a more primitive level say a mass stage. So, that would be an example of local stability. And, then if you have a situation where you have a global stability and you are pushing your species to a very large extent.

So, here you have an example of stability and then you are pushing your community to a very large extent. So, the large scale disturbances will result in extinctions of the of some of the species and probably the structure of the community will change completely. So, again to do or to come back to the topic, if you have global stability then even large scale disturbances will bring your community back to the initial state. In the case of a local stability, if you have small amount of changes the community will come back to the initial state, if you have a larger change the community will change and become another community. And, if the changes are very large then you will have extinction of some species or maybe colonization by some new species. So, it will become a very different community altogether.

Now, the question is what governs this stability. So, if you talk about 2 communities 1 is a more bio diverse community is that having a more amount of stability, or if there is another community that has less biodiversity, does that have a higher level of stability. Now, through ages the common knowledge has been that if you have more amount of biodiversity. So, you will be having a greater amount of stability.

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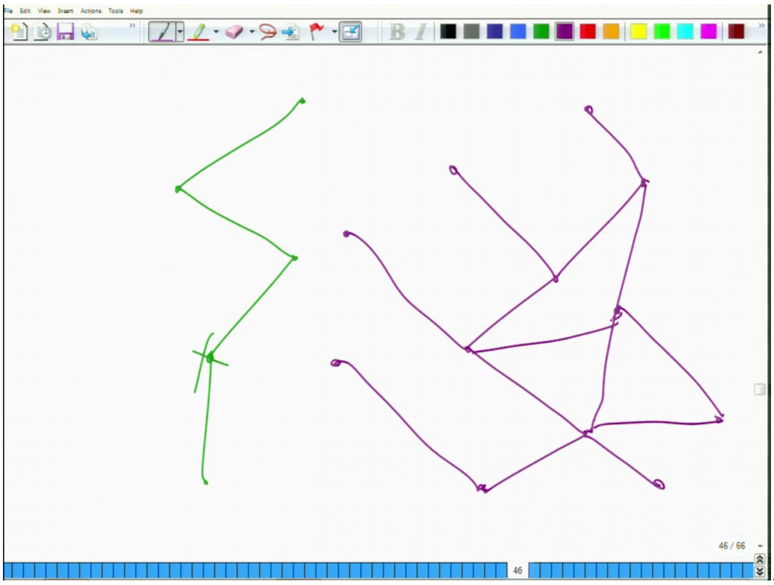

Why, because if you have a lesser biodiversity you will probably have a few food chains. And so, if there is some change at some particular tropic level the whole community will collapse. Whereas, in the case of those communities that are extremely biodiverse, you will have a number of food webs and in the case of these food webs. Even, if there is some species that is changing, you will have a situation where there will be some other species that would be able to bring it back to the normal.

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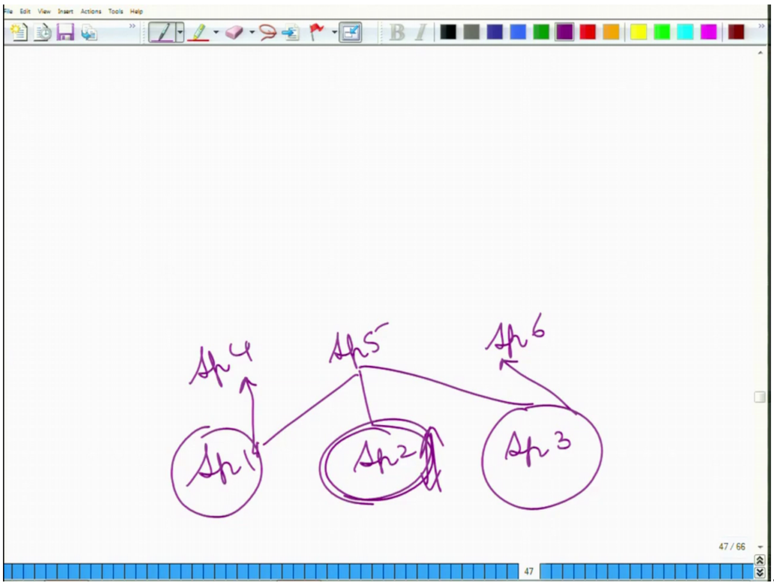

So, for instance if you have a situation where there are say 3 species of grasses and you have say your 3 species of organisms that feed on grasses. So, in that case if the number of individuals of species 2 reduces.

