Wildlife Ecology
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Indian Institute of Technology, Kanpur

Lecture – 36
Revision

[FL]. We begin with the final lecture of this course and this will again be a Revision lecture.

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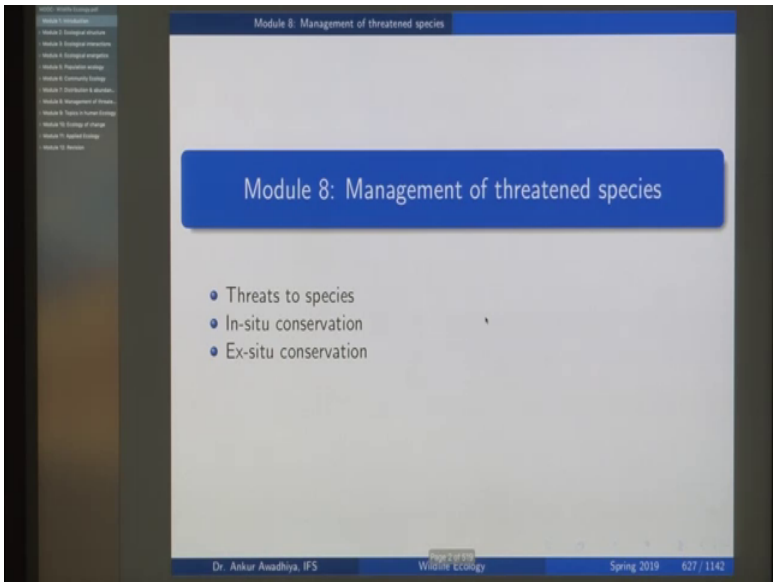

So, we begin with the 8th module, we covered till the 7th module yesterday. So, the 8th module was management of threatened species and they said threats to species in situ conservation and ex situ conservation.

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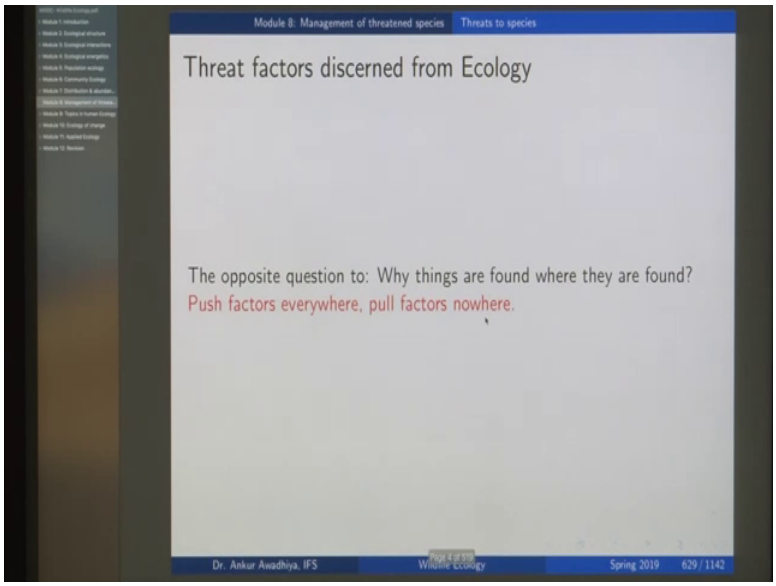

Now, in threats of the species the threat factors are the opposite question to why things are found? Where they are found? So, if you have push factors everywhere and you do not have a pull factor anyway, it means, that everywhere and the organism is getting pushed from all sides and it is not having a good favorable environment anywhere. So, that would be called as a situation of the threat.

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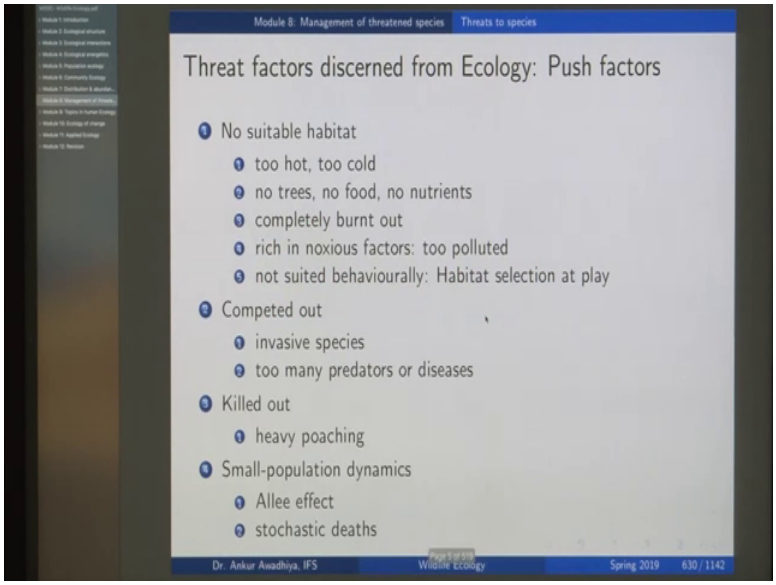

So, we looked at different push factors, no suitable habitat competed out killed out small population dynamics.

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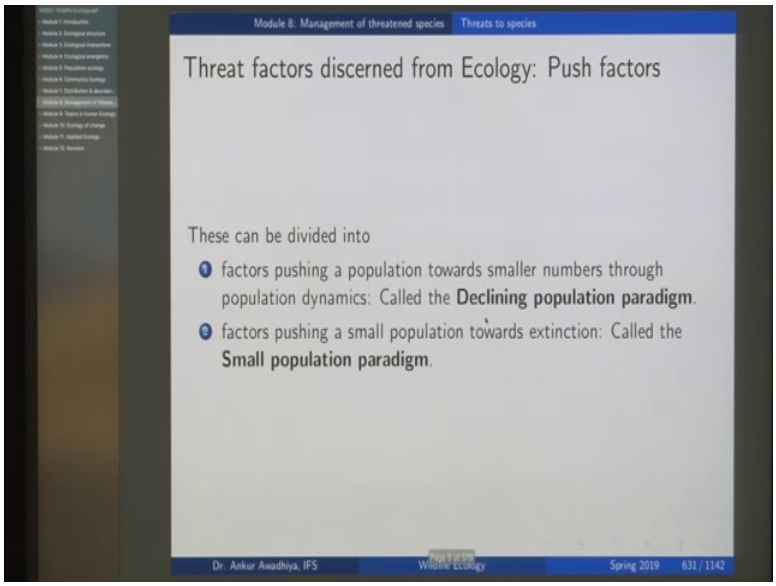

And then these push factors are divided into 2 paradigms declining population, paradigm and small population paradigm. So, for any population, it becomes smaller and once it has become small enough, then it becomes extinct.

So, the factors that push a population towards a smaller numbers are declining population paradigm and the factors that push a small population towards extinction fall into the small population paradigm.

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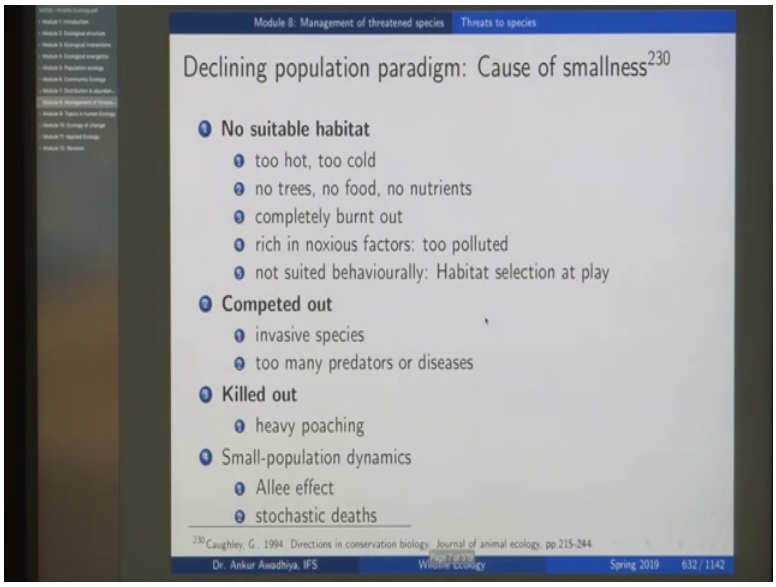

So, when we look at different causal factors, the different push factors. These 3 form a part of the declining population paradigm. So, you have no suitable habitat, they are getting competed out, they are getting killed out. So, in this way the population becomes small.

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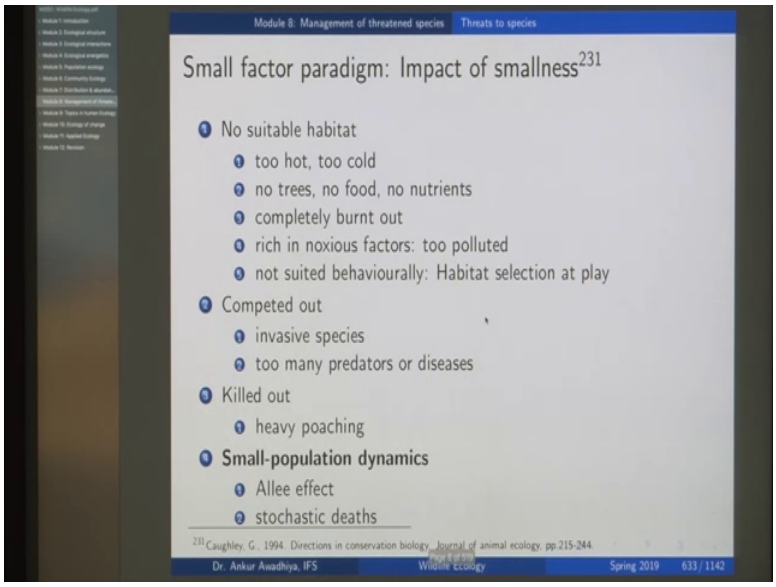

And once the population has become very small in that case, you will have this small population dynamics Allee effect and a stochastic deaths, which will play a big role and this will form the part of the small population paradigm.

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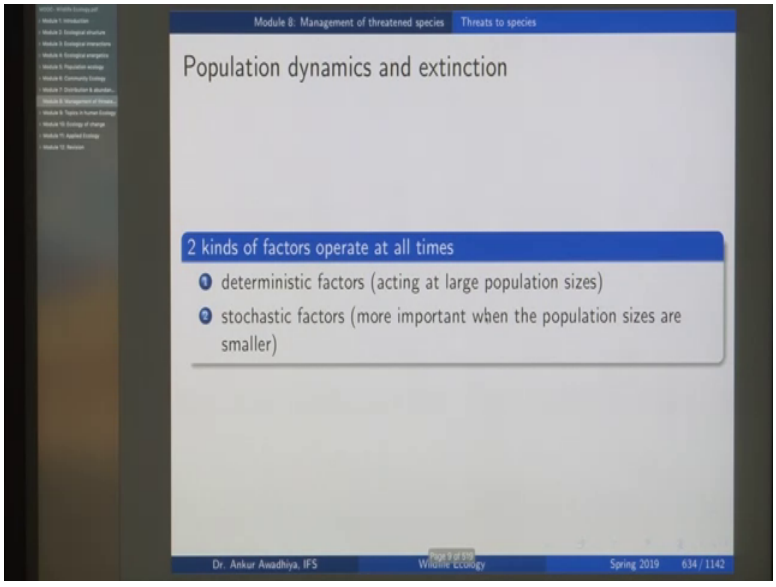

Then we looked at 2 kinds of factors, deterministic factors they act at large population sizes and stochastic factors act at small population sizes.

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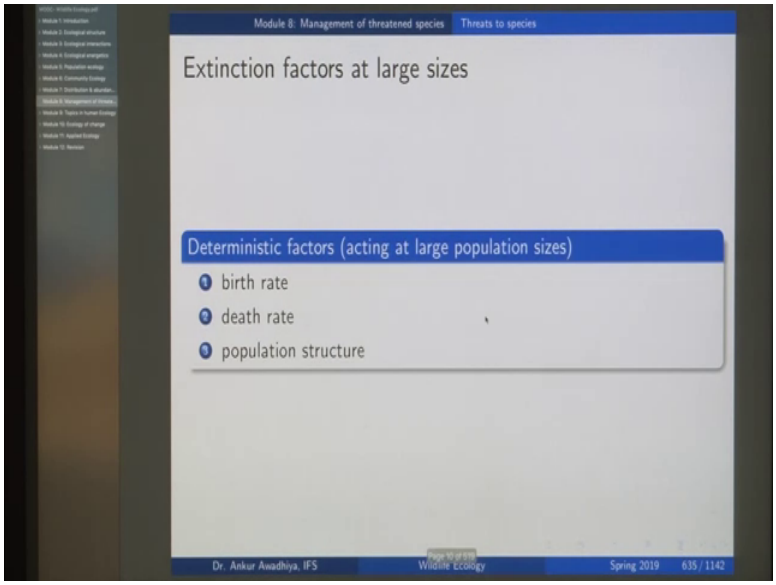

Deterministic factors are birth rate and death rate and the population structure and stochastic factors includes; demographic, stochasticity, environmental variations, catastrophes and genetic processes.

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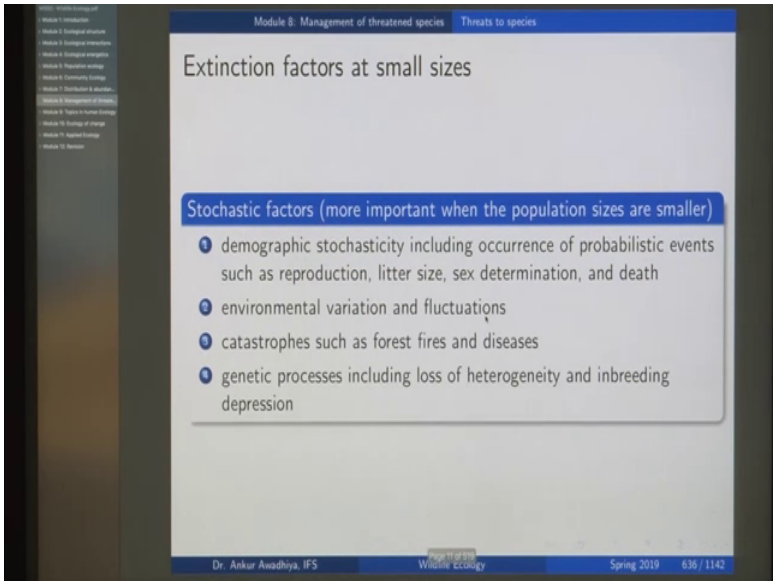

Such as loss of heterozygosity and inbreeding depression and we will discuss all of these and these are very important in stochastic factors.

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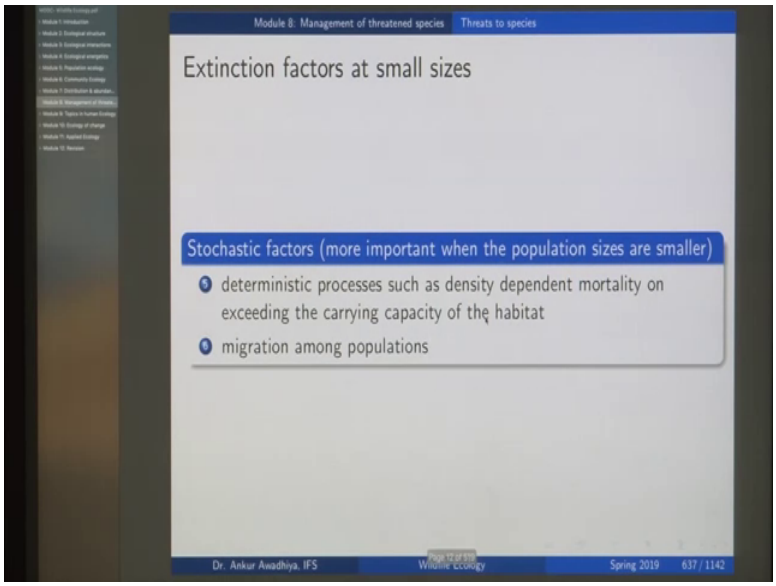

We also have deterministic processes, such as density dependent mortality and migrations.

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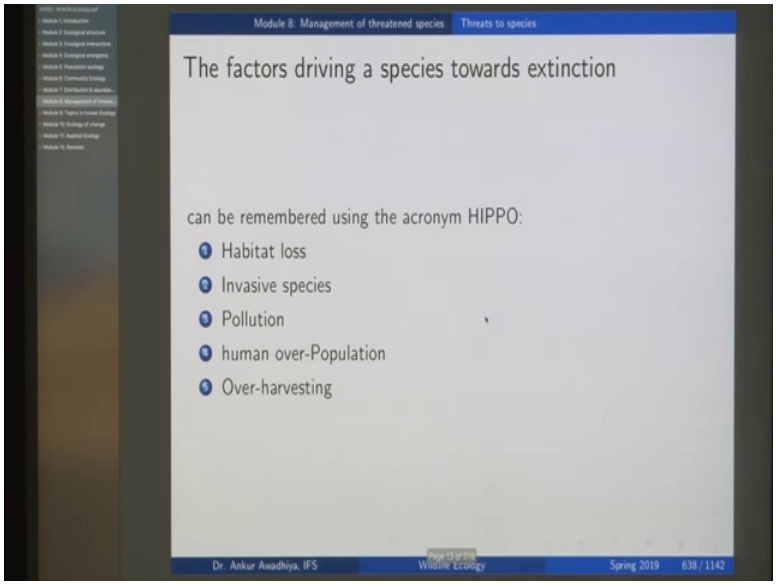

Next we had a look at the factors that drive species towards extinction, we can remember them using the acronym of hippo. So, this is habitat loss invasive species pollution overpopulation and overharvesting.

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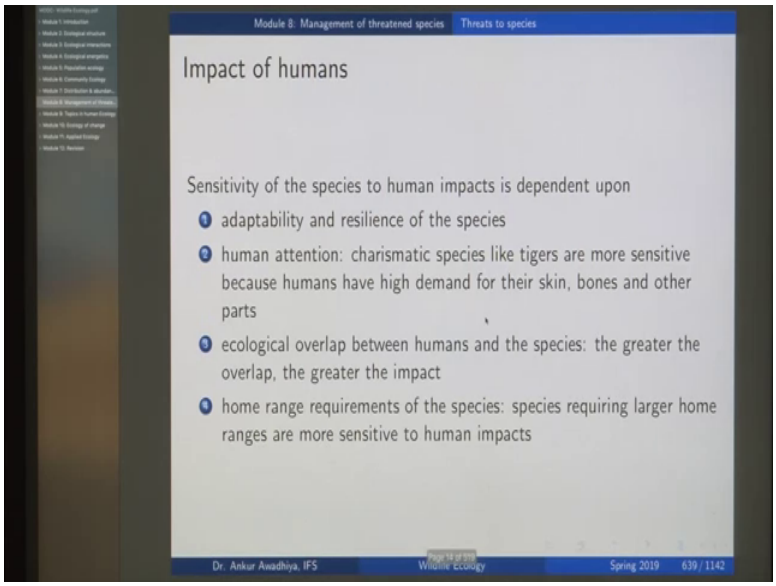

And we looked at the impact of humans it depends on adaptability of these species, the attention that humans get to that species, the ecological overlap between humans and the species and the home range requirements, if species has a large home range requirement it is more susceptible to the impacts.

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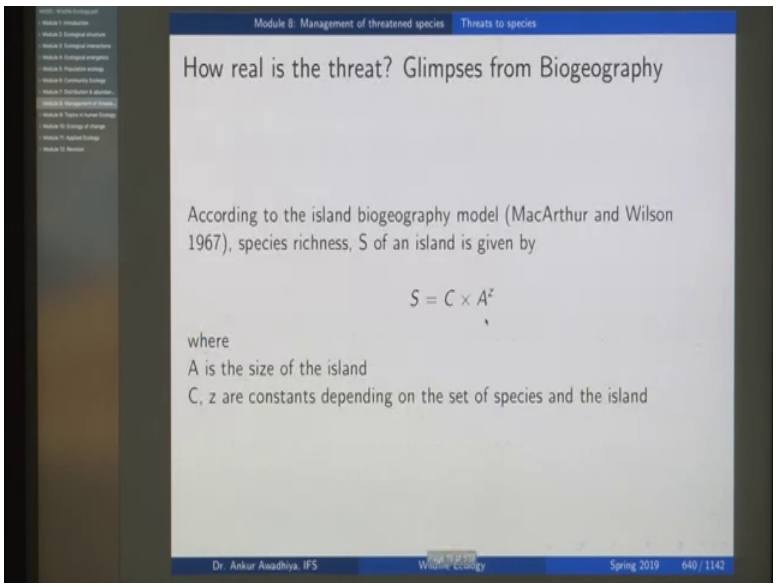

Then we looked at this theory of biogeography island biogeography model to predict how many species are getting extinct.