So, in that case the individuals of species 1 and species 3 will be able to counter the loss, because the organisms that were earlier feeding on species 2 they can now also feed on species 3 and species 1. So, there is much more amount of stability and which will provide some time for species 2. So, that it is able to recuperate itself back to the original position. So, that has been our common knowledge, that the more is the amount of biodiversity in a system the more is the level of stability that we see in that particular system, but then these days this common knowledge has been questioned.

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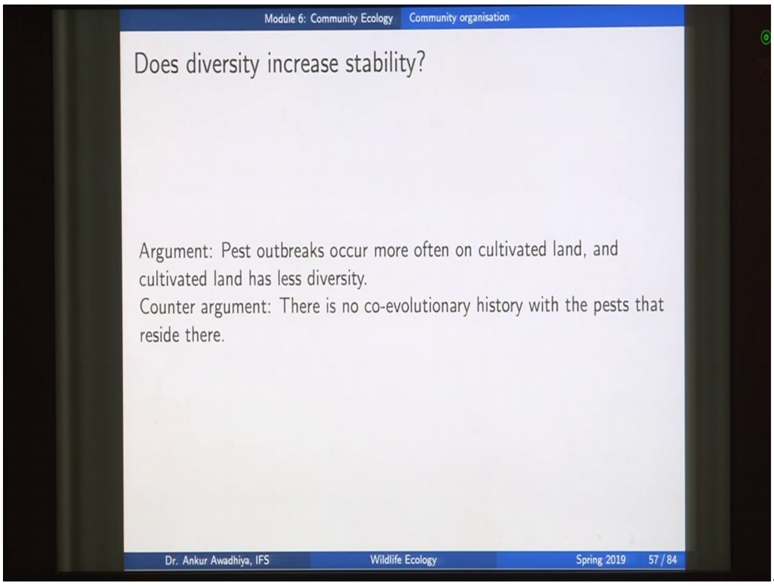

So, some examples are we have always said that best outbreaks occur more often on cultivated lands.

And, cultivated land has less diversity. So, if we look at a national forest, the pest outbreaks there are lesser as compared to agricultural cultivated lands. And so, we have always stated that, because the cultivated land has listed biodiversity, it is less stable and so, it is more prone to the attacks. However, there can also be a counter-argument that there is no co evolutionary history with the pest that resides there.

So, because in the case of a forest there has been a co evolutionary history all these organisms have co evolved with one another, that they are all dependent on each other and through time they have been able to make out mechanisms through which they would be able to resist those changes.

So, it is not because of the more biodiversity that we have in this area, but because of co evolution that a number of species are having mechanisms to thwart their attack. So, that can also be another argument, or if you look at things like tropical rainforests.

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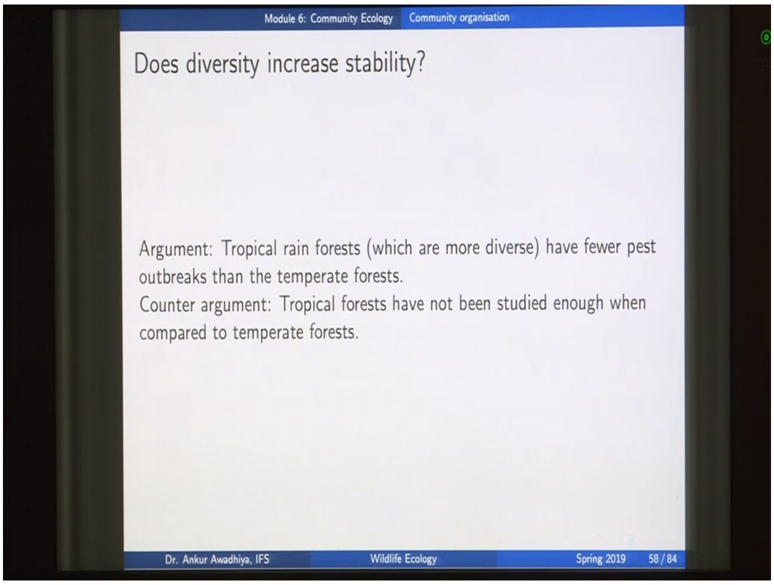