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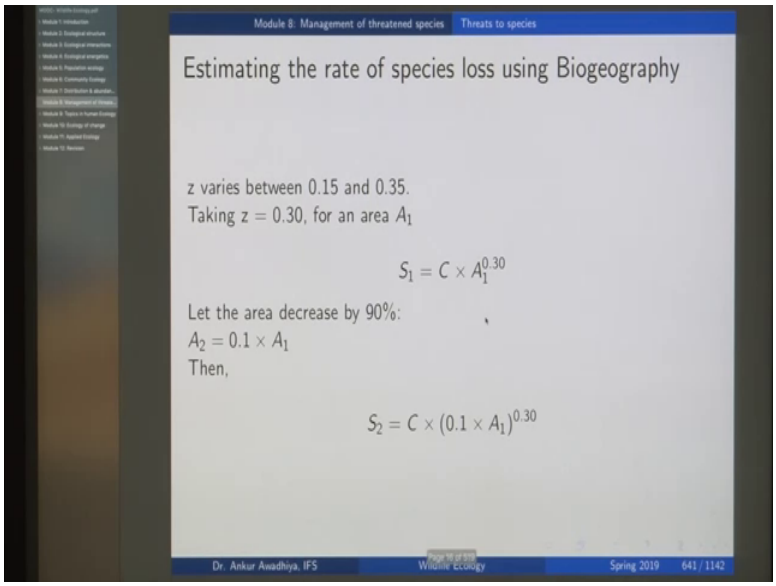

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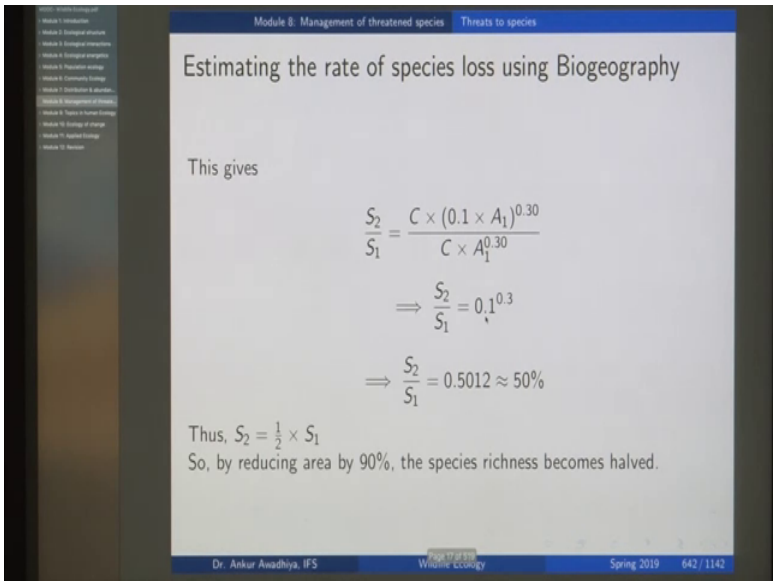

And even if you reduce an area by 90 percent, the number of species only becomes halved it does not become only 10 percent.

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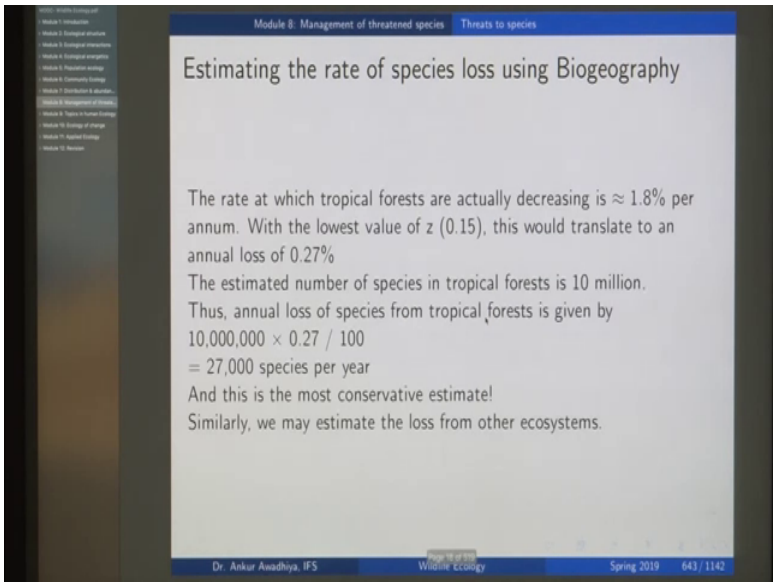

And in this case, we estimated that we are losing as many as 27000 species every year you know it will very conservative estimate.

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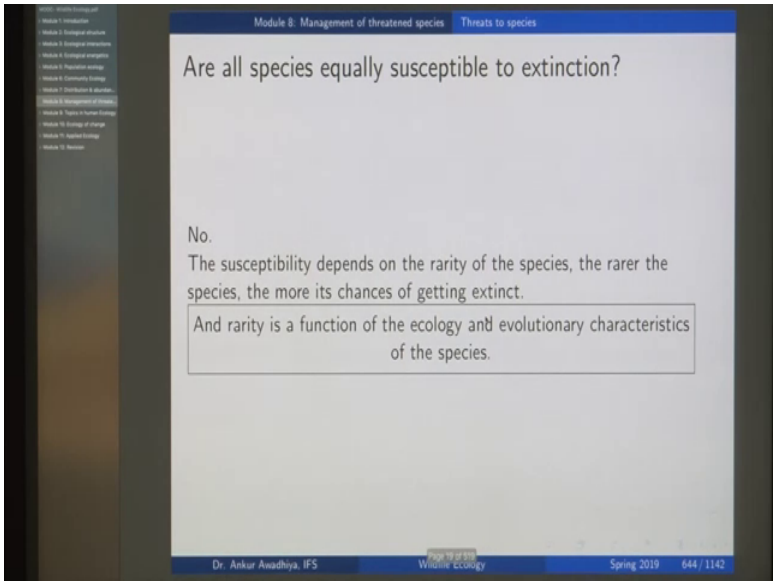

Next we said that all species are not equally susceptible to extinction the species that are rare are more susceptible.

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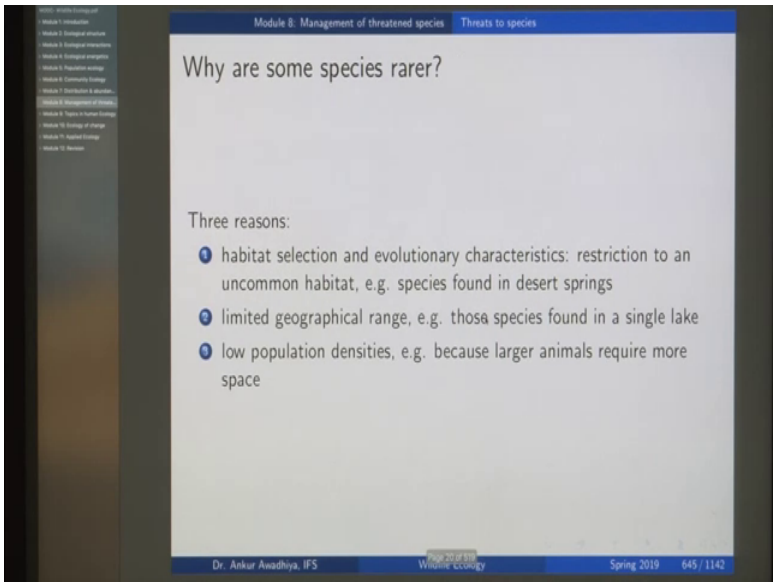

And some species are rare, because of their habitat selection choices, evolutionary characteristics, limited geographical range and low population densities.

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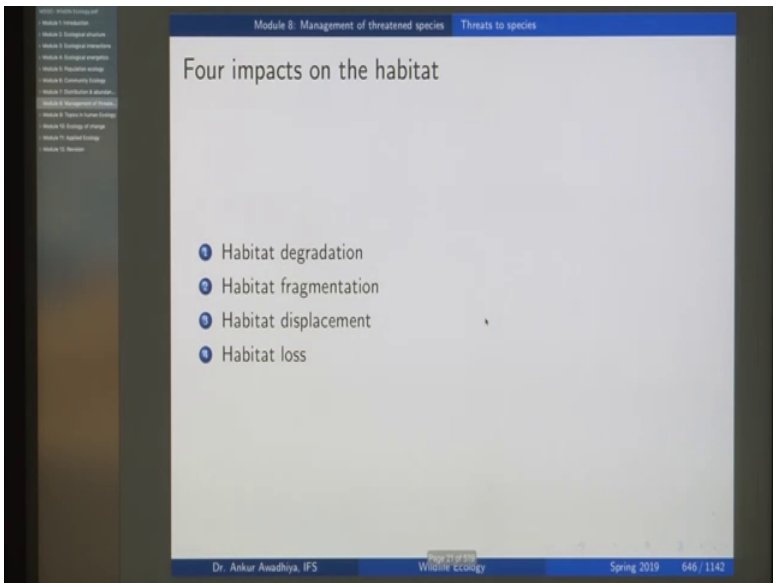

Then there are four impacts on habitat, they are habitat degradation, fragmentation, displacement and loss. So, in the case of degradation the quality goes down.

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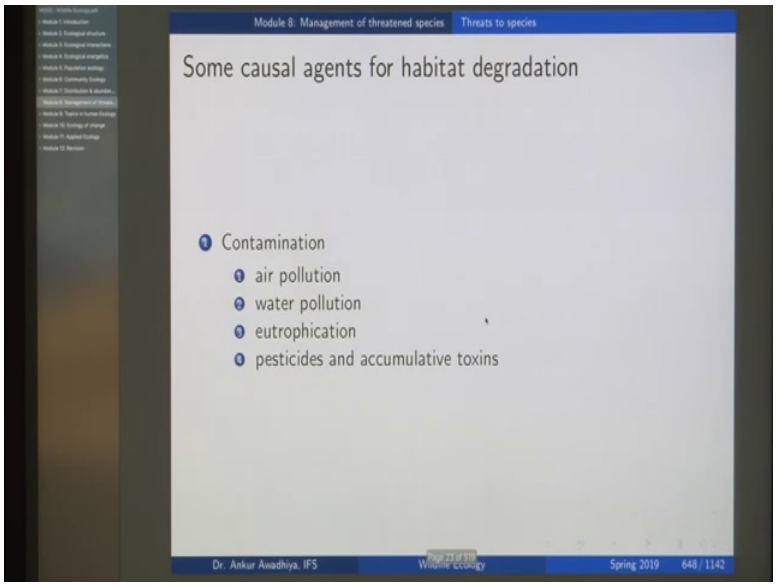

And this can occur, because of contamination.

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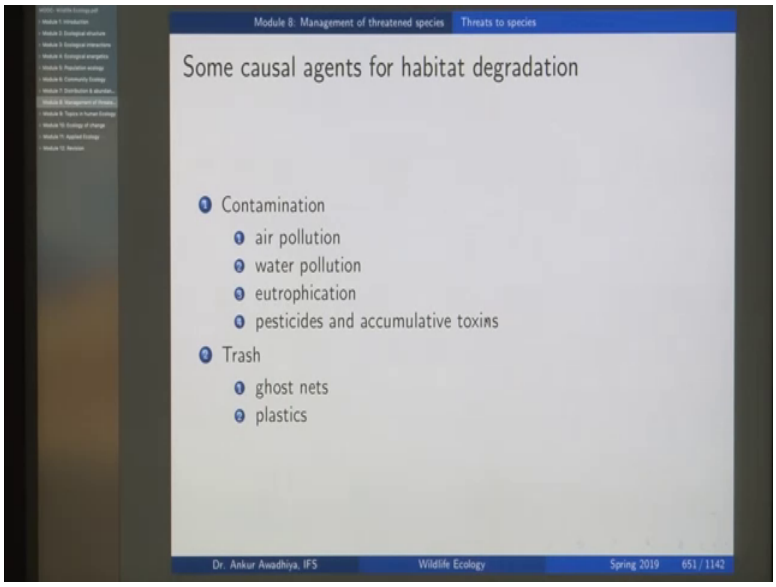

So, which is accumulation or because of the presence of different trashes in the habitat which reduces the quality.

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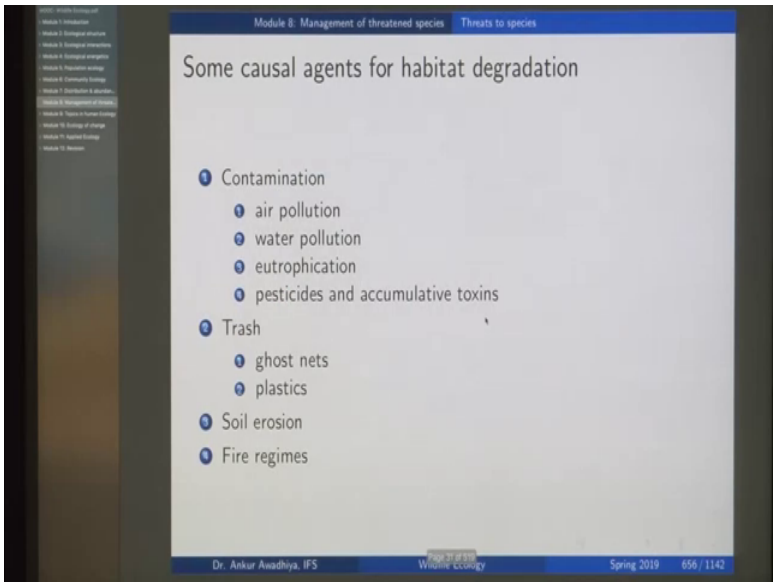

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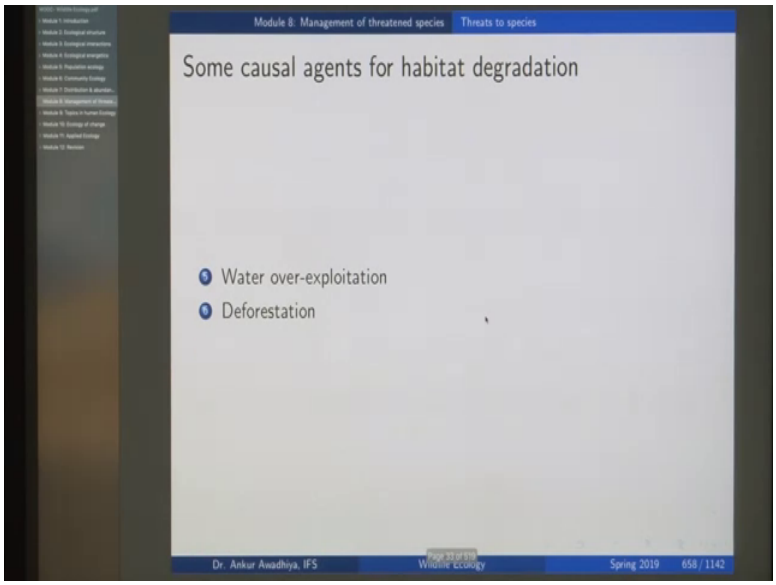

Or because of soil erosion and the presence of forest fires or because of over exploitation of water or deforestation of the area or because of desertification.

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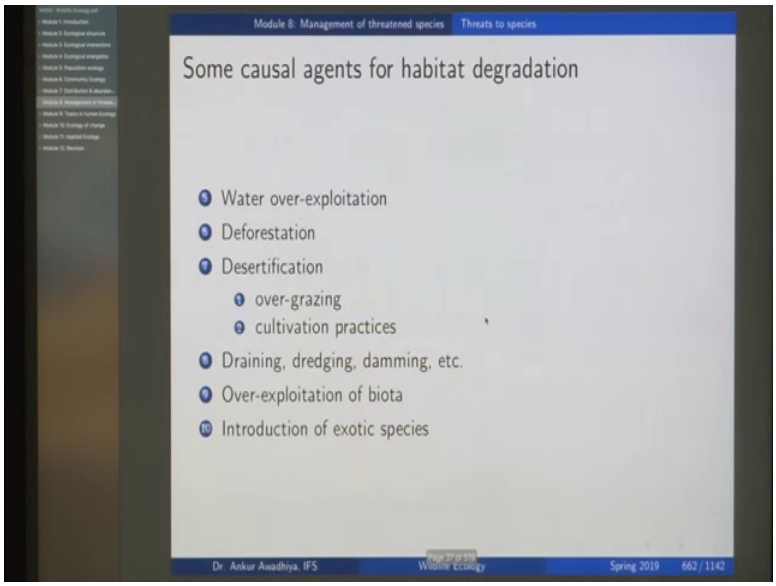

Or because of over exploitation of biota or draining dredging, damming or the water bodies or introduction of exotic species.

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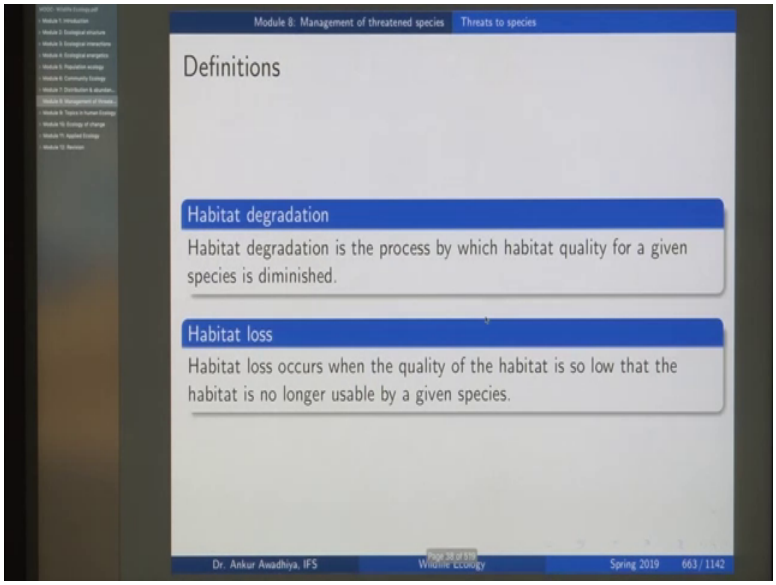

When degradation becomes very high, so, the quality is so low, that the habitat is no longer usable and we call it a habitat loss.

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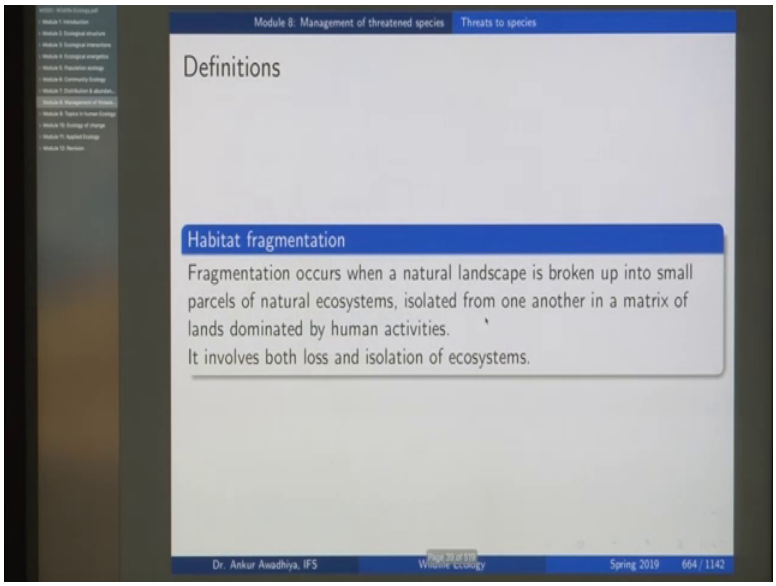

And in the case of habitat fragmentation, the natural landscape is broken up into smaller parcels and they become isolated from each other and it involves both loss and isolation of ecosystems.

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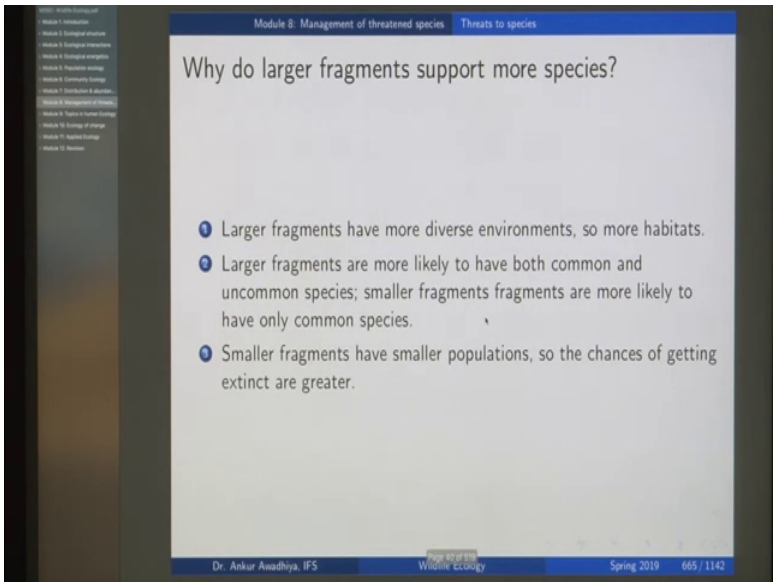

Now larger fragments are better, because they have more diverse environments, they are likely to have both common and un common species and they have larger populations. So, stochastic factors play a lesser role.