So, tropical rainforests which are more diverse they are having fewer pest outbreaks as compared to temperate forests, where you have less number of species or less amount of biodiversity, but then a counter-argument is also that the tropical forests have not been studied enough when compared to the temperate forest. So, it is also possible that we do not know the kinds of pest outbreaks that are erupting in the case of the tropical forest. Now, if that be the situation what should we see does biodiversity increase stability or is there no relationship between biodiversity and stability.

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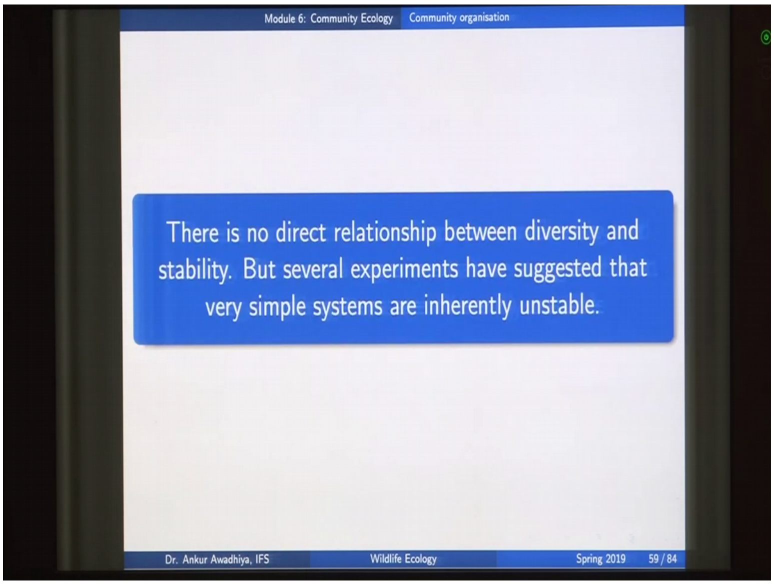

When the current knowledge would say that yes we have seen situations, in which if you have a very simple system then there is an inherent amount of unstability or instability in that particular system. So, if there is a system that is very simple that will tend to become unstable or will tend to have more amount of instability. However, if you have a simple that is more complex so, there is more amount of stability, but then if we talk about a direct relationship between diversity and stability that has not yet been known. So, probably we should say that yes biodiversity increase the stability, but only to a certain extent.

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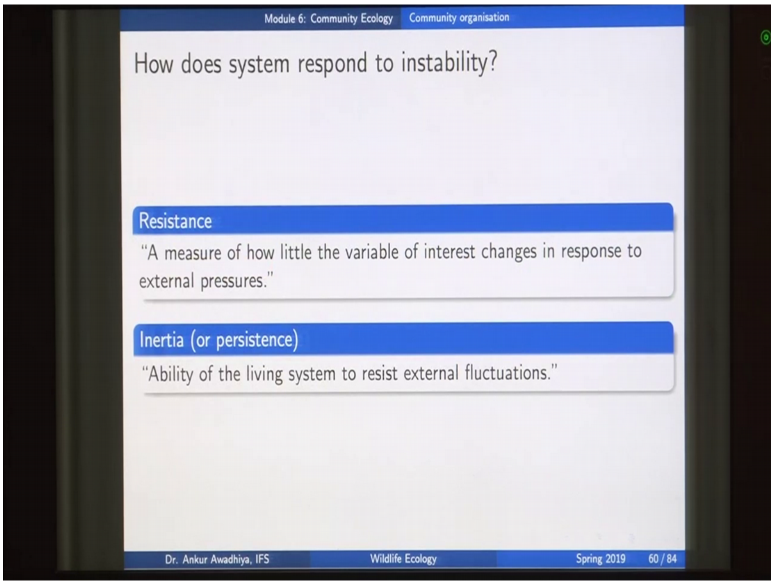

Now, if there is a change in the system. So, how does the system respond? So, again we talked about these 2 things one is resistance, resistance is a measure of how little the variable of interest changes in response to the external pressures, or how much is the amount of resistance your community is able to put towards the external threat. So, if your community is a very resistant community they will not be much changes in any of the variables that you are measuring.

However, if your community has less amount of resistance then the more than the level of changes will be very high. The second thing is a related concept is inertia or persistence, which is again the ability of the living system to resist the external fluctuations.

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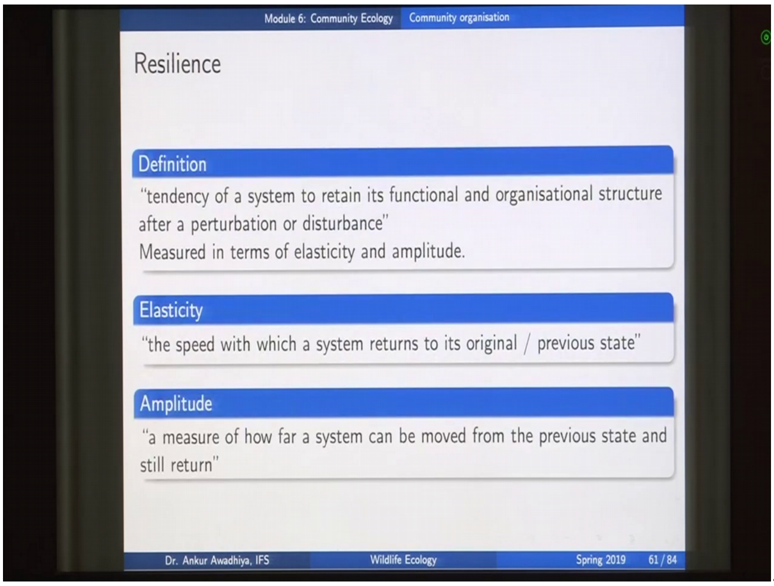

So, this is about resistance or resistance can also be explained in terms of energy or, the other definition is that of resilience. Resilience is when you have the changes how fast, how quickly, and to what extent is your community able to bounce back to normal. The tendency of a system to retain it is functional and organizational structure, after a perturbance or disturbance. Now, resistance is measured in terms of inertia resistance is measured in terms of inertia and resilience is measured in terms of elasticity and amplitude.

Now, elasticity is the speed with which a system returns to it is original or the previous state.

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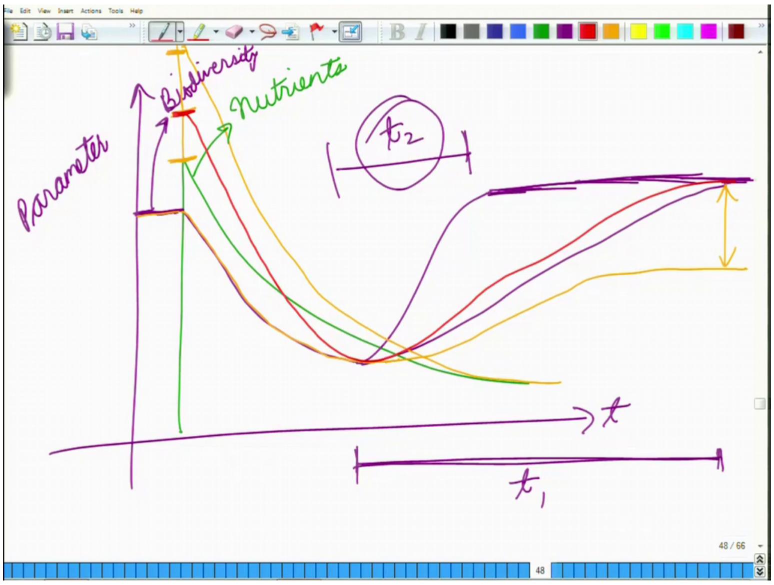

So, for instance for the community you had you gave it a nutrient spike and because of which the amount of biodiversity reduced. So, let us say the biodiversity was this much and then it reduced and then after a while it was coming back to normal. Now, the question is how fast will this come back normal? Does it take this much amount of time or is it able to come back very quickly.