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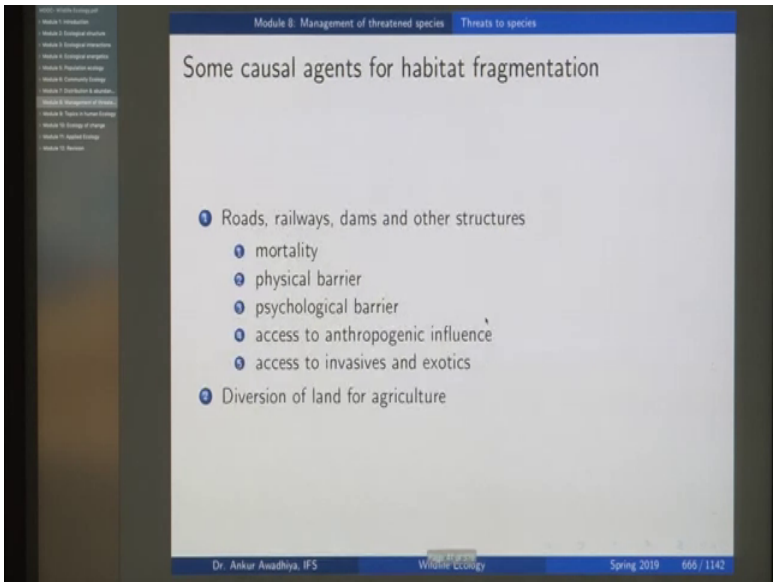

Now some causal agents of habitat fragmentation are roads railways dams other structures diversion of land for agriculture. And then we looked at the process of habitat fragmentation and loss.

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So, from this original forest, we had dissection because of the road, that lead to perforation then a small villages came up and then after perforation there was a fragmentation as the increase in size and after fragmentation, there was attrition in which case the habitat was reduced to a very small portion and we looked at habitat loss in

Amazon and then because of all this processes this is the forest before and this is the forest afterwards and this is an example of an extremely fragmented habitat in the case of Mudumalai.

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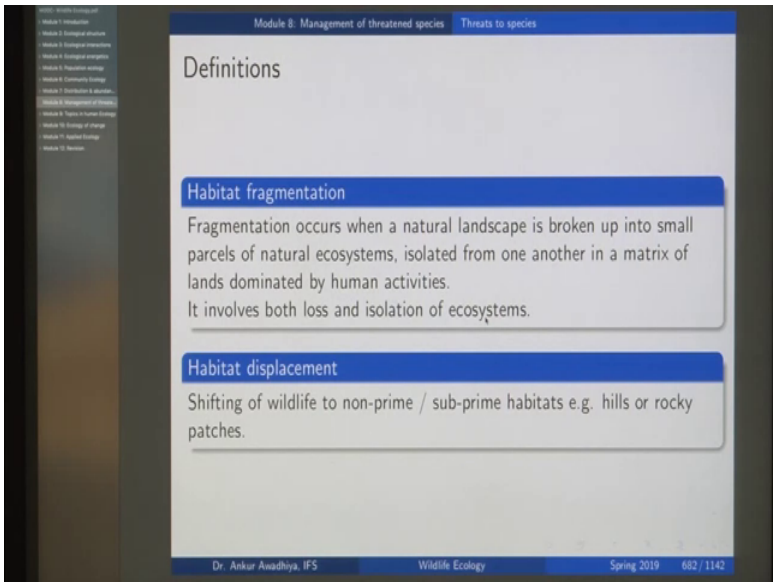

Then we looked at habitat displacement in which the wild life is shifted to non prime or subprime habitats, such as hills or rocky patches, because they are out competed by other organisms especially livestock.

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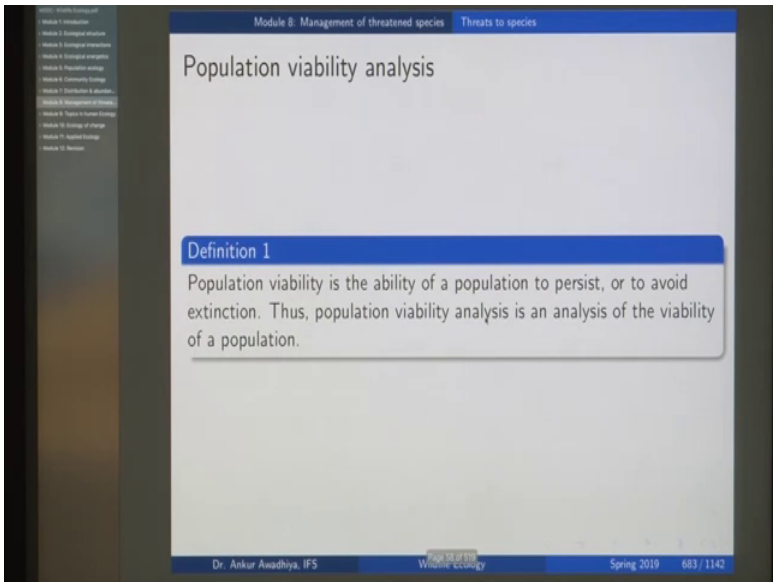

And then we said that population viability analysis is used to understand if a population is going to persist or is that going to become extinct in n number of yields.

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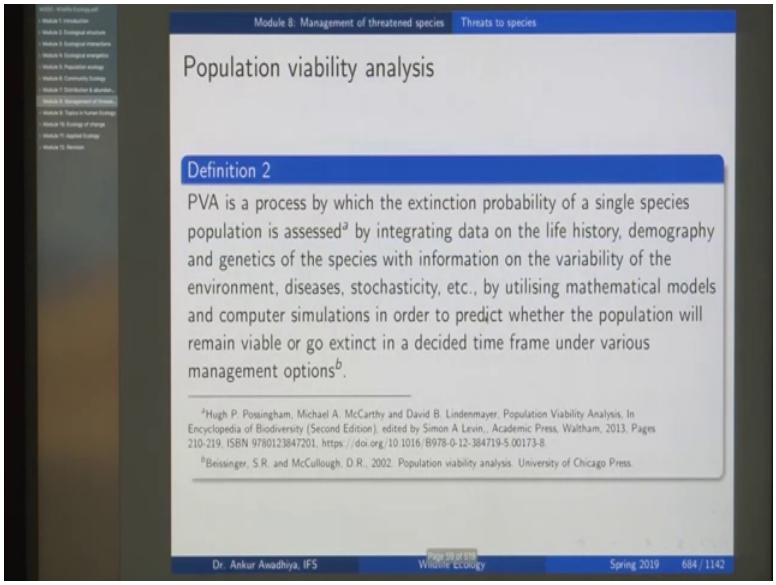

Next we looked at in situ and ex situ conservation.

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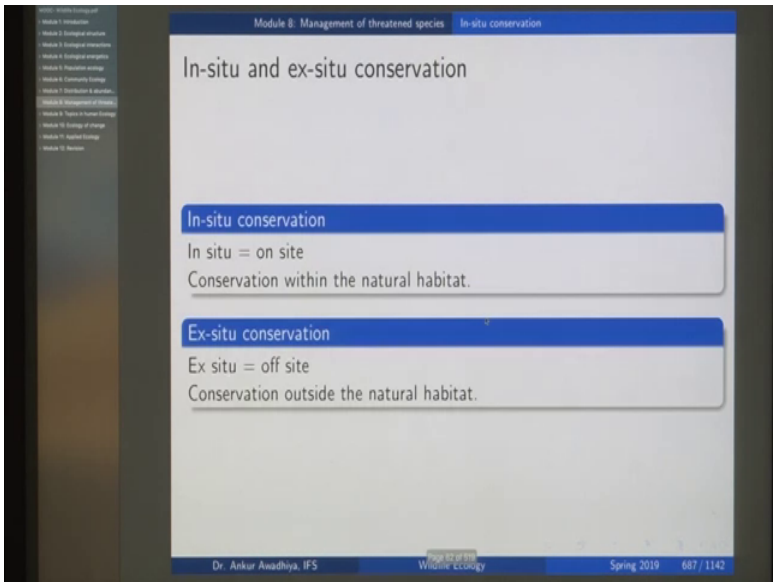

So, in situ conservation is conservation that is on the site or within natural habitat and ex situ conservation is conservation that is off the site or outside the natural habitat.

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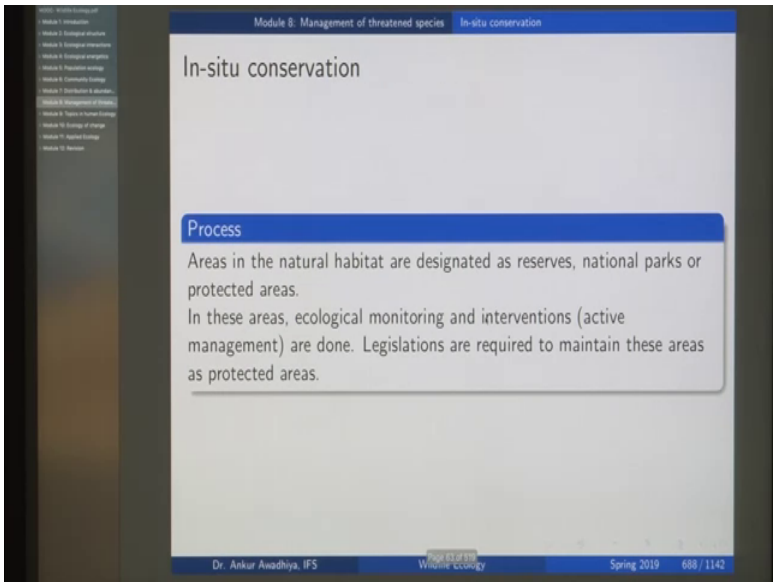

Now, in the case of in situ conservation, we are conserving in the area. So, you designate areas as reserves national parks or protected areas and then you perform monitoring and interventions in this area and do some legislations to maintain these areas as protected areas.

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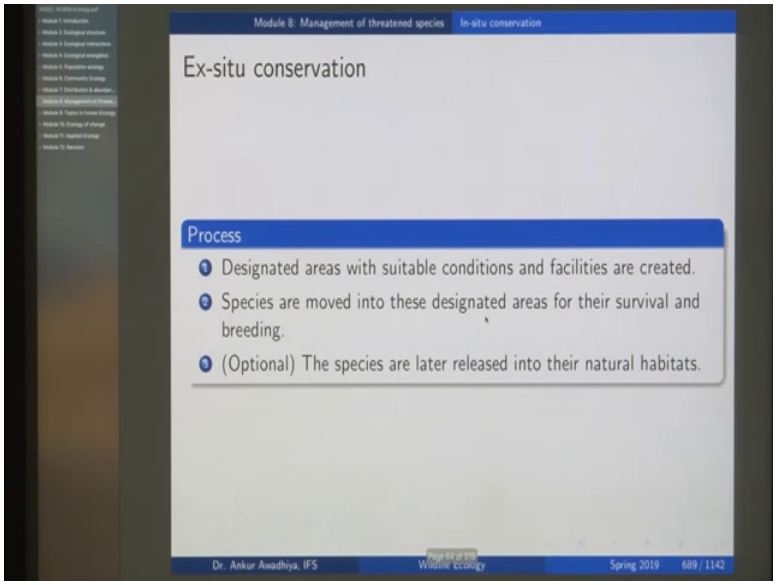

In case of ex situ conservation, you designate areas with suitable conditions, create the facilities bring animals in to or organisms into those areas and then the option is

statement that once you have a large number of organisms you can release them back into the natural habitats.

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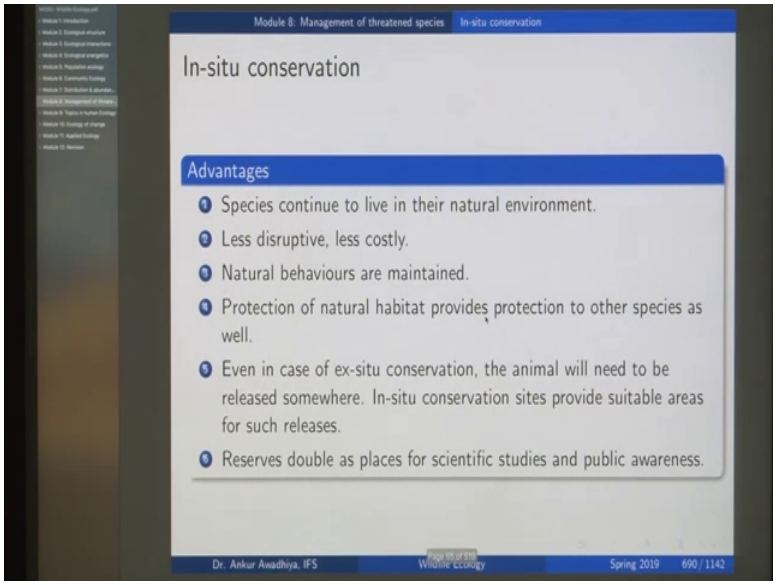

Now, in situ conservation has certain advantages, certain disadvantages and same with the ex situ conservation.

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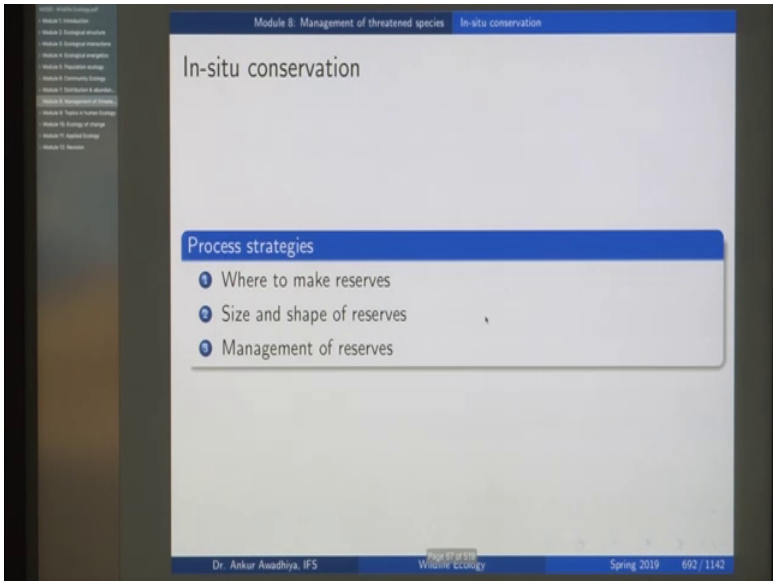

So, you can have a look at these. Now, in the case in situ conservation, there are 3 process strategies, where should we make the reserves? What should be the shape and size of these results? And how do you manage the results?

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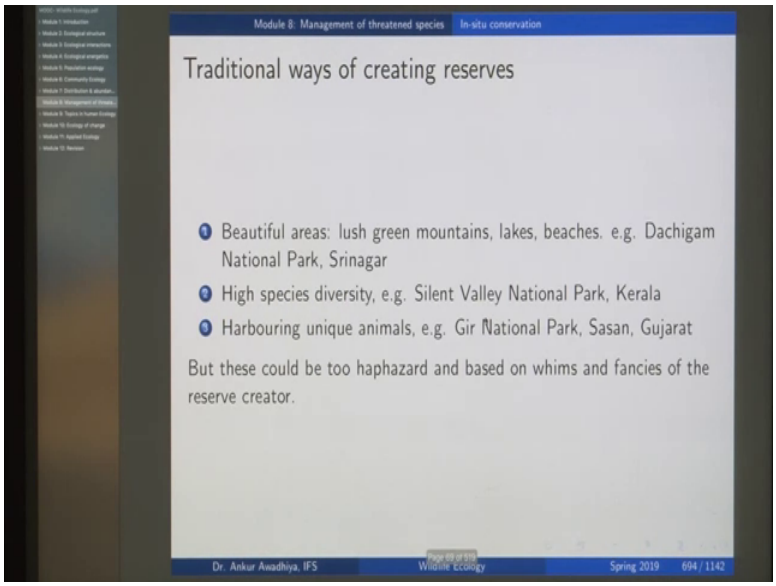

Now, if you look at way to make it. So, there were some traditional ways.

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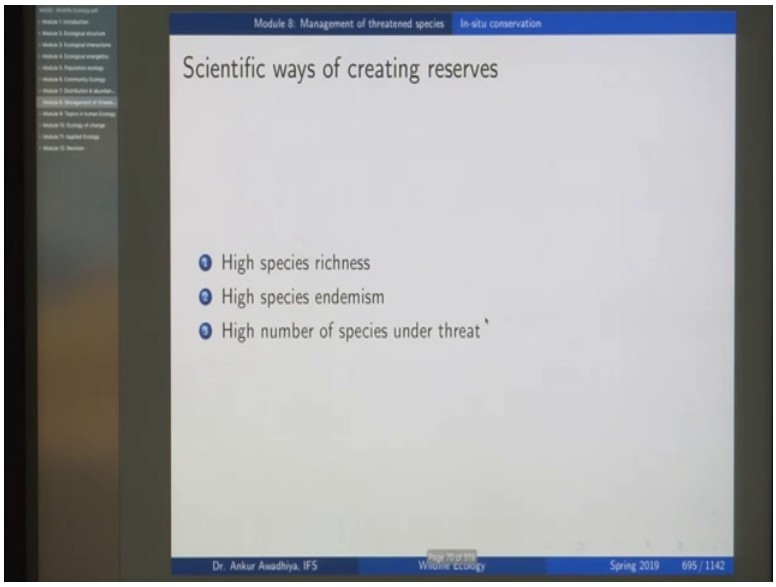

But then these way we are looking at areas, which are high species, richness, high endemism and a moderate amount of threat. So, we go for the biodiversity hotspots.

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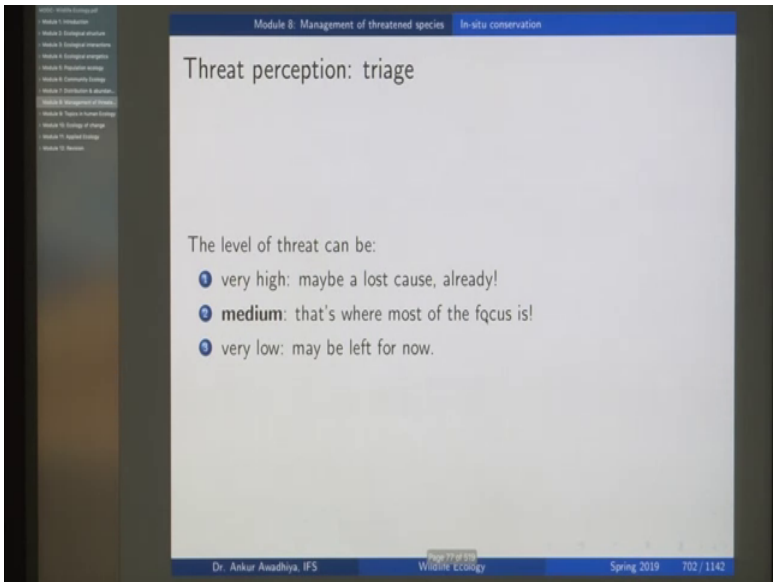

And in the case of the triage, the threat perception we go for areas that have a medium level of threat.

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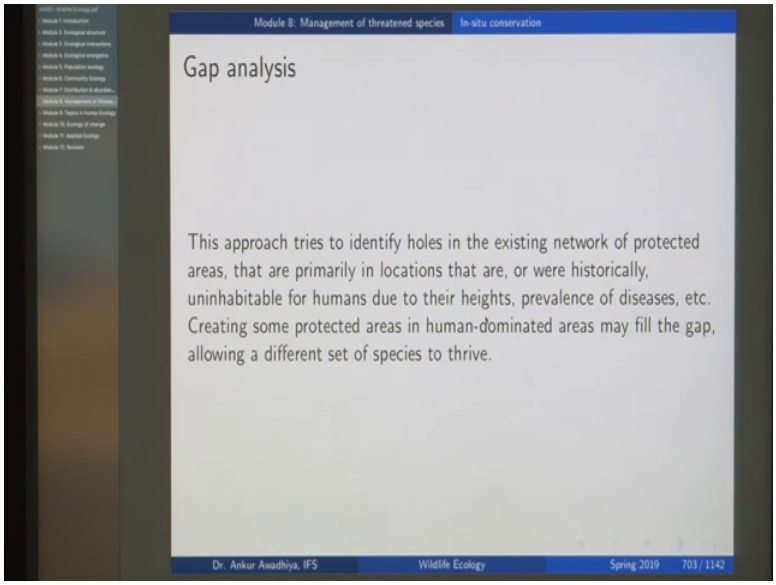

We can also make use of gap analysis, which ask this question, that what are the areas? And that are not represented in the existing framework of the protected areas and in those areas you can make a new reserve.

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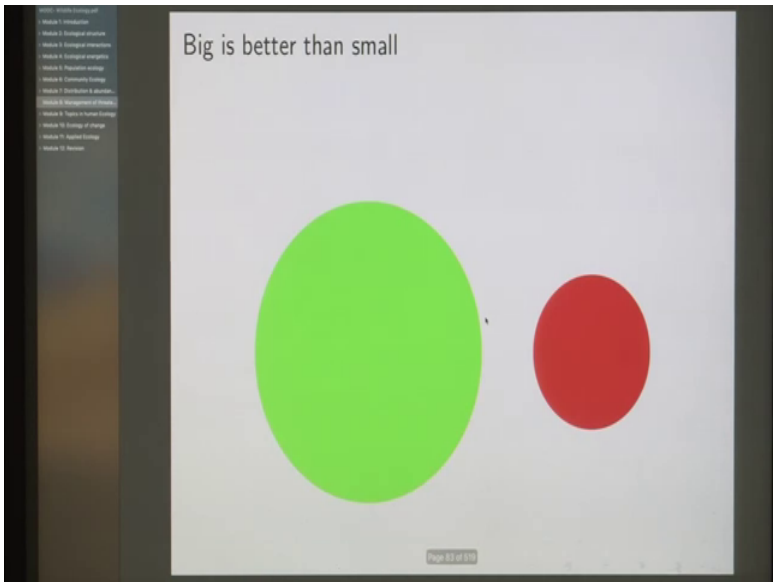

In the size and shape of reserves you have get principles of reserve design. So, big is better than small.