So, a community that is taking this much amount of time. So, here you have time and here you have the parameter and you give it the nutrient spike. So, this is the level of nutrients. And, the purple one is the level of biodiversity. Now, because this community is resilient so, the initial level of biodiversity and the final level of biodiversity are the same, but then your elasticity will ask the question take this longer period of time t 1 or does it come back very quickly which is t 2.

Now, a community that has a higher amount of elasticity will typically take a less time to come back to it is normal state. So, elasticity is the speed with which the system returns to it is original or the previous state. Now, the second related concept is amplitude. Amplitude is a measure of how far a system can be moved from the previous state and still return.

Now in the case of amplitude we are saying, that in place of giving this much amount of nutrient spike, suppose we give it this much amount of nutrients spike a very great amount of nutrients spike. Now, in that case it is possible that your system the biodiversity reduces and then it is never able to come back. So, probably it comes back to some extent, but then the there is a difference that props up.

So, the initial level of biodiversity is greater than the final level of biodiversity. Now, in if you had a spike of this much concentration the system was able to bounce back to normal, when you have a spike that is this large the system is not able to come back to normal. So, what is the maximum value of disturbance, that you can do and still the system will be able to come back to the normal state.

So, in this case suppose it goes down and probably it is able to come back. So, what is this maximum level of disturbance that the community will be resilient to that is measured by this term called amplitude? How far a system can be moved from the previous state and still return back? Now, why are these concepts of resistance and resilience so important?

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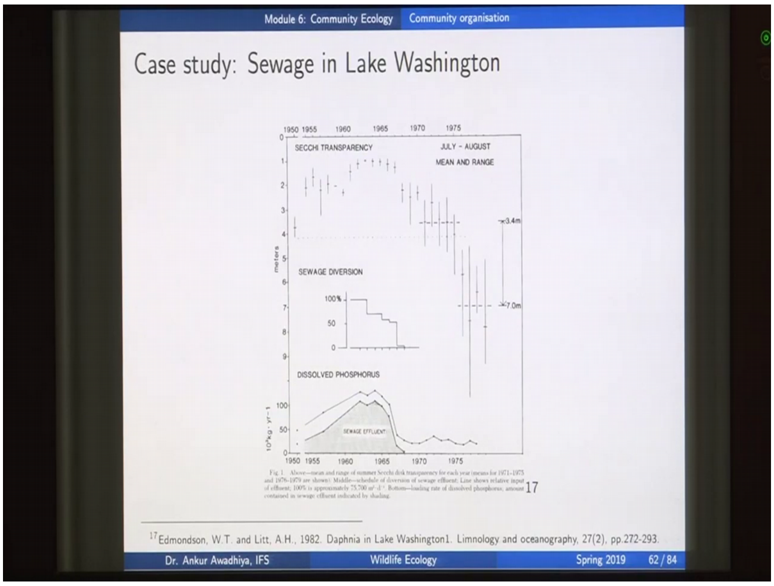

So, as we have seen because we are adding a number of disturbances to different communities now this is a case study of sewage in lake Washington. Now, lake Washington is a lake near Seattle and in the case of this lake, there were a number of sewage drains that were draining into this particular lake.

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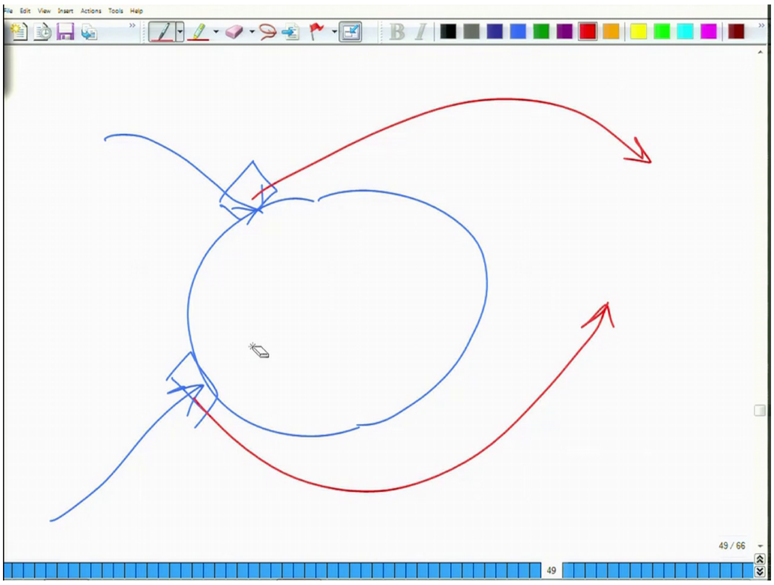

So, you have a leak. And, in this particular lake you have one stream that is giving out civilly then you have another stream that is given in giving out sewage and so on. Now, after a while it happened that people said no this is too much let us now create this waste. So, they then set up some sewage treatment plants, but then even after treatment the waste was put into the river itself.

Now, even after treatment you have a very high amount of nutrient load that is there in the treated wastewater. So, that would also result in some changes in the community that will also result in algal blooms. So, after a while it was decided that no we are not going to put any of this treated base into our lake and we are going to push it into the oceans. And so, any so, that now you do not have any more amount of sewage that is put into the lake Washington.

Now, this lake was studied as an example of how communities change. So, on the x axis here we have the years and so, near to around 1960 we had a hundred percent amount of sewage that was put into the lake and then it was reduced and then is reduced because it went in phases. So, in different phases the sewage was diverted into the seas. So, this is showing you the amount of sewage which that remains. So, after a dive diversion now at this point you do not have any particular amount of sewage that is being put into the system.

Now, this great curve is telling you the sewage effluent that was there in the lake. So, at this particular point of time you have started reducing it and after the while you do not have any other effluent that is now being put into the lake. Now, in this case this is showing you the level of dissolved phosphorous. Now phosphorous is only coming because of the sewage.

So, in this case if you have more amount of sewage you will have more amount of phosphorous when you have less amount of sewage less amount of phosphorous is coming. And, then after a while it reduces as well. Now, once you have these nutrients in the water, here we are looking at the psyche transparency.

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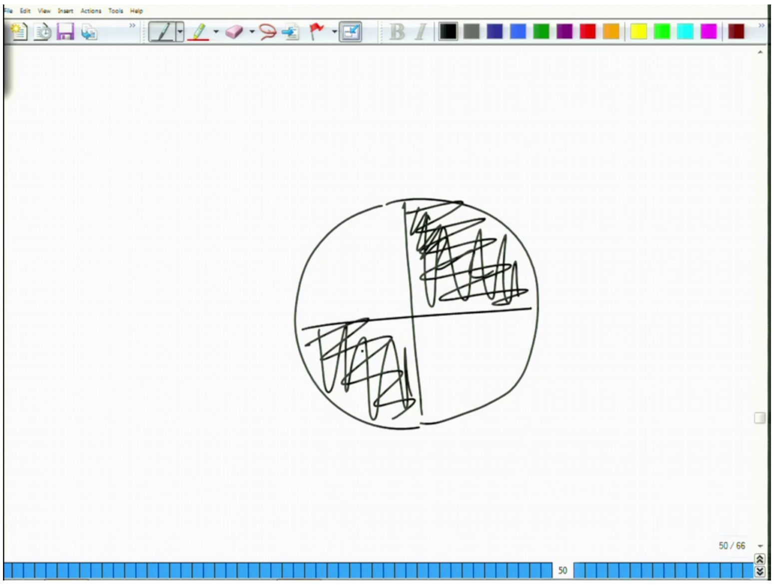

Now, shaky disc as we have seen in one of the previous lectures, it is a disc that is roughly 30 centimeters in size and in this dish you have these 4 portions, and 2 of the portions are black in color, and 2 of the portions are white in color. And, then this disc has a rod. So, with this rod you are able to push this disc into the water. And, then you look at the depth at which you are unable to differentiate between the black portions and the white portions.

So, that is the depth at which the turbidity of the water is so, large that it is that you are unable to see the black portion is black and the white portion is white. So, if you have more amount of turbidity in the water, if you have more amount of planktons which are giving rise to more amount of turbidity. So, in that case the silky depth will be low. Now, here we are saying that when you had sewage that was being put into the system the silky transparency or the silky depth was close to around 1.5 meters. Now, later on we can see that the level is coming is going up so, after a while so, once you have stopped putting your sewage the silky depth increases. So, the water is now becoming more and more transparent.