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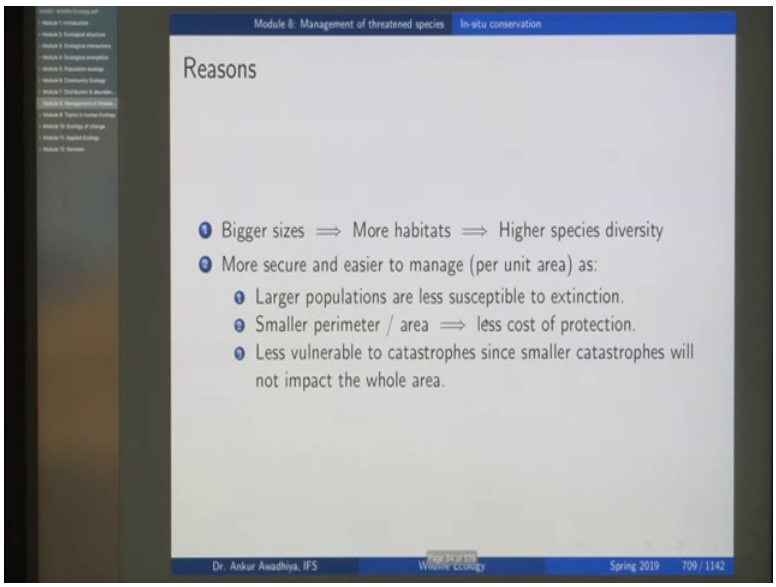

We looked at the reasons we have larger populations, we have more habitat diversity, more species diversity, you have less cost.

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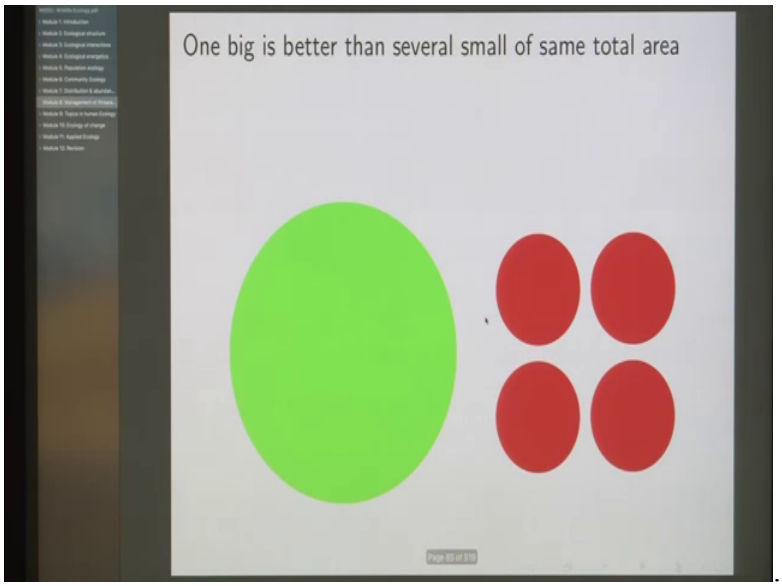

And if this less vulnerable to catastrophes, then we said there one big is better than several small of the same total area closer reserves are better. Cluster is better than a linear structure and circular reserves are better, because they have less biotic pressure and the some of our reserves are not quiet circular in shape. So, that creates a lot of biotic pressure there. Then we said that connection is important, so, that the organisms are able to move from one place to another and if nothing else works then we should aim at maintaining or enhancing the connectivity.

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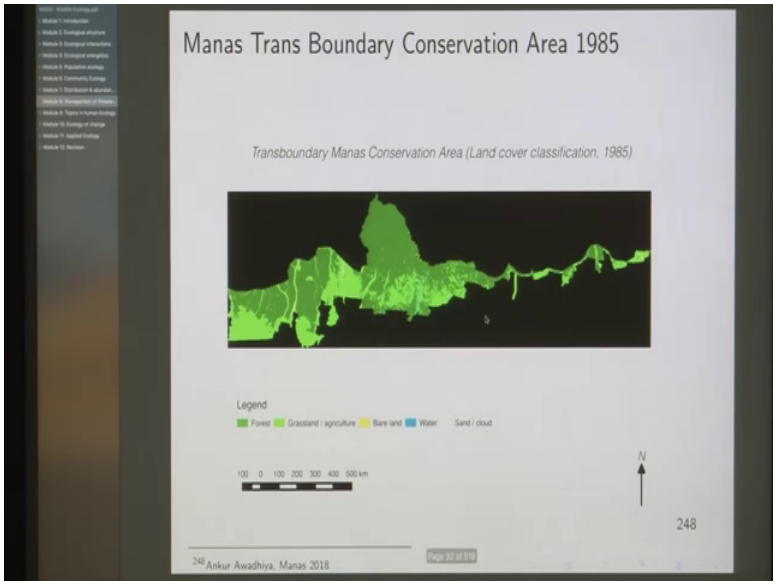

And then we looked at this example, from Manas and which we are losing up the habitat.

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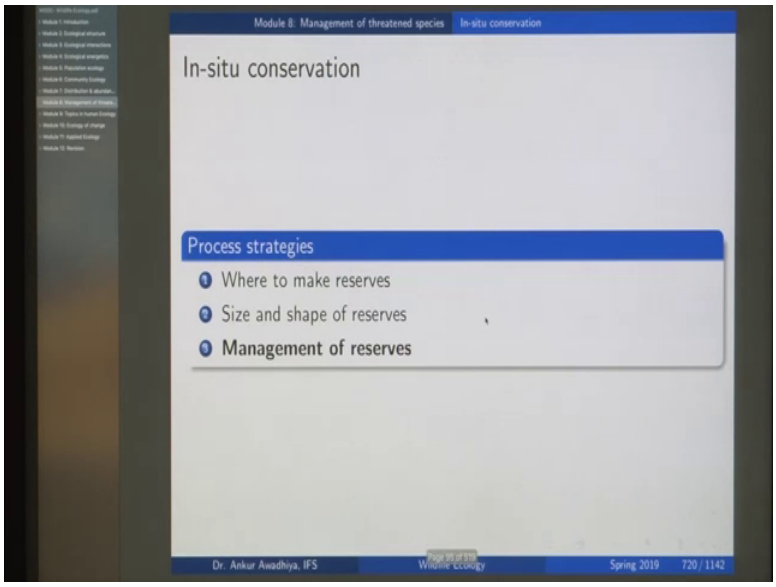

That a very far place and even the connections are not being maintained then we looked at the management of reserves.

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Where we looked at the 5 different tools of habitat management which are the axe, the cattle, the plow, the gun and the fire and even though these tools can also be used for destruction.

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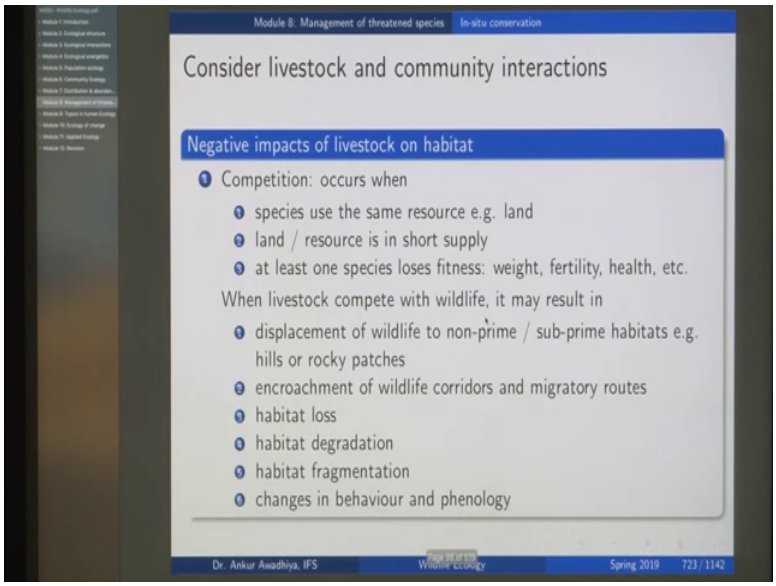

But if we use them properly, so, we can maximize the positive outcomes and minimize the negative outcomes.

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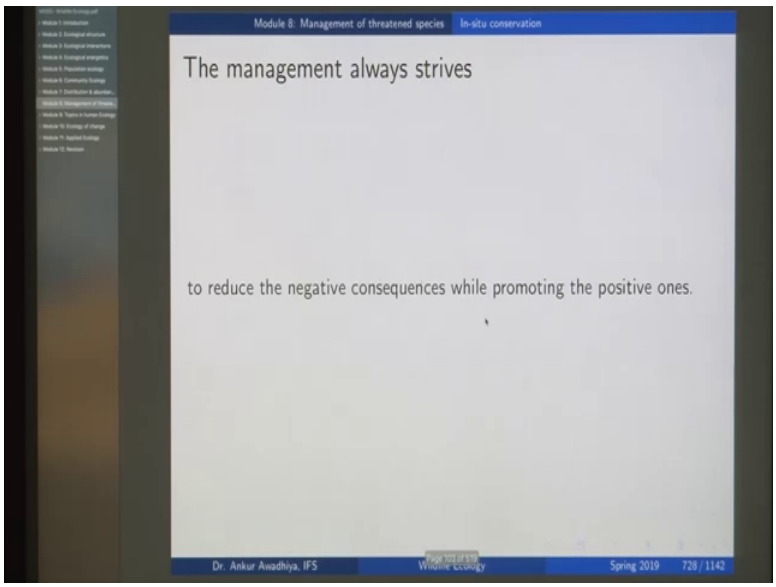

So, we looked at the example of livestock and look that, how we can maximize the positive outcomes and minimize negative ones.

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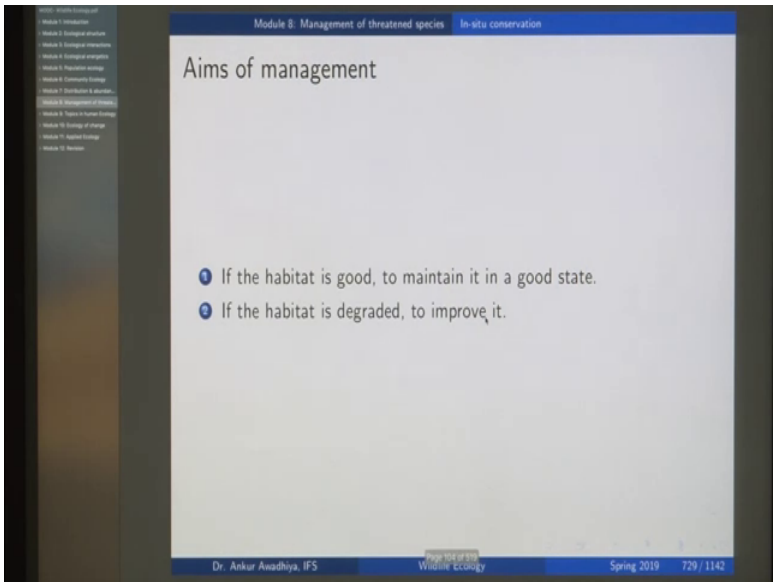

So, the aim of management is that is your habitat is good, maintain it in that state if the habitat is degraded you try to improve it.

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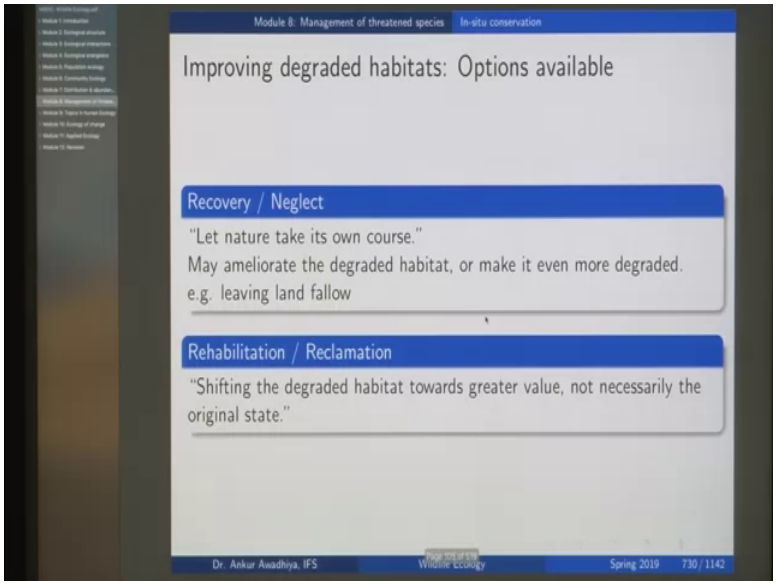

And then we looked at the option, that are available first is recovery you do not do anything and let nature take its own course. So, it may ameliorate the degraded habitat or in certain situations, it can make it even more degraded. Next is rehabilitation or reclamation in which you shift the degraded habitat towards a greater value, but not necessarily towards the original state.

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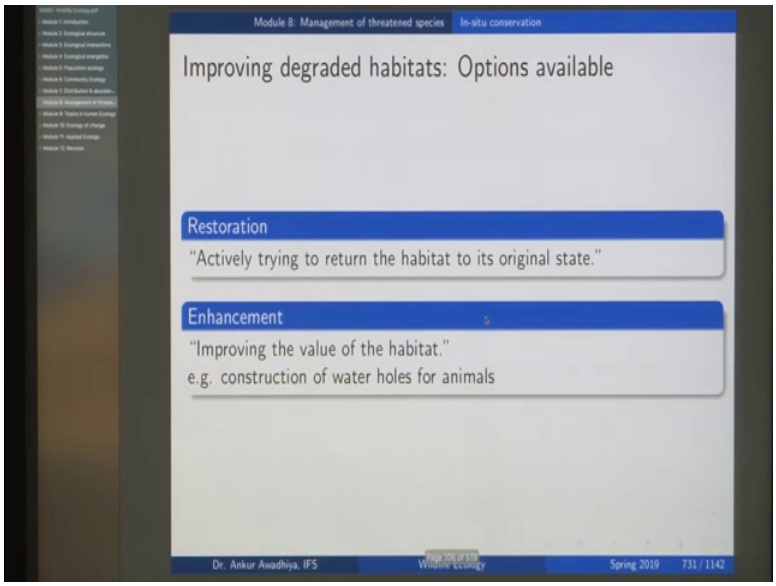

Third is restoration, where you are actively trying to return the habitat to its original state. So, you restore the whole system and fourth is enhancement, in which you are trying to improve the value of the habitat, such as construction of water holes.

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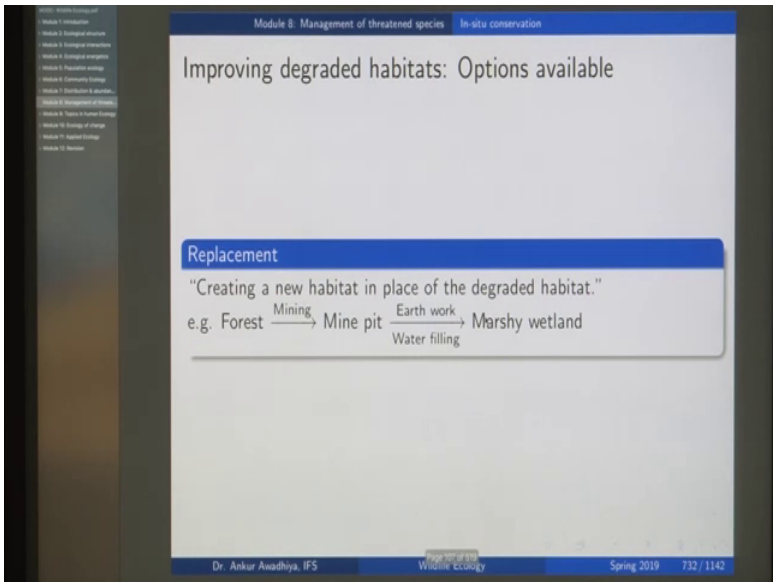

And the first one is replacement, in which you create a new habitat in place of the degraded habitat and the classic example is that a forest is converted into a mine.

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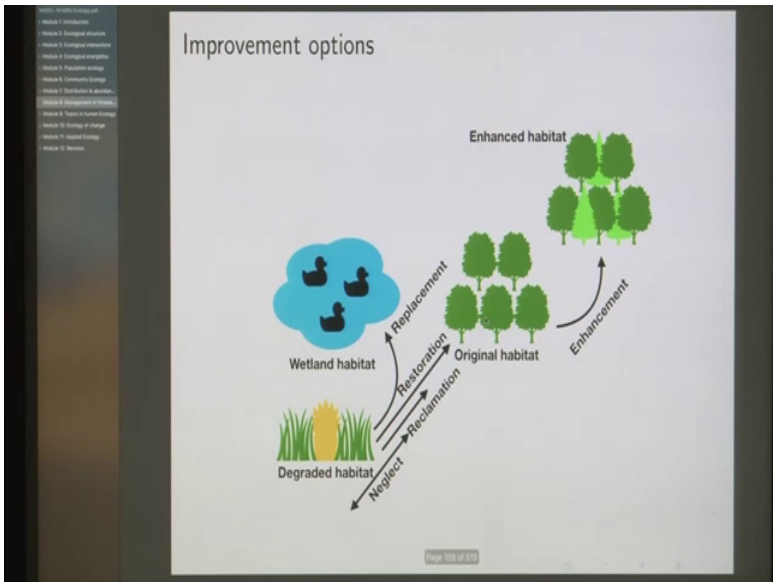

And then this mine has converted into a Marshy wetland.

So, we looked at this 5.

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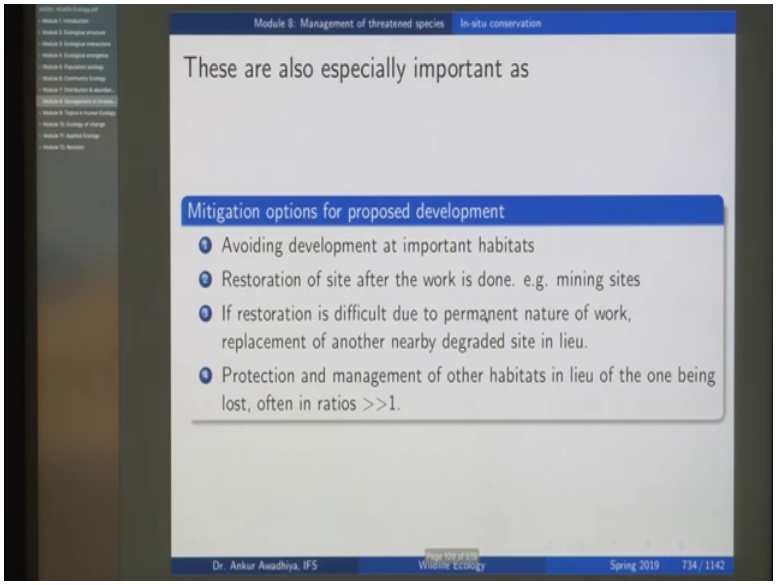

Improvement options and these are also mitigation options, when you have a proposed developmental activity you can avoid development in certain areas, you can restore it or you can go for replacement or you can go for protection and management of other habitat in lieu of the one being lost often in ratios that are very much greater than one.

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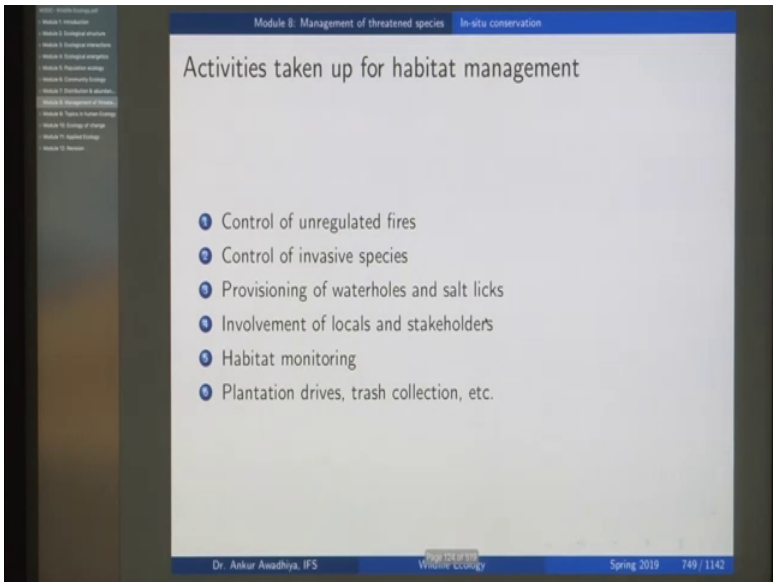

And so like, that certain activities that we do for habitation management control of unregulated fires, control of invasive species provisioning of waterholes and salt licks involvement of locals and stakeholders habitat monitoring plantation drives trash collection etcetera.

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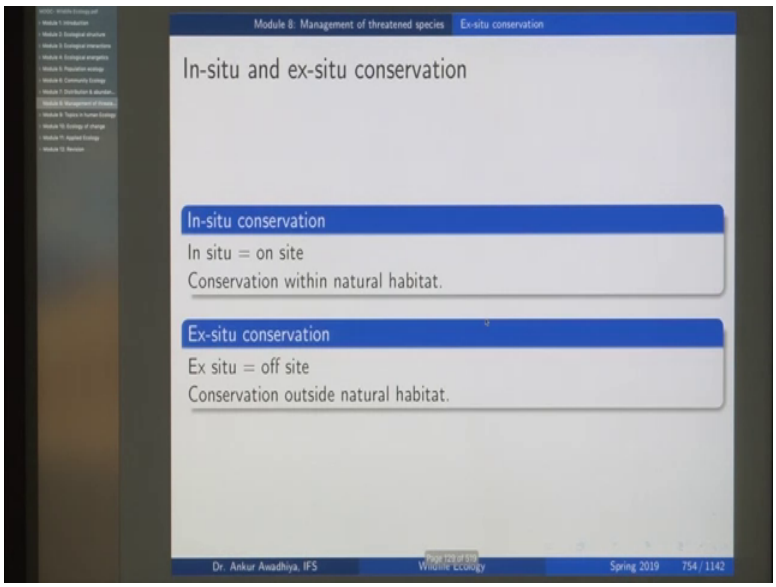

Next we looked at ex situ conservation. So, ex situ is conservation that is off the sites that is also in the natural habitat.

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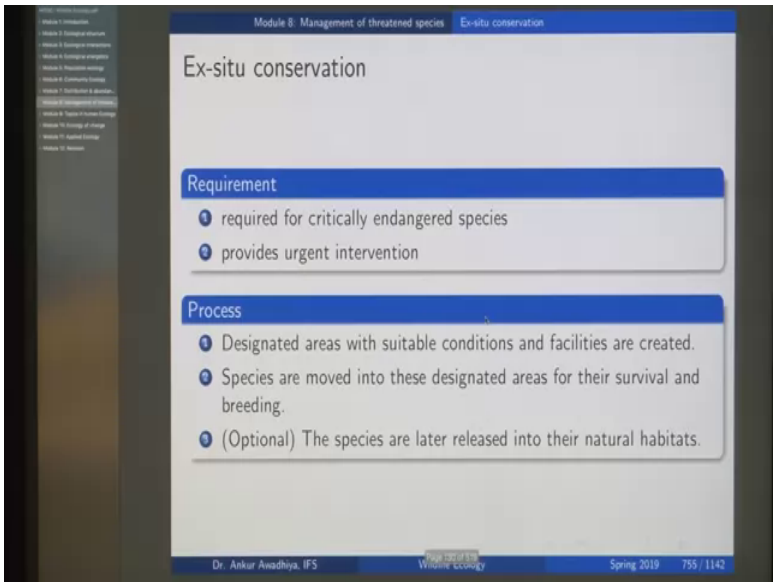

Now, it is a required specially for critically endangered species, because it provides urgent intervention and you have designated certain areas as you would ex situ conservation areas, create facilities bring the animals.

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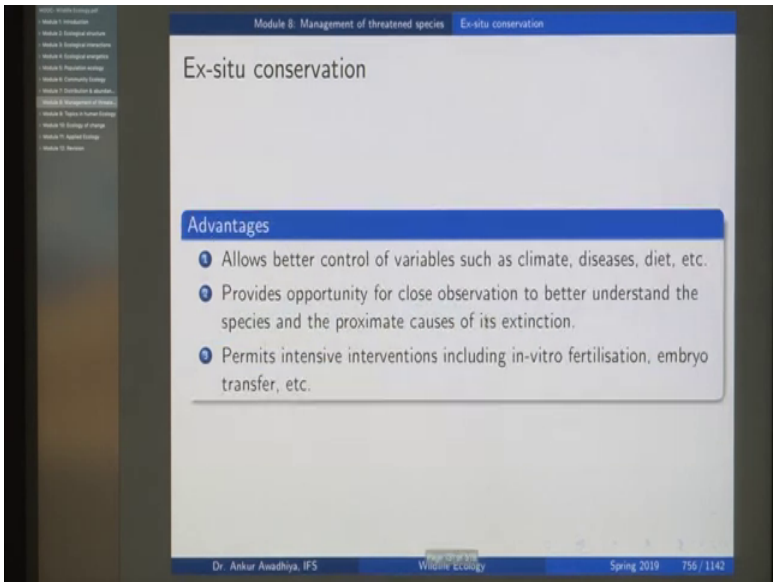

And if required you release them later on it allows much better control of variables, it provides opportunity for close observation of organisms and it permits much more intensive interventions including in vitro fertilization embryo transfer and so on.

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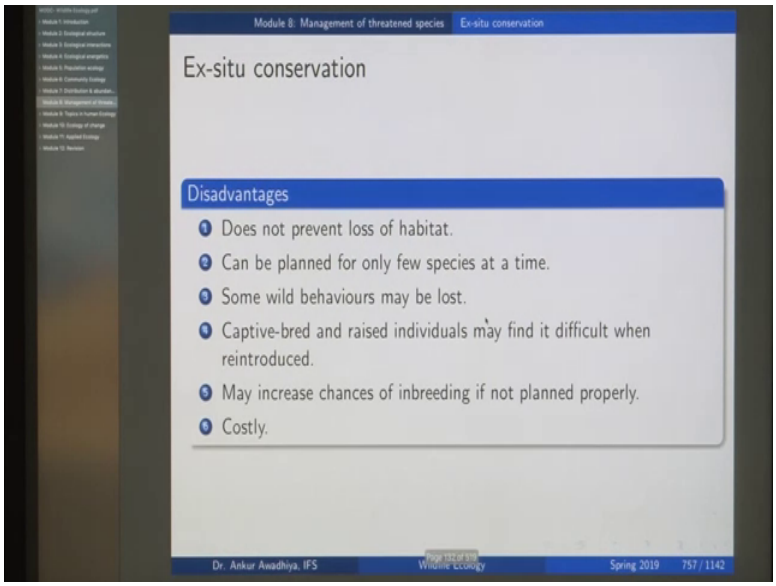

But, then it does not prevent the loss of habitat, it can be planned for a few species at a time some wild behaviors may get lost captive bred and raised individuals may find it difficult, when reintroduced. It may increase the chances of inbreeding if it is not planned properly and it is extremely costly.

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We looked at the example is zoo aquaria and so on certain organisms can be very easily maintain in ex situ conservation, where as a certain organisms are require more in situ operations.

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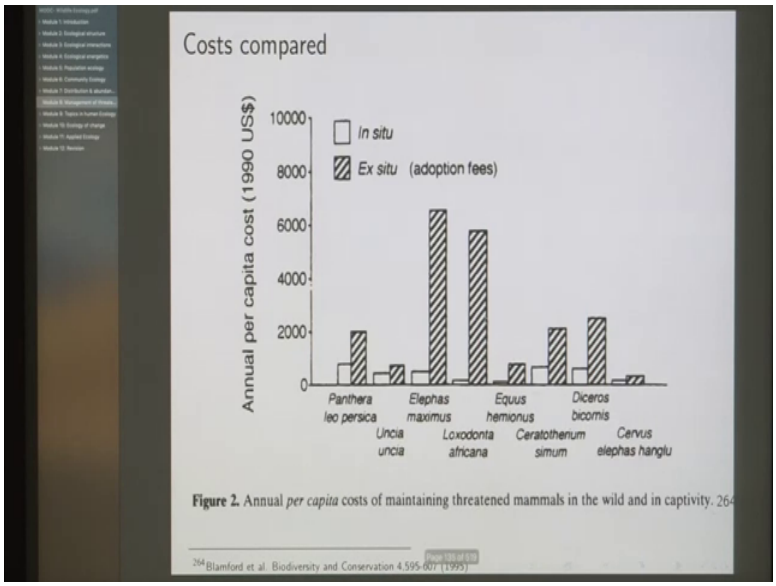

Then the costs are much or typically greater in the case of ex situ conservation in situ is cheaper.

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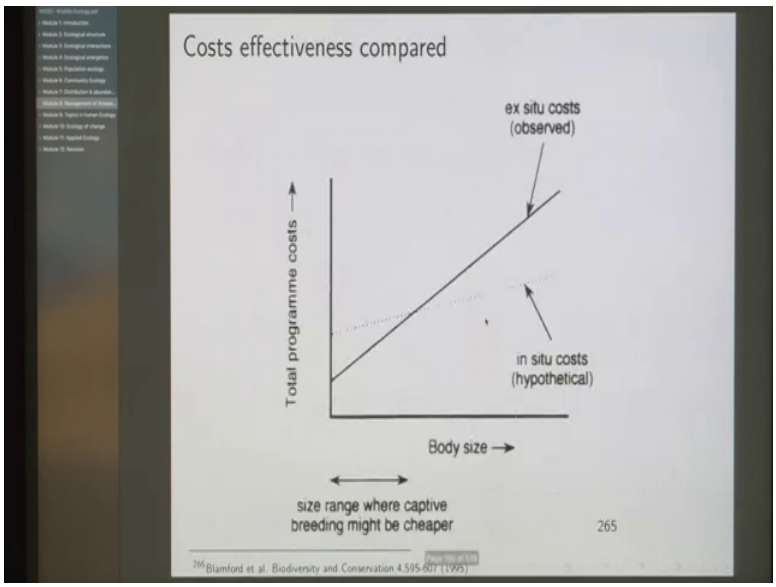

And especially, it is cheaper for the larger organisms. So, if we talk about larger organisms, such as elephant ex situ costs are much greater than the in situ costs.

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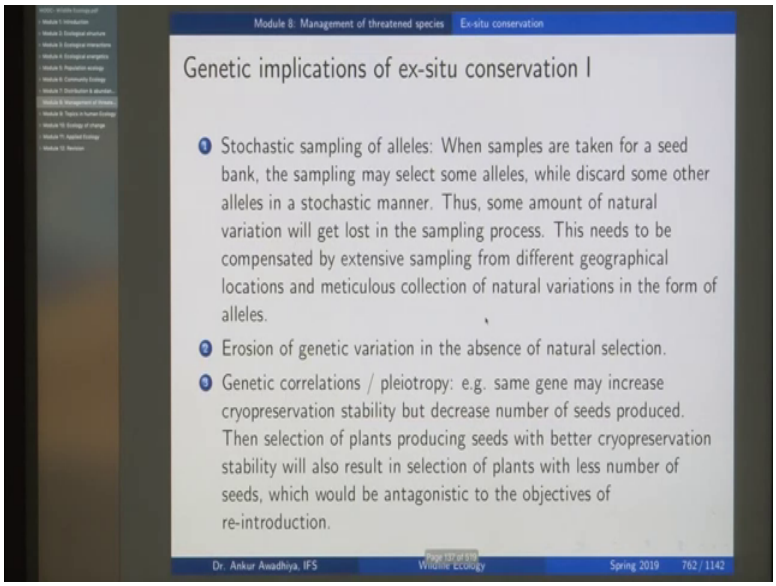

Next we looked at the genetic implications of ex situ conservation, you have stochastic sampling of a alleles erosion of genetic variation, the pleiotropy effects and it is genotype environmental interactions that can play a role. Next we looked at some ex situ conservation facilities in details, the first one was zoo and this is the definition of zoo as per the wildlife protection act. So, it is an establishment with a stationary or mobile, where captive animals are kept for exhibition to the public and it includes a circus and this is important includes a circus in rescue centers, but does not include an establishment of a licensed dealer in captive animals.

Zoos are managed as per in master plans and number of them are doing conservation breeding and they maintain studbooks for different animals, that are involved in the captive breeding now, we look that case study of Mysore zoo. So, you need to create a cosy environment look at the feed.

The feed has to be given in proper time in sort, it can meals have where exotic requirements, that needs to be we might need to synergistically leverage the landscape maintain proper documentation of things. Do capacity and infrastructure building research and in reach activities go for eco friendly activities as far as possible try to convert, some waste into wealth. Then you also need to take care of the people, who are visiting in to a zoos, we need to build you image and we need to have innovative actions and then you can also have things such as, areas where you are having a collection of

butterflies or collection of hydrophytes and so on or collection of orchids open aviary or collection of cacti and so on.

When you we also had a look at the bear rescue facility. So, that is also counted as part of a zoo, because it is a rescue facility mean, in the turtle rescue facility, you bring the eggs, you let them hatch and then you raise them tell a particular point of time and then you reach them back. Now, there is a need to prevent stereotypical behaviors, which another step, you will get into when they will go and so, there is a need for behaviour enrichment. Next we looked at vertical gardens, a garden dedicated to the collection cultivation and display of a wide range of plants labeled with the botanical names.

Now, there are several rules, that we play and we had a locate location question botanical garden. So, you have a number of play cards, it caters to the needs of several different people different in interest people can spend a quality time. So, that they become more tuned to the causes of conservation, you have multiple use areas and you have certain highlights such as, the canopy walk and you have a number of these play card, that tell you what is what and they also give you a lot of information about the geology history.

Why do we need conservation? What are the kinds of adaptation? What a invasive species? Why do you need to control invasive species and so on next we looked at seed banks in cryopreservation facilities. So, if you have a seed that is kept in a cold area or a seed that is kept extremely dry. So, it is able to grow back and seed is an embryonic plant that is enclosed in an outer protective coating.

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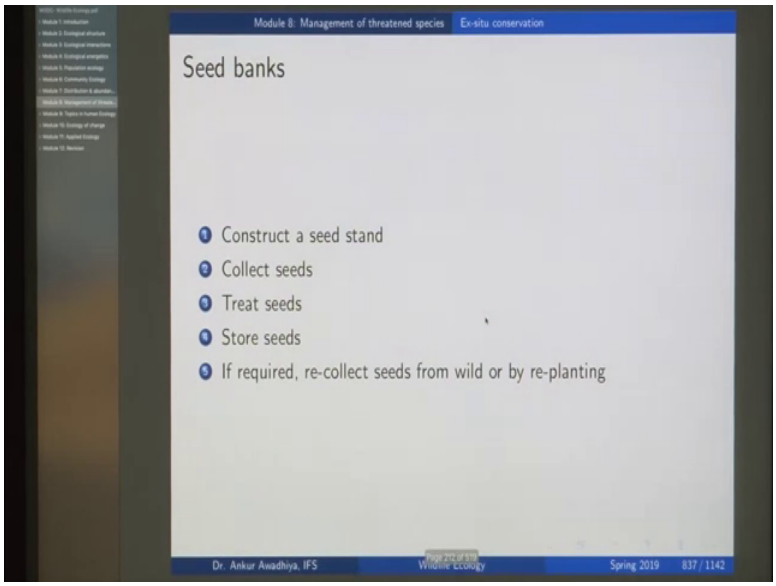

So, if you want to create a seed bank, you need to take into account a number of things one is that, you can create an ex situ conservation stand, you need to have good seeds. So, these are the characteristics, you need to determine the best days for collection, determine the best trees for collection in this case, you need to take into account that a adequate variety is maintained in your collection.

And then there are certain requirements, you maintain all these stocks there are several ways of collecting the seeds, they can be natural or they can be artificial, you perform several operations to enhance the shelf life seeds are of three kinds depending on their life on and depending on the amount of oil or the amount of drying, that they can tolerate, they can be orthodox or recalcitrant seeds. And there are a number of factors that determine the longevity of the seeds that is seed condition the age and the storage conditions.

So, you need to take care of all of these and we looked at the Svalbard Global Seed Vault and these facilities can also be used for certain animals spills as well. Next we looked at topics in human ecology; the first one was introduction and impacts. So, our population is growing and this era is correctly known as anthropocene, it is a proposed epoch dating from the commencement of significant impact on the earth's geology and ecosystems including, but not limited to anthropogenics climate change, and the number of people

say that, trinity in experiment or explosion in 1945 can be taken as the beginning of anthropocene.

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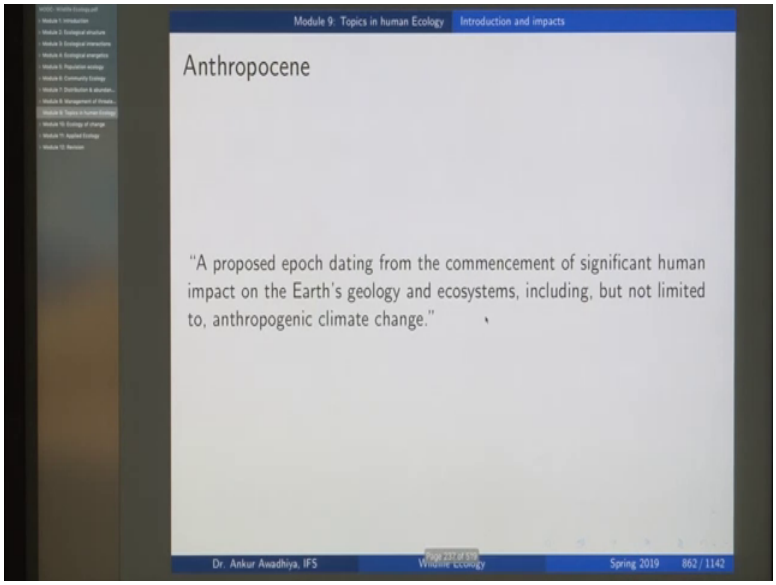

And we are seeing several impacts on the environment ozone depletion, ocean acidification climate change desertification habitat destruction and so on. Now, we looked at how to quantify the amount of impacts of human beings? It is this equation I is equal to P into A into T. So, we have population multiplied by affluence multiplied by the level of technology that we have then we saw that the population has been growing for quite a while the technology the affluences also been growing in terms of GDP per capita and then the technology is also growing exponentially.

So, in this case are a impact on the environment is also increasing, because all three parts are increasing. But then you can make use of technology, so, that you are able to reduce the impact by say recycling. Even in the case of our population growth, we are we have cross the peak growth rate and.

So, now our growth rate is much lower, than what we had in the 1960 and so, the population is now reaching into a steady state. The fertility rates are reducing and our population is now becoming more and more stable with time and then we looked at this demographic transition the 5 different stages, that happened and these days we are entering into an era, where we will be having low birth rates and low death rates. Next we had a look at human population growth and food requirements.

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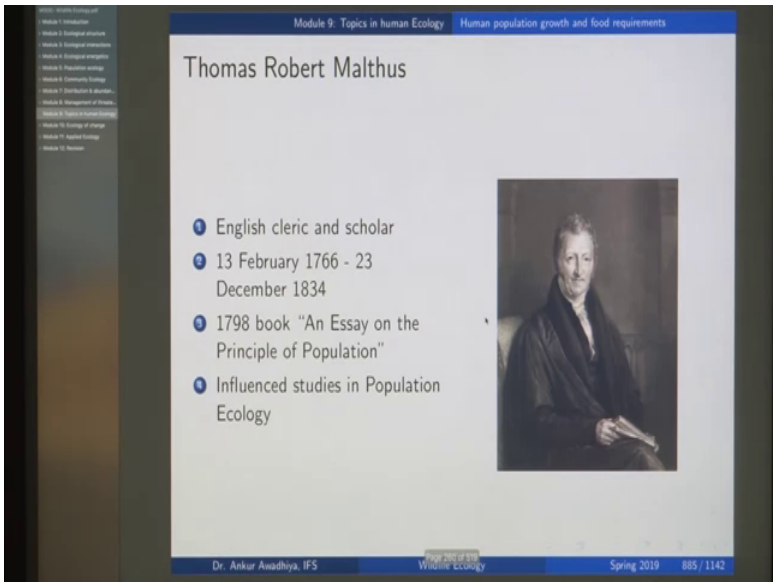

Where we looked at the theory of Thomas Robert Malthus.

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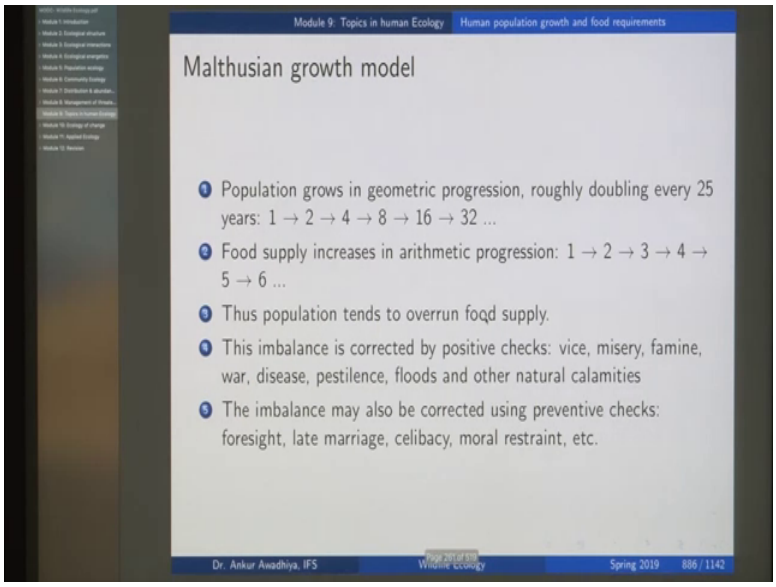

Who said that, the human population grows exponentially or in geometric progression whereas, the agriculture grows only in arithmetic progression, in this case the population tends to overrun the food supply and in which case, we will have an imbalance.

Because you will have more people, you will have less amount of food to feed all of them. So, this imbalance is corrected by 2 measures, you can have positive checks that nature brings in vice misery, famine war, disease pestilence flood and natural calamities,

these are all imbalances that are brought in by nature and these he refer to as positive checks. And he said that because all of these are bad for us, it should go for preventive checks such as foresight late marriage celibacy moral restraint and so on.