So, the things that we are asking in this system is that, once you are putting in your sewage there will be some amount of disturbances to the communities. Now are the community is able to come back to normal and to what extent and how that is the question.

So, in brief in this lake we were putting in sewage the sewage was bringing in phosphorus and nitrogen, because of which we were seeing a very high amount of growth of algae and phytoplankton. And, then after a while it was stopped and we are asking the question what happens in next.

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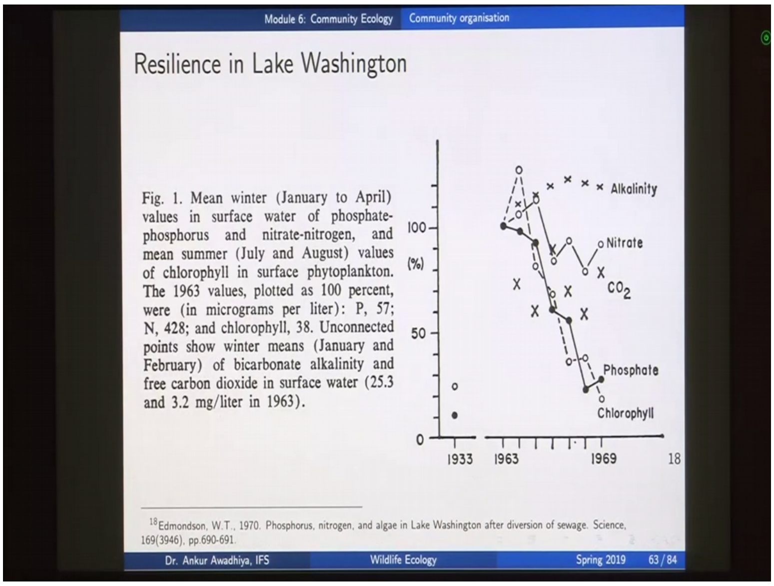

So, this lake was studied for a very long period of time and we see here that this is the point where you have the 100 percent level which is the point where you stopped at reducing the amount of sewage. Now in a very short period from this 0.1963 to 69 the level of phosphorus has dropped considerably.

So, from hundred percent level that we measured in 1963 here the level is close to say 20 percent or 25 percent. Now, why was this phosphorus able to come out of the system? How was this community able to how was this community resilient enough that it was able to get rid of the phosphorus, because as long as you have a heavy dose of phosphorus in your ecosystem, there will be more and more amount of growth of these planktons.

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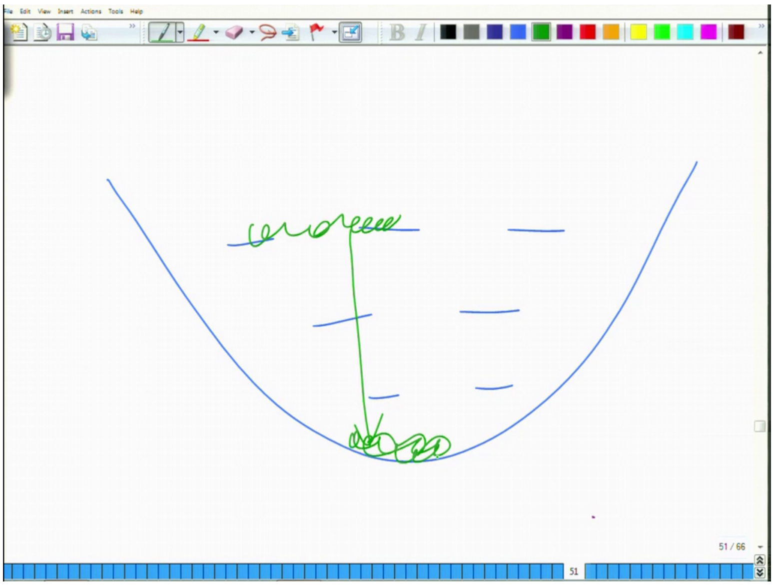

So, as we have seen before if you have a lake and you here you have the planktons which are now using up the phosphorus when these planktons die. So, this comes the dead matter comes to the bottom. And so, the phosphorus gets trapped to the bottom of the lake. So, that is how the community or the ecosystem in this case is able to bring the phosphorus down. The nitrates take a very long time to come down.