Now, on one hand, the population thus show an exponential growth and so the Malthusian theory looks correct and we looked at the derivation of the doubling time. So, doubling time is 1 by k log 2, but then there are a number of criticisms to Malthus the population growth is not exactly exponential, because the doubling time has been changing with time. The agricultural growth is not as suggested, so, in a short while, you can see that the agricultural growth is showing an arithmetic increase, but then you also have exponentially. So, if you look at the larger time spans.

Then third Malthus does not incorporate new land that becomes available. So, we have been increasing the lands that are available to agriculture by diverting our forest and other areas. So, there has been a very exponential increase in the amount of agricultural areas, that we have both cropping increasing areas, then he also neglects the rule of technology, such as exponential increase in yields, that has been brought that has been made possible to process, the use of pesticides, which whose use has been increasing and also the fertilizers whose also use has been increasing to a very fast rate and if you increase the amount of fertilizers the crop yield typically increases.

And these days, we have our productivity very high and if you increase productivity your requirement for land becomes less and less. So, essentially there are ways to tackle the problems.

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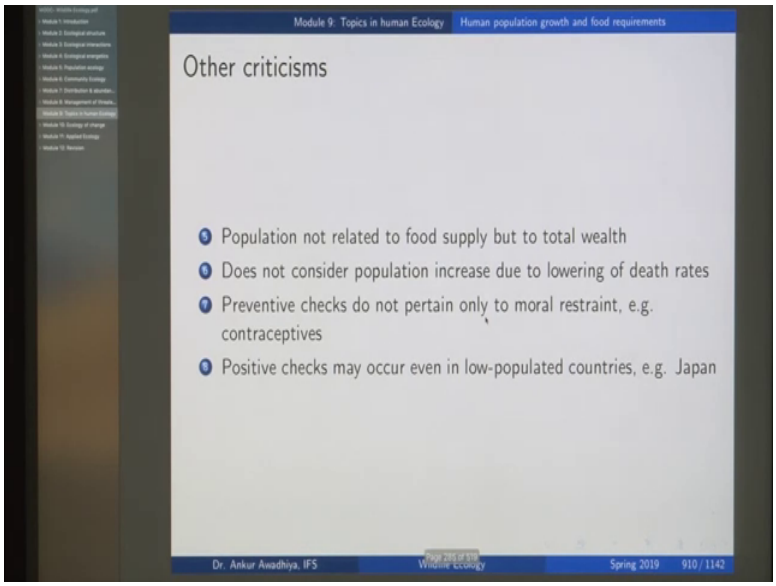

The other criticisms are that the population is not actually related to the food supply, but actually to the total wealth that is available with the population not just a food supply. Then he does not consider population increase that is due to the lowering of death rates, which has been seen through for some time that are death rates have been going down, because of a use of modern medicine modern technologies.

Then preventive checks do not pertain only to moral restraints. So, in his time he did not consider the use of contraceptives he only talked about moral restraint, but then these days we also have a number of contraceptive that are available, then positive checks may occur even in low populated countries. So, he said that populated, the positive checks will occur and you have a high population, but even in low population countries, such as Japan, you can have things like earth quakes, tsunamis and floods. Next we looked at sustainable development.

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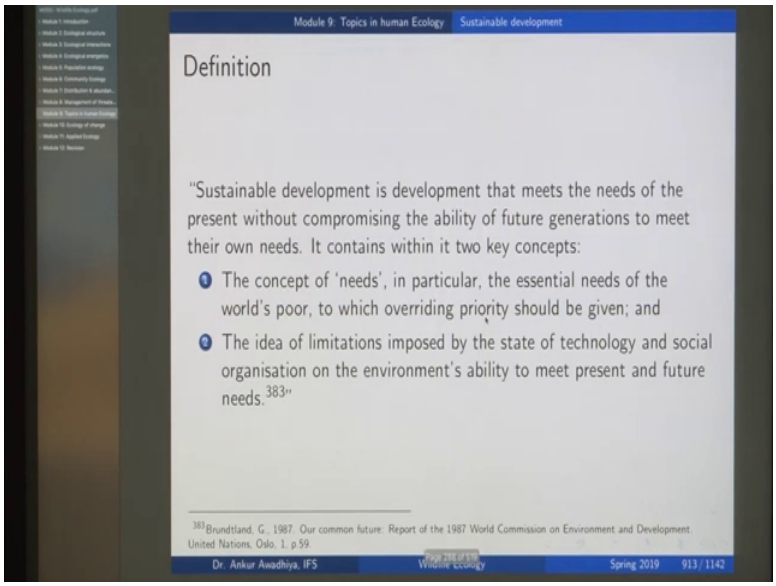

So, this is the definition, sustainable development is the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. So, here we have 2 concepts, one is the concept of needs as a needs wants. So, needs of everybody has to be made especially those of the world's poor who have to be given an overriding priority and the second is the idea of limitations, because we do not have an infinite amount of resources. So, limitations are imposed by the state of technology and social organization on the environments ability to meet the present and the future needs.

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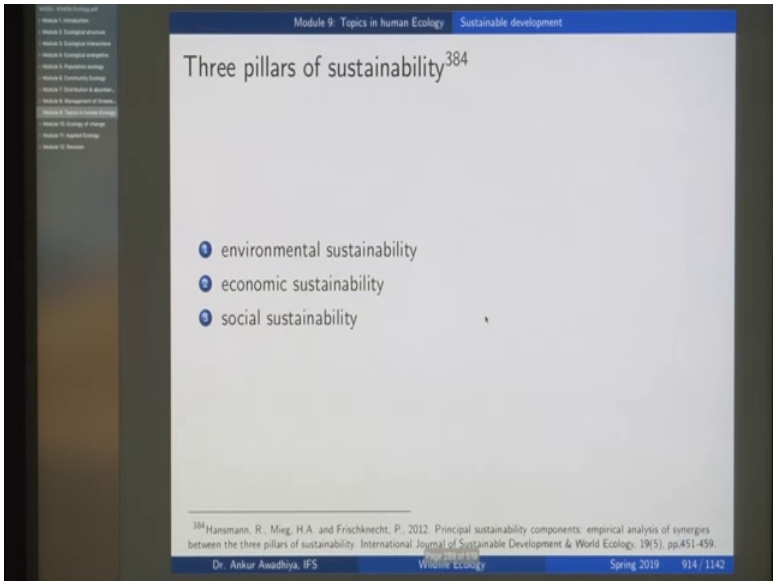

Then we have three pillars of sustainability environmental, economic and social sustainability and we looked at what points to be considered in all three of these. And when you are considering all three of these and you put it into your accounting framework. So, you have a triple bottom line.

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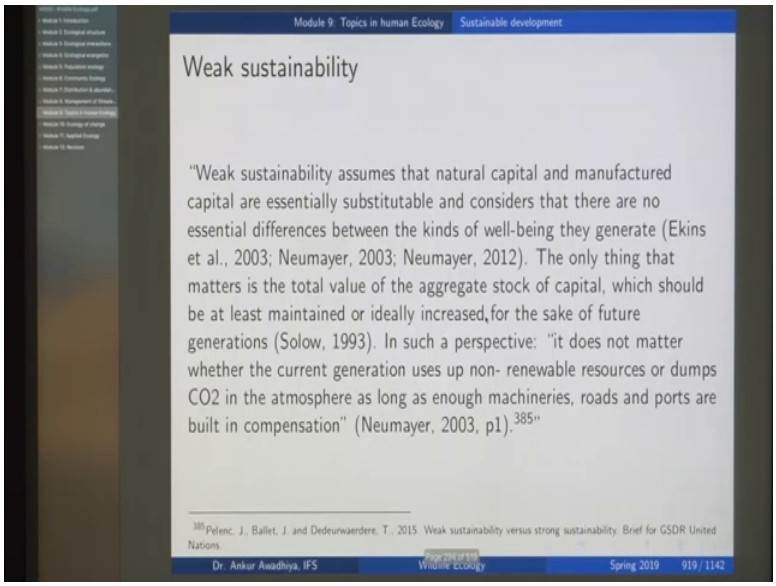

Now, sustainability talks have an characterized by 2 sets of people, when talk about weak sustainability, which says that national capital and manufacturing capital are essentially substitutable. So, if you lose your national capital, such as forest and you make more and more of your manufactured capital, such as roads and houses. So, you are able to provide much more amount of social good as compared to what your forest would have given. So, they say that it is perfectly ok.

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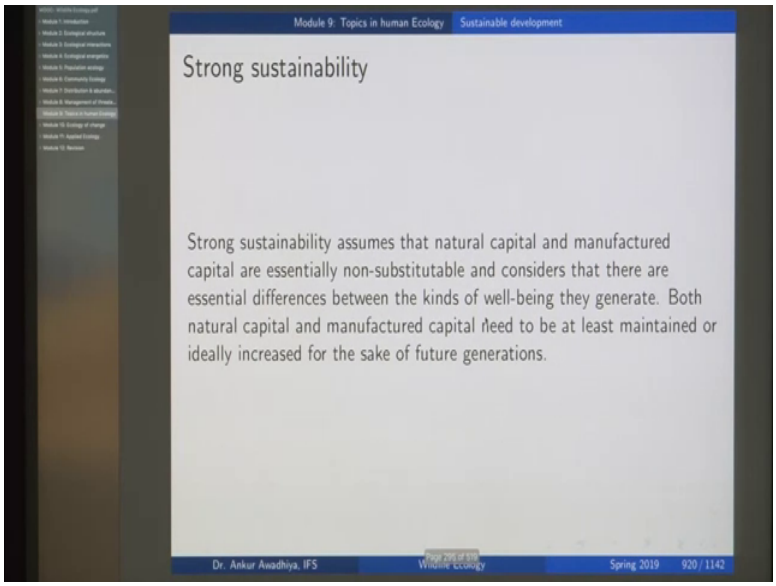

But in the case of strong sustainability it has assumes that national capital and manufactured capital are non substitutable and the kinds of well being that they generate are very different. So, the society needs both the national capital as well as the manufactured capital and both have to be sustainably used. So, we looked at the differences between both of these and then this argument of strong sustainability brought into pictures, the idea of sustainable development in the 21st century in the form of Agenda 21, then we looked at 17 sustainable development goals.

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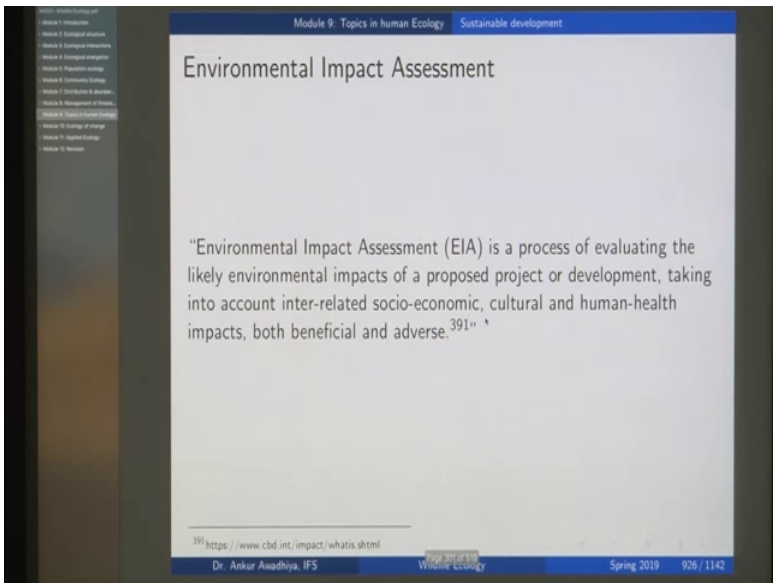

And to meet these goals, we go for environmental impact assessment which is the process of evaluating the likely environmental impacts of a proposed project or development taking into account interrelated socio economic cultural and human health impacts both benefit both beneficial and adverse. So, all the positive and negative impacts are taken into account in the case of environmental impact assessment.

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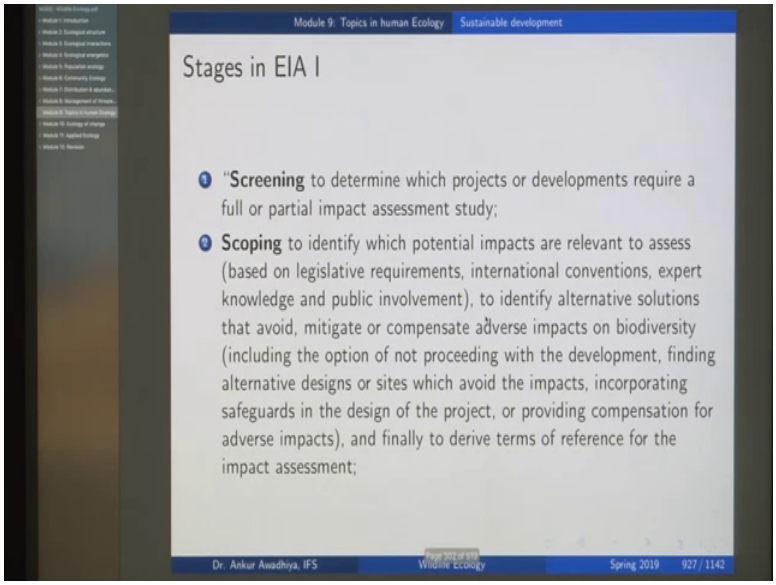

Now, there are several stages, the first one is screening to determine, which projects require in EIA, the second one is scoping which ask you what are the impacts, that you want to measure, what are the alternative solutions that you have and what are the terms of reference of this impact assessment.

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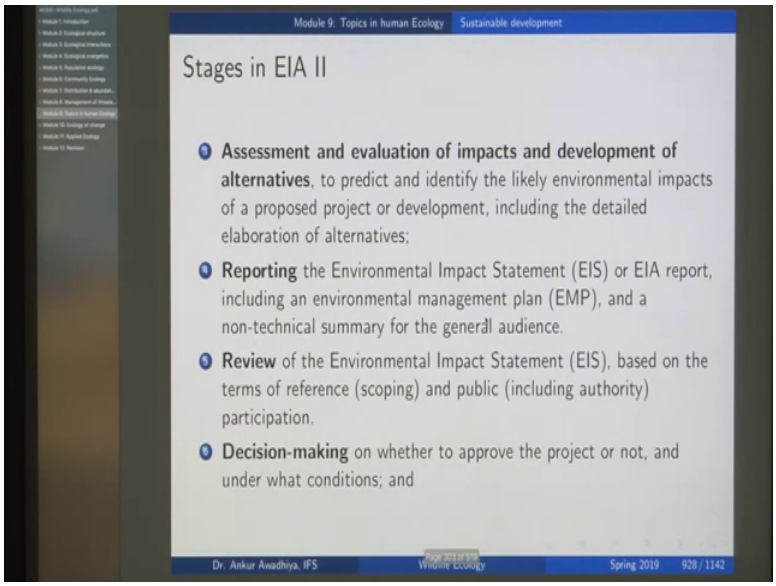

Third is assessment and evaluation of the impacts and development of the alternatives. So, you actually go and access the impacts. Once you have access the impacts, you make a report based on the report, you go for a review in which case you also go for public consultation and on the basis of that report and review you go for a decision making.

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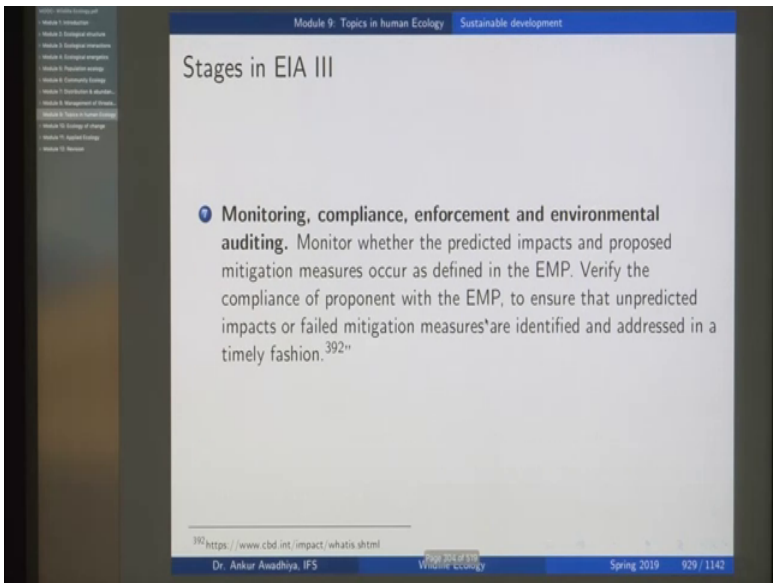

Once you have made a decision, that you want to go with a project with certain writers, you need to go with the monitoring compliance enforcement and environmental auditing of the particular project to see to it that all the writers are being met.

Then we had a look at clean technology, which is any process product or service that reduces the negative environmental impacts through significant energy efficiency improvement, the sustainable use of resources or environmental protection activities. So, we looked at number of themes in clean technologies, such as renewable energy, water purification air, purification sewage, treatment or waste treatment environmental, remediation solid, waste management, energy conservation and appropriate sustainable technologies. And then we had a look at certain clean technologies that have been proposed in the past few years. Now, in the 10th module it was ecology of change where we looked at oil spills plastics and climate change.

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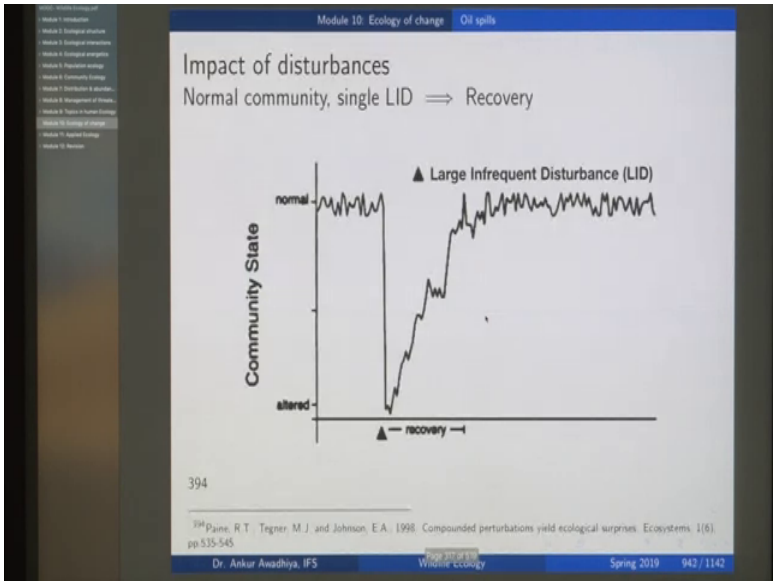

So, in the case of oil spill, we began with the impacts of disturbances. So, if you have a large infrequent disturbance in a community, that is essentially a normal community it is a stable community, we view at a large infrequent disturbance and it will be able to recover back right. If you have a community that is stable and you give it multiple large infrequent disturbances.

So, if you give it multiple disturbances, it might not be able to recover or it might take a very long period to recover. And the third case is, if you have a community that is already stressed. So, it is not completely normal it was somewhere in between and you give it a large infrequent disturbance and you have a community, that is not able to come back.

Now, we looked at several large infrequent disturbances like, fire storm, tsunami, oil spill, climatic, extreme heavy pollution and so on. And disturbed communities include diseased communities weed infested facing competition from livestock pollutants rich or facing climatic changes and so on. Now, oil spill is defined as the release of liquid petroleum hydrocarbon into the environment and there are 2 kinds; terrestrial and marine.

So, in the case of terrestrial it comes upon land, in the case of marine it comes upon the seas or it can be classified as natural accidental or intentional depending on whether it happen naturally, because of an accident or because people actually wanted to give rise to this oil spill as in the case of Gulf War oil spill.

So, this is an example of a natural oil, spill this is known as an oil seep. Then hydrocarbons are organic compounds, that consists entirely of hydrogen and carbon and there are several different kinds and we classify them based on their specific gravity. So, there are those that have no specific gravity they float on the surface of water, there are those that have a high specific gravity they settle to the bottom. Then hydrocarbons are also classified as petrogenic that are derived directly from mineral oils pyrogenic that results from an incomplete burning of mineral oils and biogenic that are derived from certain biological processes that are acting on the mineral oils.

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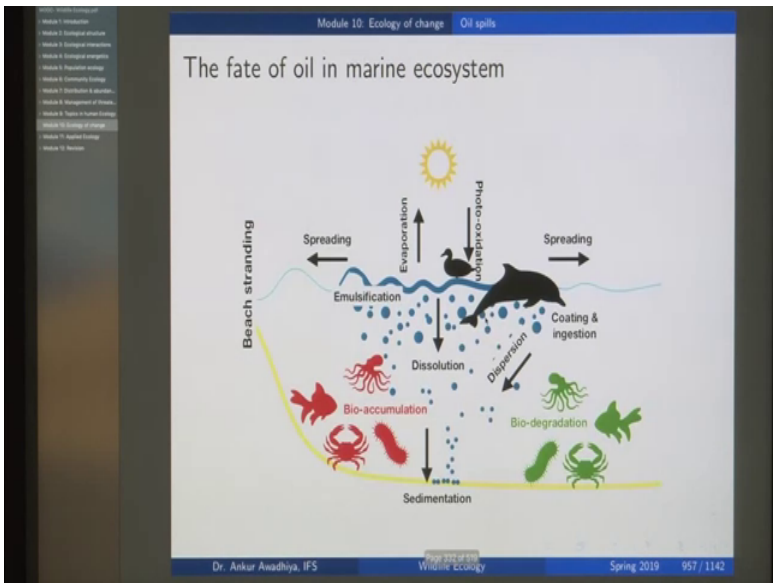

Then we looked at the fate of oil. So, if there are oils that have low specific density. So, they come to the bottom, they come to the top and then there is spreading, there is evaporation, there is photo oxidation and there is certain amount of emulsification, because these are being acted upon by regular action and if it spreads to the beach, they can be standing on the beach. Now after now there can be certain soluble some components of the oil, which can get dissolved or it can become dispersed in the water and there could be some portion that will sediment down.