So, even after say 6 7 years the level had only come down to say around 80 or 85 percent, because nitrates take a very long period of time, but even though we have these nitrates in the water still we can see there that the level of chlorophyll has gone down or the amount of algae and phytoplankton that has come down. So, the chlorophyll is shown here in this circular curve.

So, the chlorophyll it increased and then it came down and then it is less than 10 percent of what has remained of what was there in 1963 now why is that. So, even though you have a high amount of nitrate, but still the amount of chlorophyll is able to come down.

Now, that is because different species have differed tolerances to different to different perturbations in the environment.

And, when we talked about Shalfords law of tolerance or when we talk about limits law of the minimum. In this case the growth is not driven by the amount of nitrogen that you have in the water, but it is actually driven by the amount of phosphorus that is there in the water. So, if you are able to bring 1 nutrient down, even if there is another nutrient that is still there in the system. So, the growth will come down.

In this case the level of nitrate is so, high that you probably will not want to drink this water because you have a very high concentration of the nitrate, but then because the plants require nitrogen phosphorus and potassium. So, in this case just because the phosphate level came down so, the nitrate level also came down. And, in this case if you look at the measures that were taken in 1933. So, this black one is the phosphate and if this was say 10 percent of the 1963 level, from this 10 percent it is on the final level is no only close to around say 15 or 20 percent. If, we look at the amount of chlorophyll that was there in 1933, it has roughly come down to the same level as was there before the sewage was put into the system.

Now, remember that we had started putting in the sewage at this particular point of time and then if you look at the 1933 concentrations it has come back to the 1933 concentrations. So, which is giving us an indication that even if you have disturbed a community to a very large extreme you have added. So, much amount of nutrients into the system even when you have added so, much amount of sewage into the system, you are still able to come back. The communities are still resilient enough that they are able to come back. The amount of turbidity goes down the amount of nutrients goes down and the lake again starts to support a number of different organisms.

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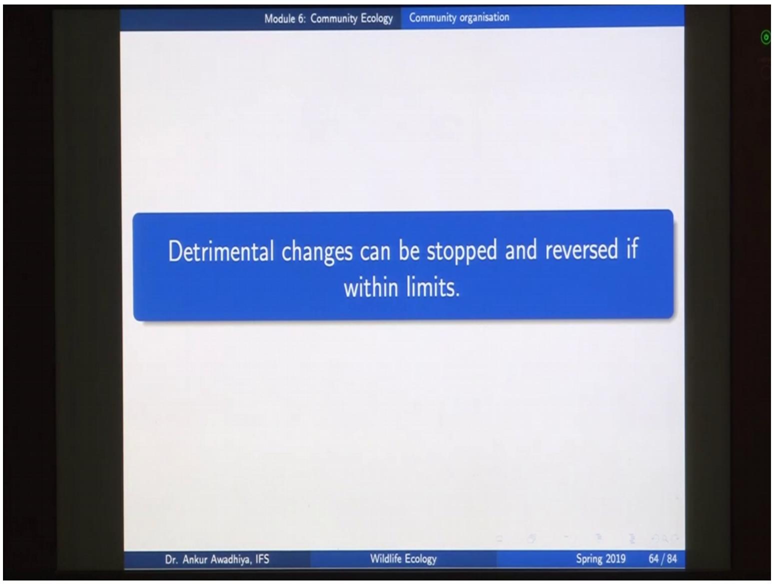

So, it is telling us that the detrimental changes that we are bringing into the environment they can be stopped and they can be reversed if they are within the limits.

If you have crossed the limits, if you have brought about a change that is greater than the amplitude of rays of resilience of the community, then probably this lake would change forever, but then still today even after you have made so, much amount of changes into the environment.

If it is still within the limits, you can still bring back the system to the normal sea level, which tells us which gives us the hope that all is not lost even though we have plate width or we have disturbed the communities and the ecosystems to a very large extreme, we still have hope we can still bring things back to the normal. So, that is all for today.

Thank you for your attention [FL].