Now, if there are things on the top. So, if there is an animal that is coming to the top to have a grasp of air it might get coated with this oil or it might be eating up this oil. Even if there is some bird that comes to the surface, it might again get coated with oil or this oil may get into its mouth parts or say lungs. In the oil has a region to the ecosystem, there can be 2 kinds of things one is that there will would be biodegradation by certain organisms or otherwise there will be bioaccumulation and biomagnification as we move up the trophic levels.

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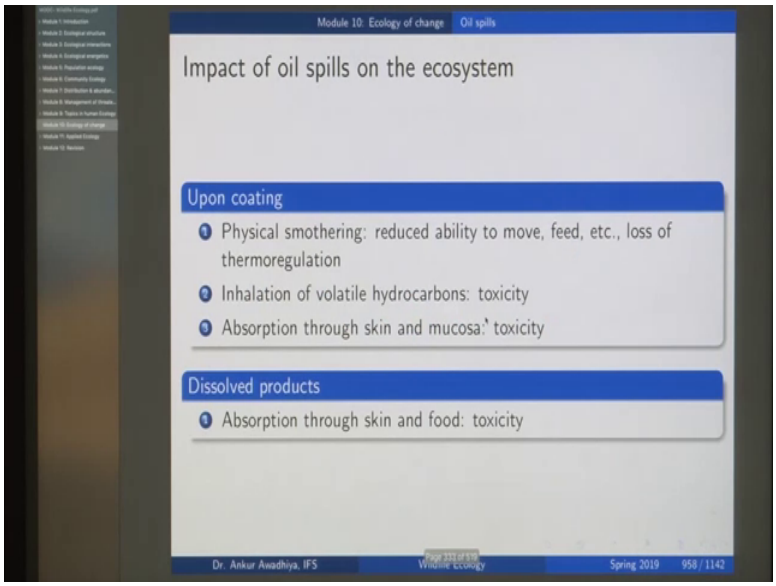

Now, the impact of oil spill on the ecosystem is varied depending on what is happening. If it is coating, then it may lead to physical smothering or inhalation that lead to toxicity absorption that lead to toxicity, if it is dissolved then it will lead to toxicity, now the factors that will influence their impact on organisms will be things like seasonality. So, if they it is a breeding season or there are presence of eggs or juveniles, the impact is much

more. If it is impacting a key species or keystone species, such as mangroves, then the impact on the whole of the ecosystem is much larger. Then it will also depend on the lifestyle factors whether the organism is k selected or r selected, if it is an organism which has a long life span and is k selected. So, the impact will be much greater.

If there is an organism that is having certain stress or it is having a bad health, so, the impact will be much more. Then we looked at vulnerability and sensitivity. So, sensitivity tells you if something is exposed to the oil. So, what will be the impact of it and vulnerability ask the question, what is the likelihood? That your resource or the organism will be exposed to the oil so, deep water coral may be sensitive, but not vulnerable whereas, a rocky shore seaweed maybe vulnerable, but not sensitive. Then we looked at toxicity, which is of 2 kinds acute and chronic, then exposure is the combination of duration of exposure and the concentration of the chemical.

Then there are several exposure routes, which could be say ingestion that is it is getting into the food or it is getting absorbed, because of the skin or because of the gills or it is getting in healed and so on. Magnitude is it depends on the sensitivity of the organism and the concentration of the chemical and the duration of exposure to the chemical. Next if you have a toxic chemical, it may lead to a lethal effect or a sub lethal effect, the lethal effect the organism dies in the sub lethal effect, it may lead to a reduction in biological function or health.

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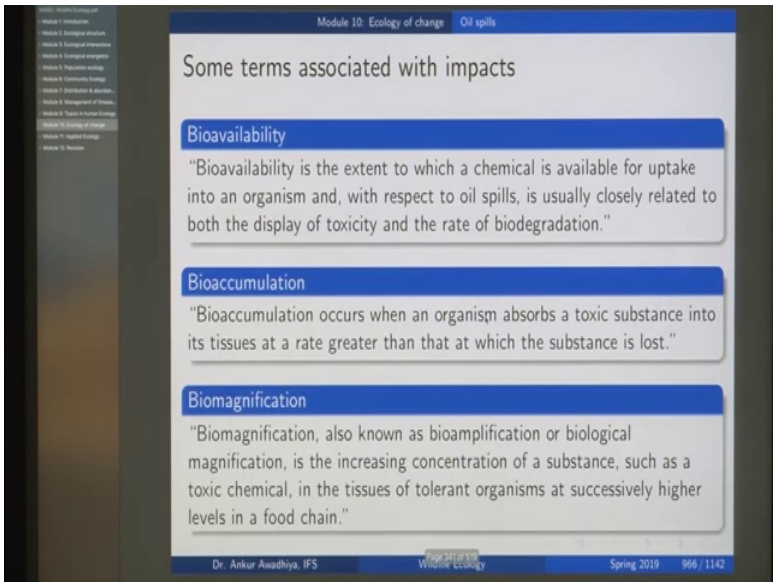

Now, we looked at bioavailability, bioaccumulation and biomagnification. So, bioavailability is the extent to which a chemical is available for update into an organism bioaccumulation occurs, when an organism absorbs a toxic substance into its tissues at a rate greater than at which the substance is lost. Now, this loss could be because of degradation in the body or it could be because of excretion out of the body. Third is biomagnifications, which is also known as bioamplification or biological magnification it is increase in the concentration of the substance as you move up in the food chain.

So, this was an example of biomagnifications, the concentration of DDD in the water was 0.01 ppm, but as we move up the food chain to the fish eating birds it will increases to as highest 2500 ppm. Now, the impacts on different animals is very different. So, we looked at impacts on planktons seabed animals fish marine mammals, marine reptiles, birds shore line in coastal habitats.

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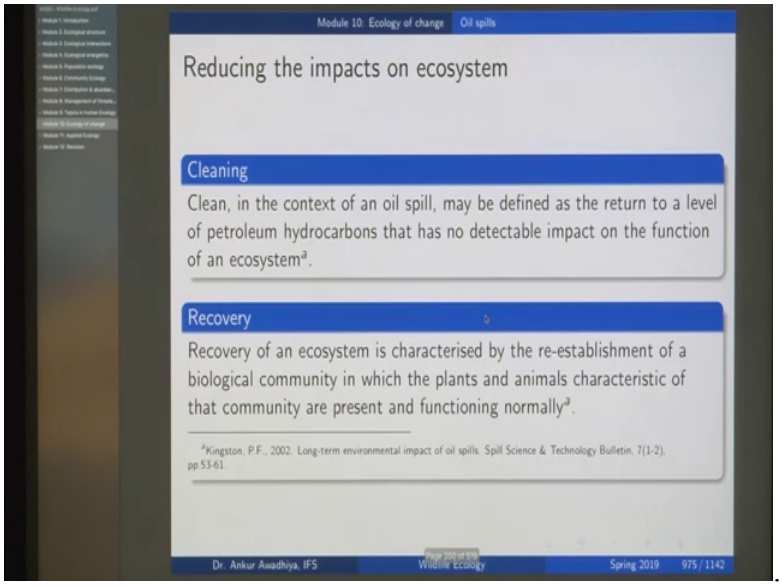

Now to reduce the impacts on the ecosystem, you can go for a cleaning operation, which means, a return to a level of petroleum hydrocarbons that has no detectable impact on the function of the ecosystems. So, in this case, you are not removing the hydrocarbons completely, but you are only reducing its amount to a level that you are not able to detect any impact on the function of the ecosystem.

And recovery is a term, that tells you other about the reestablishment of a biological community after it has suffered with the disturbance. Now the clean-up operations

include contain and scoop in which you collect the oil from the top or you can burn the oil in situ or you can disperse the oil using chemical dispersants, such as detergents or you can let nature act and do nothing, if it is a very small leak or if there is a little possibility of it impacting the ecosystems.

Or you can make use of biological agents and fertilizers. So, you can spread microorganisms or you can spread fertilizers. So, that the microorganisms are able to multiply and they are able to degrade the oil.

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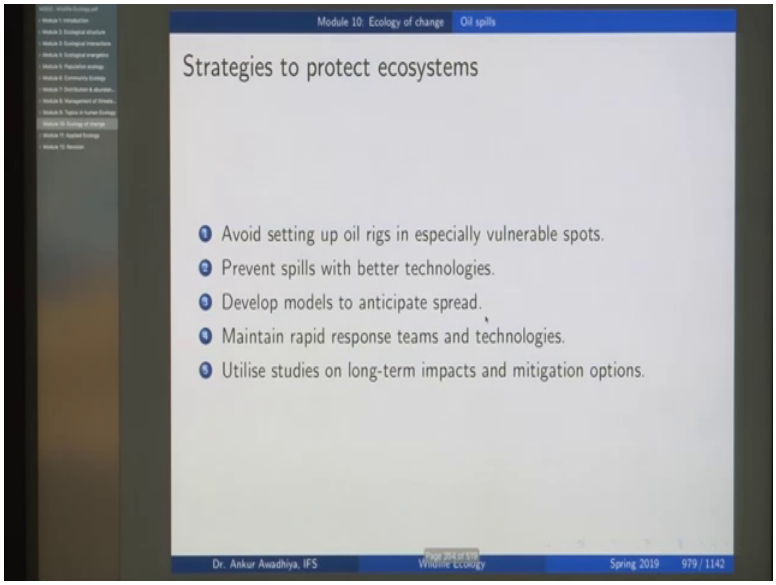

And then there are certain strategies to protect ecosystems, you avoid setting up oil rigs in especially vulnerable spots prevent spills with better technologies develop models to anticipate spread maintain a rapid response teams and technologies and utilize studies on the long term impacts and mitigation options.

Next we looked at plastics and biodiversity. So, plastic is a synthetic material that is made from a wide range of organic polymers, such as polythene PVC that is polyvinyl chloride nylon etcetera, that can be moulded into shape while, soft and then set into a rigid or slightly elastic form. So, plastics around us and we looked at a short history, it is as old as 1600 BC the plastic production has been increasing with time and a very small fraction has ever been recovered.

So, all this plastic it can be either reused and recycled, which we know is a very small fraction or it can be burnt, when it is burnt it releases carbon dioxide and nioxines or it can be put into landfills, but then we are running short of landfills or it can be released into the environment, which ultimately does if you do not do anything and it can reach into the terrestrial and marine environments. If ultimately it reaches the sea is 15 percent floats on the surface, 15 percent washes ashore and 17 percentage as tends and sinks to the bottom. So, we looked at all these different examples and on the basis of size that is classified as macro debris and micro debris.

Then once you have this larger size fragments, they can undergo physical collusion with each other or with the rocks or probably it could be acted upon by light oxygen microbes and worms. And through a variety of reactions, it may become more fragile and it will start breaking up into smaller portions. So, then you can have different kinds of decomposing debri. Now, if you have this smaller debri, they can get aggregated as well to form the micro debri and the macro debri that is also possible.

Now, if it reaches to the marine animals, they may mistake it for food, they may eat it in which case their intestines will become completely chocked with plastics and they will die and then we are seeing this plastics everywhere, they are even getting into the food chain.

Because in the form of micro plastics, which are now getting into the zooplanktons as well. If it reaches into the bottom, then it might get filtered and concentrated or it might be even incorporated within the seabed, because of the burrowing animals. Then if it comes in contact with the animals, it may lead to entanglement or smothering, such as these ghost nets in which if an animal is trapped, then this animal will have a slow death or these entanglements in which it cuts through the skin or we can have the impacts in terms of persistent bio accumulative in toxic substances such a bisphenol a which is used as a plasticizer of brominated flame retardants which are again bio accumulative toxins.

There can also be accumulation and concentration of the hydrophobic toxins on the surface, because these are hydrophobic as surfaces, then there is a potential to alter the habitat and behaviour. So, this is an example of a hermit crab, which is now using a cap of a bottle as its shell or the sea horse, that is using this ear bud or this hyenas, which are now accumatized to the plastics everywhere. Even in the case of Manas tiger reserve, we

found plastics in the dungs of rhinoceros. So, it is reaching even those areas, that we considered most pristine areas. Then it can aid in the disposal of organisms, which can even be invisible organisms and basically if you look at any plastic.

Because it gets converted into micro plastics through several rules of degradation, we can see that it impacts everything from sub cellular organelles to the whole of the ecosystem. So, we can you help by reducing, reusing and recycling these plastics, lifestyle changes alternative materials like bioplastics. So, in the case of bioplastics, these have all the good properties of plastics without having the bad properties, because these are biodegradable and these are made from biological molecules.

These have strengths that are comparable to that of existing plastics and so, they can be used to replace the number of plastics. Next we had a look at the impacts of climate change.

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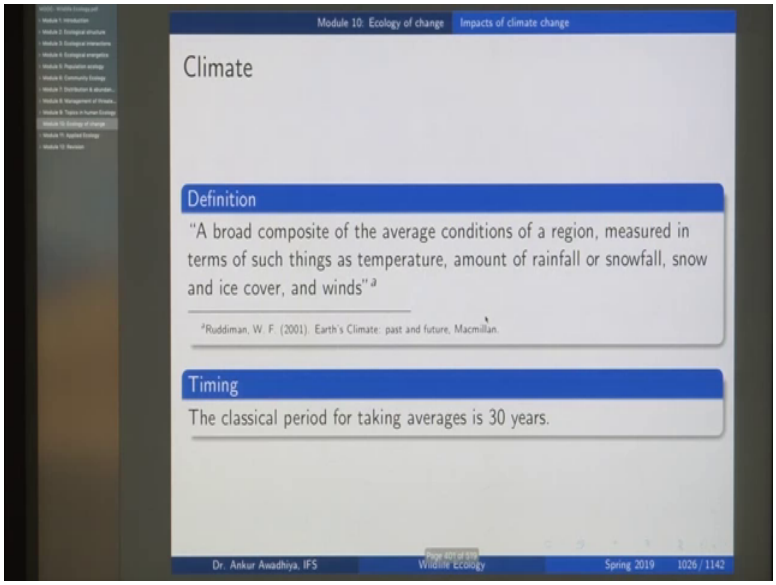

So, climate is defined as a broad composite of the average conditions in a region measured in terms of things like, temperature amount of rainfall, snowfall, snow and ice cover and winds. So, this is a long term average and the classical period of taking the average is 30 years, it has 5 components, the hydrosphere, lithosphere, atmosphere, cryosphere and the vegetation, which is the biosphere and all these components interact with each other.

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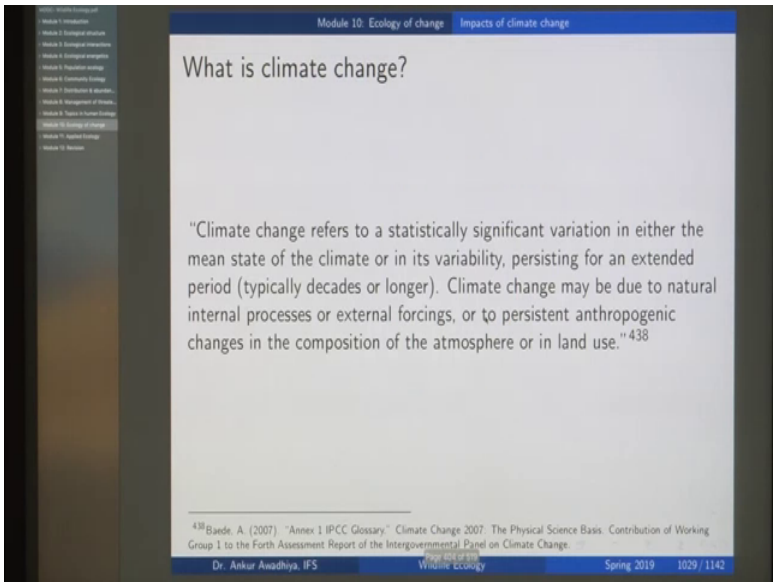

And then they interact they form the climate system and climate change is defined as a statistically significant variation in either the mean state of the climate or in its variabilities. So, when you say main state if it is getting warmer, we say that it is a climate change and in variability, if we say that we are getting more frequent cyclones or more frequent extreme events, more frequent droughts, then we say that it is climate change.

And it should persist for an extended period typically decades or longer. Climate change may be due to natural internal processes or because of external forcings or to anthropogenic changes in the composition of the atmosphere or in land use. So, when you have the climatic system, you give it certain stimuli it gives it produces a certain response.

So, these stimuli and whereas, forcings and they produce the responses forcings include changes in the plate tectonics changes in the earth's orbit or changes in the sun strength or changes in the anthropogenic forcing and anthropogenic forcing is the most prominent forcing, that is occurring today. In the case of responses, we can have changes in all the 5 components and these responses can be in terms of physical responses, biological responses mineralogical responses, habitat changes, bleaching of coral or large scale destruction of habitats, in terms of coral reefs or kelp forest or mangroves or the ice sheets that are there for the polar bears.

And we had seen a number of these examples these days such as rise in the level of rise in the invasion of exotic species or we are also looking at different ecological responses, how we can make use of model to predict, what are responses will be there? We are seeing responses in the hills, we are seeing changes in the comfort levels. So, if you are increasing the temperature. So, there will be an expansion in the cold edge and there will be an extension in the warm edge. And this is something that we have seen these days, we are the number of extinctions is also predicted to rise with time and there will be a change in the spatial distribution.

So, for instance organisms that preferred warmer climates and are till now there on the bottoms of the mountains, they will be able to reach to the tops. If you have more amount of rainfall, then it may lead to an increase in the number of insects that are born on these water pools, we are seeing an increase in vectorial capacity of different vectors, such as mosquitoes and then we are also seeing changes in the allele frequency.

So, in the case of tawny owl a few decades back most of the owls were green in colour, there were very few that were brown in colour, but then because of climate change, now there is less amount of snow and the trees and so now, we are seeing most of the owls that are brown in colour and very few number of owls, that are green in colors. So, there are changes in allele frequencies that we are seeing today.

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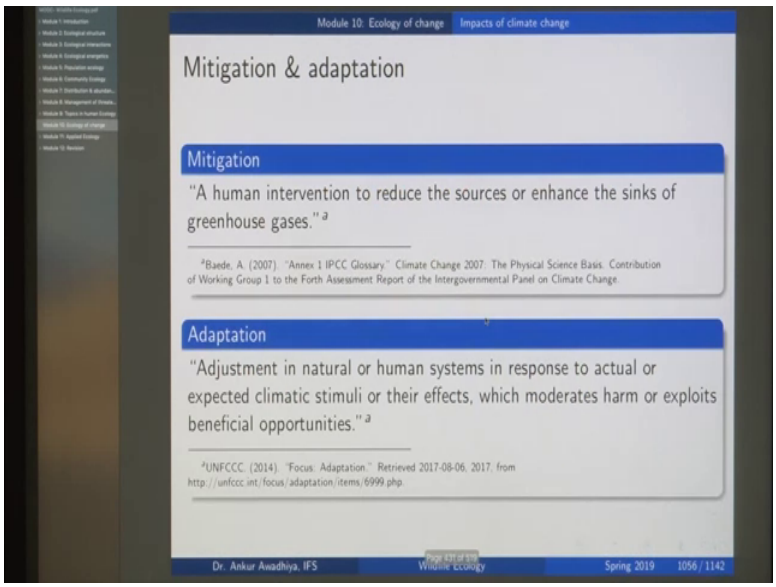

So, it is not theoretical. Now to overcome climate change, we can go for mitigation or adaptation. Now, mitigation is a human intervention to reduce the sources or enhances the sinks of greenhouse gases. So, essentially we try we want to limit the amount of greenhouse gases, we are putting into the atmosphere and we want to increase the amount of greenhouse gases that we are taking out of the atmosphere.

And the second option is adaptation, which says that climate change is going to happen, what can we do to make our systems more resilient to the impacts of climate change. So, it is an adjustment in the natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits the beneficial opportunities that is adaptation both have to be carried on and together at the same time.

Mitigation options including reducing emissions and creating sinks, such as green energy REDD or REDD plus or afforestation and in the case of adaptation, we can have anticipatory or proactive versus reactive adaptation or autonomous versus planned adaptation or private versus public adaptation. And then we talked about the adaptive capacity, which is the ability of a system to adjust or the ability of the system to adapt to climate change to moderate the potential damages to take advantage of opportunities or to cope with the consequences. We looked at the elements of adaptation you observe and access and then you go with the deming cycle and use it to give you more inputs regarding observation.

Now, adaptation options are creating resistance to change creating resilience to change and permitting responses to change. And whenever we are going with an adaptation option, you also have to keep in mind the maladaptation which is a negative adaptation or inadaptation that is not working any change in natural or human systems that inadvertently increase the vulnerability to climatic stimuli and adaptation that does not succeed in reducing vulnerability, but increases it instead that is a maladaptation.

Now, in the final module, we looked at applied ecology optical yield problem, biological control and ecotoxicology and pollution management along with restoration ecology.

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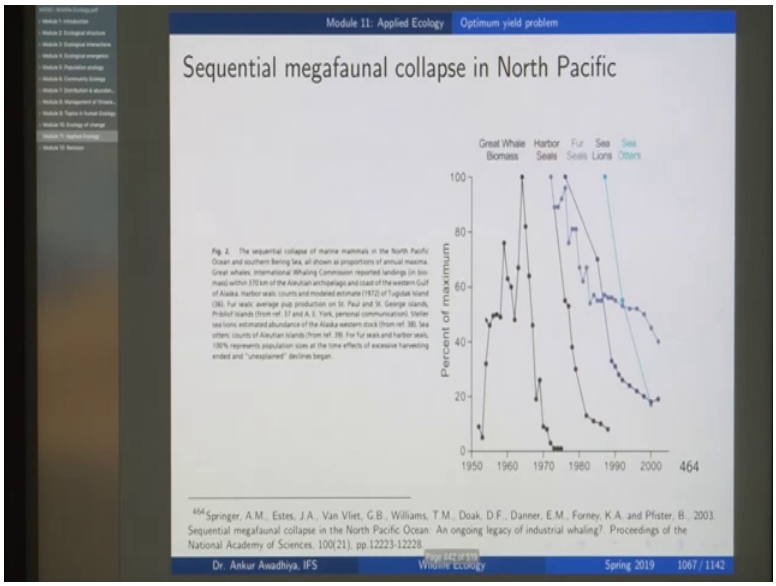

Now, optimum yield problems we began with looking at different megafaunal large sized animals, that whose populations are collapsing one after the other, because once we are done with one particular species, once we have brought its population down, we then change our taste and go with another species and begin putting the second species.

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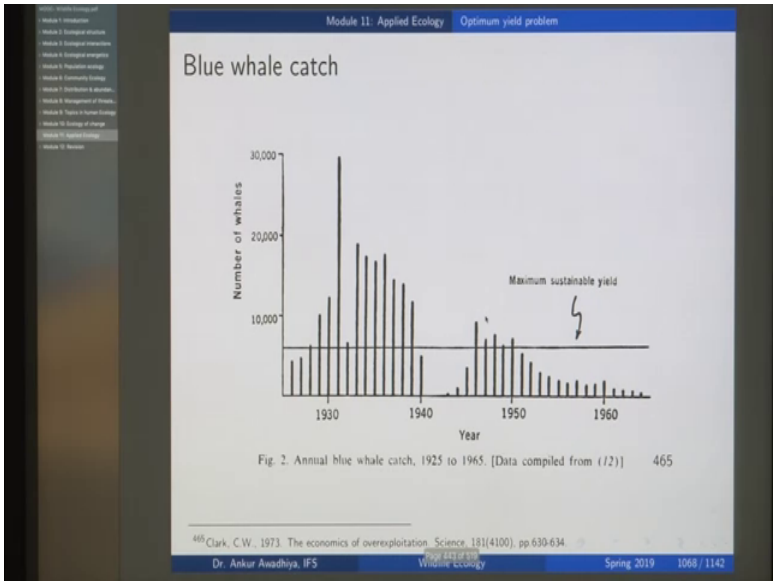

And we are saying that not only in certain oceans, but also even in certain groups of species, such as the whales. So, in the case of whales, we have crossed the maximum

sustainable yield for such a long period, that now the population is so low, that we are not able to get any more whales specially in the case of species, such as a blue whale.

So, what do we do next? Ones we are done with the blue whale, we shift to fin whale, once we are done with the fin whale, we shift to sea whale, once we are done with that we shift to minke whale, then we shift to humpback whale. So, essentially we are using all the species one after the other and we are leading to sequential megafaunal collapses in a number of different ecosystems. Now we want to know what is the sustainable size to which we can go for the poaching of these animals or removal of these animals; so, we began with the population size.

So, population size n plus 1 generation is the population size in the nth generation plus number of births minus number of deaths plus number of animals, that came in from outside minus number, if animals that move to some other areas.

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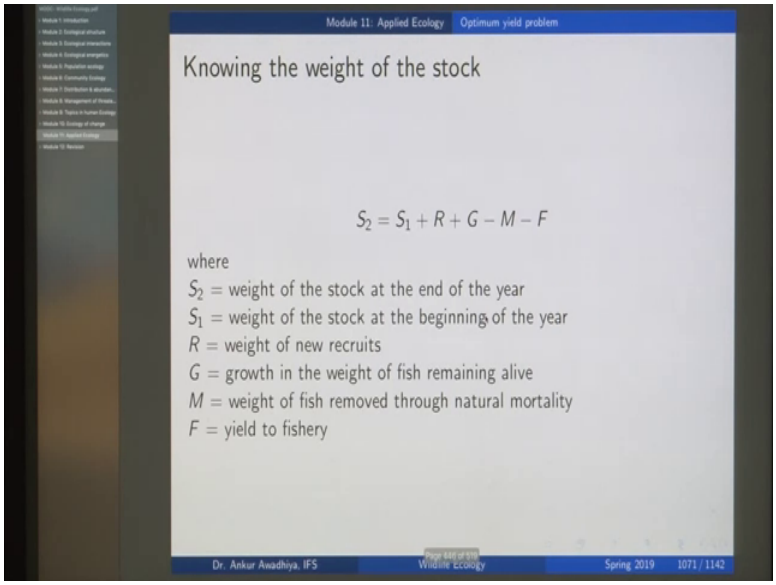

Now, in the case of weight, we have this equation S 2, which is the weight of stock at the end of the years is equal to S 1, which is the weight of the stock at the beginning of the years, plus weight of the new recruits that is the number of organisms that were born plus the growth and the weight of the fish, that are remaining alive in the system or the animals that are remaining alive in the system.

Minus the weight that is removed, because of natural mortality minus the weight that is removed, because of fishery or the poaching operation. Now, in the case of sustainable yield, we want to have the S 2 is equal to S 1. So, we get this equation R plus G is equal to M plus F and then we can make use of the logistic growth equation to predict the best yield. Now in the case of logistic growth equation, we can go for those areas, where we have a maximum growth rate and that maximum growth rate occurs in the midpoint of the log phase. So, that is where we want to maintain the population.

And that will also give us the number of or the weight of individuals that we can take out at all times. And so, the maximum yield is near the midpoint of the sigmoidal curve, but then this does not take into account the environmental variability. So, in the case of variable anchovies, we saw that there was an El Nino event, which drastically drop the population and then it took roughly 25 years to recover. So, in the case of such events you have low nutrients that are available, low nutrients leads to a low growth of planktons, which lowers the availability of food for the fish larvae.

In the because they had less amount of food available for them. So, there is large amount of mortality in this larvae and at the same time, they are not able to grow properly. So, in that case the population is not able to cope up. So, even in nature, there is a need to match timings. So, we have the match mismatch hypothesis, that the if the larvae if they are coming out of larvae the timing matches with the time of in abundance of foods. So, in that case the population will increase. If there is a mismatch, then the population will collapse.

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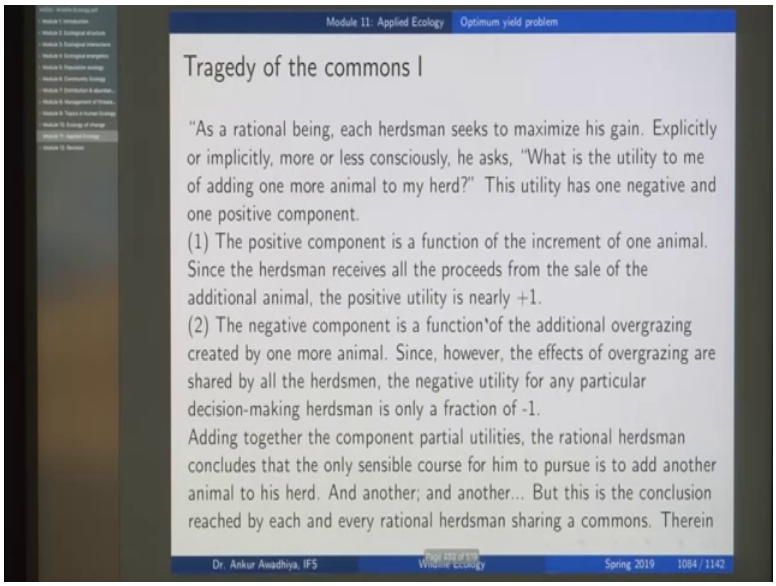

Then in our equation of taking the midpoint of this the sigmoidal curve, it also does not take into account a number of other factors, such as human factors. So, we looked at tragedy of the commons. So, in the case of a common resource, such as ocean it is a rationistal strategy for every fisher man to take fish out as much amount of fishes as possible. So, that is rational strategy at the individual level. But then at the overall level or at the community level, that will lead to a depletion or an unsustainable use of the resources.

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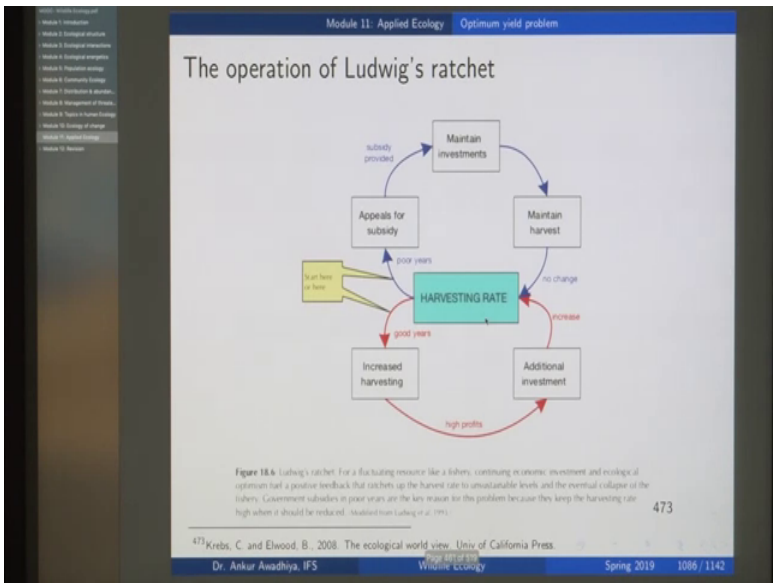

So, that brought us to the Ludwig's ratchet, in which case at all times there are phenomena that are trying to increase the harvesting rate. So, we need to maintain this harvesting rate at the sustainable rate, but in the case of a good year, people will tend to increase the harvesting rate above what is the sustainable rate. And even in the case of a bad year people would ask for a subsidies to maintain their investments and still go on fishing at a higher rate, than the sustainable rate. So, essentially the (Refer Time: 48:31) dynamics do not operate, when the human beings are in the picture.

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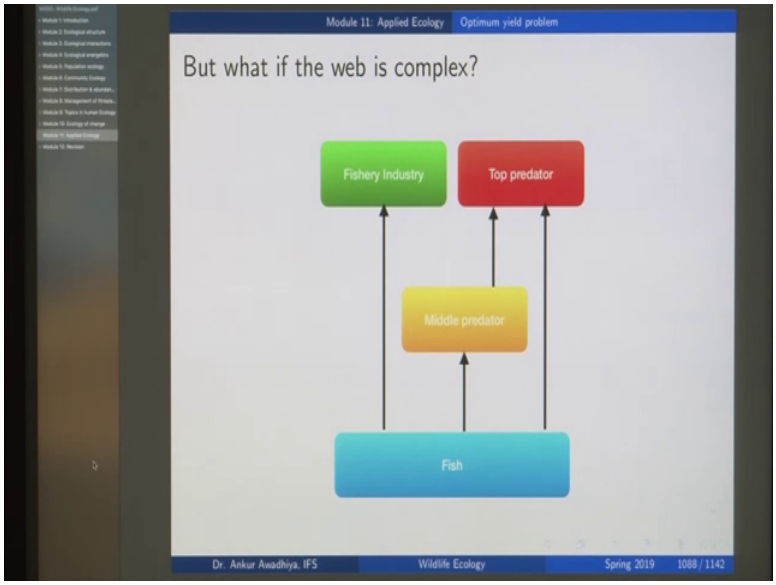

Then they are have been called to remove the top predator so that we can have access to more number of fishes, because there are competitors so to speak, but then if the web if the food web is complex and if you have a middle predator. So, in that case removal of the top predator will increase the number of middle predators and in that case your fisher stop will be depleted very fast and food webs are so, complicated that we should not be making any such assumptions.

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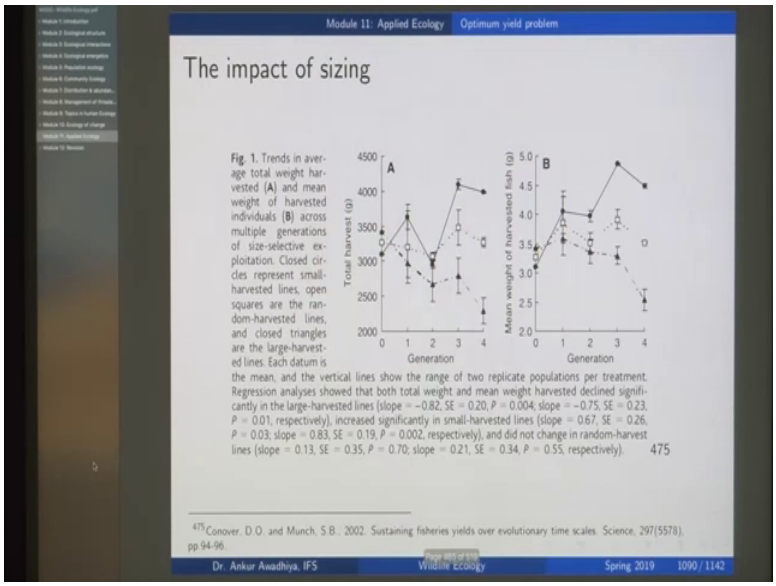

Next we looked at the impact of sizing, if you go for fishing of the last highest individuals in that case, your population will very quickly become full of individuals that are small in size and so, any heuristic equation will not be useful in this case.

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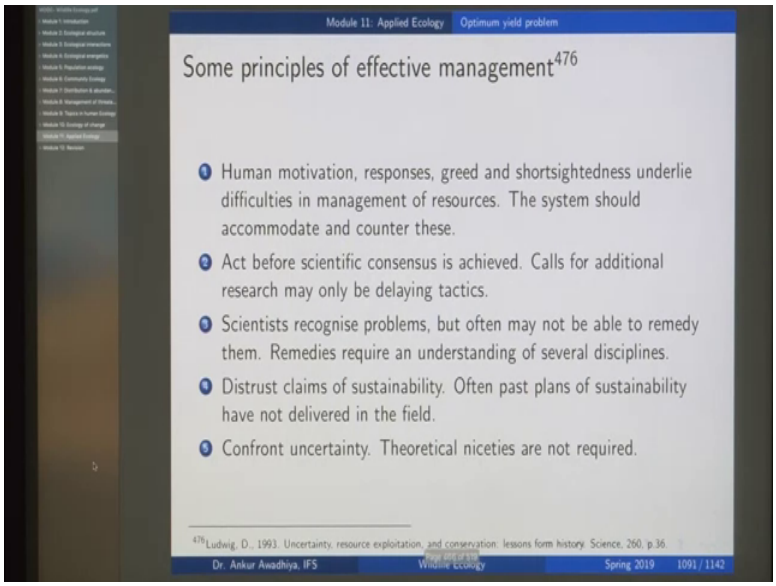

So, for effective management, human motivation responses grid short sightedness everything has to be accommodated into the system you have to add before a scientific consensus is achieved. You have to act even as soon as the scientists are able to recognize the problems, you cannot wait for them to give the remedies, because they will

probably not give you the remedies because in the case of giving a remedy it requires a number of disciplines, you need to know the science, you need to know the economics, you need to know the behavior of people.

You need to know the politics of the area and so on and then if there is any claim of sustainability, that has to be distrusted, because a number of past plans of sustainability have not actually worked. And if there is uncertainty that will always be a part of the system and that has to be confronted next we will looked at biological control.

So, we started with pest, a pest is a plant or animal, that is detrimental to humans or human concerns including crops livestock in forestry and this is also used for organisms, that are a nuisance looked at examples of pest, then there are controlled and uncontrolled pest, a pest is uncontrolled if it is leading to an excessive economic damage otherwise we call it a controlled pest.

And there are several methods to control these pest, you can go for natural control in which case you let the system act on nature act itself or you could go with application of pesticides, which is the long these day or you could go for cultural control, such as crop rotation, strip cropping or burning crop, residues or you could go for biological control using the natural predators or pest or parasites of the pest or you could go for any integrated pest management. Now, we looked at pesticide their substances that are made to control the pest including the weeds their use has been increasing with time and they have different kinds of impacts.

And especially in the case of complex food webs, they may even lead to an increase in the number of secondary pest, because we are removing the top predators in that area. Then in the case of biological control, it is reduction of pest by biological introduction of predators parasites or diseases by genetic manipulation of crop or pest by sterilizing pest or by meeting destruction by the use of pheromones or sex attractants. So, in this case, if you are going for a predator approach in the case of biological control, you start by selecting a pest that is causing a heavy damage give a preference to the invasive alien species.

Find this specialized predator or parasite or pathogen, that is harming the pest in its home country and when you introduce the agent into your own country and then you monitor and if it is successful the pest population will go to a level, where there will be no

significant economic damage anymore. Then we looked at the prickly pear infestation case study, where the prickly pear was an introduced species, but then it became an invasive species and it spread to large areas and then as early as the 9, the 1920 people started thinking about biological control, went to the Americas got the predators in this case, the predator was a moth and then brought those moths into Australia, which led to a rapid decline in the population.

So, earlier the areas that were completely infested with prickly pears, now those areas were freed of the prickly pears. Now, rather these updating resistance in your crop genetic engineering immunocontraception pheromones and integrated pest management. Now, if you want to eradicate your pest completely you need these 6 factors, you require to have sufficient amount of resources both time money and I mean time money and manpower.

Is there has to be a clean line of authority for decision making, the target species should be easy to find and kill there should be effective means to prevent reintroduction easy detection of the species, when it is scarce and plants for restoration management, if the species becomes dominant. And in this case we have been able to eradicate a few islands on a few areas from say rodents because we were able to bring in all these concepts.

Then we looked at this story of the foolish crane and the mongoose. So, the crane wants to get rid of a snake through biological control and it brings in a mongoose and the mongoose is able to kill the cranes. So, whenever we are doing any biological control, we need to ensure that the controlling agent that we are bringing into our system does not harm our native vegetation or other crops.

We saw this interesting example where the Indian mongoose itself is becoming a pest in areas, where it was introduced as a biological control, which brought us to integrated pest management, which says that biological controls, cultural controls, mechanical controls, genetic controls, sterile male ,techniques pesticides everything has to be integrated in the pest management system.

So, that we are able to get the maximum yield with the minimum cost and minimum environmental impacts. Lastly, we had a look at ecotoxicology and pollution management with the restoration ecology. So, ecotoxicology is the study of the effects of toxic chemicals on biological organisms at the levels of population, community,

ecosystem and biosphere. And some common toxic elements, they are toxic chemicals, that are considered are pesticides, their residues heavy metals, plasticizers, volatil organic compounds like, formaldehyde and mycotoxins, which are the fungus derived toxins like, aflatoxin. Toxins have different toxicity levels, they have different lethal doses and the impacts can be lethal sublethal genetic, teratogenic developmental or an impact on reduce fecundity or there can be addition to the existing stressors.

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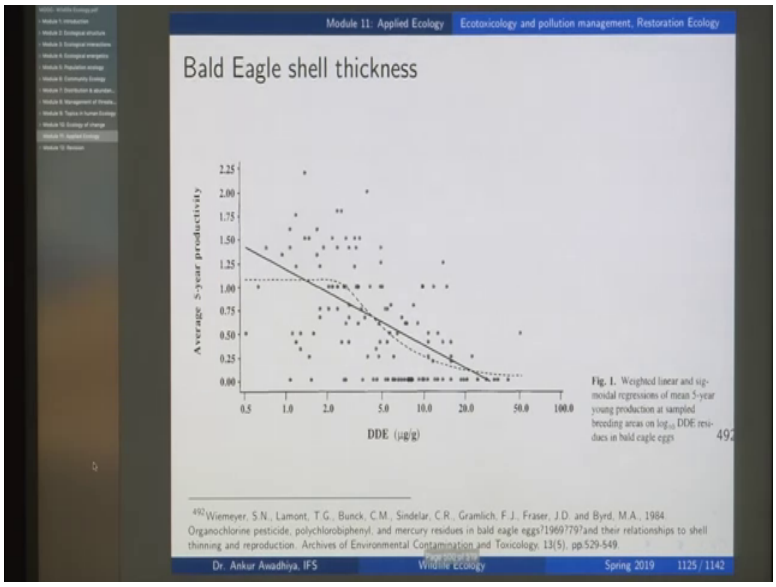

Then we looked at this bald eagle shell thickness problem, no because of the presence of DDT, because of the spraying of the DDT it reached to the top level in the food web and so, it reach to the bald eagles disrupted the calcium metabolism in their bodies and lead to the creation of shells that were extremely thin and broke before the chicks got a chance to come out. So, because of that the productivity of the bald eagle declined considerably, but then once you brought up DDT banned it came back to the normal levels, because the population was resilient enough.

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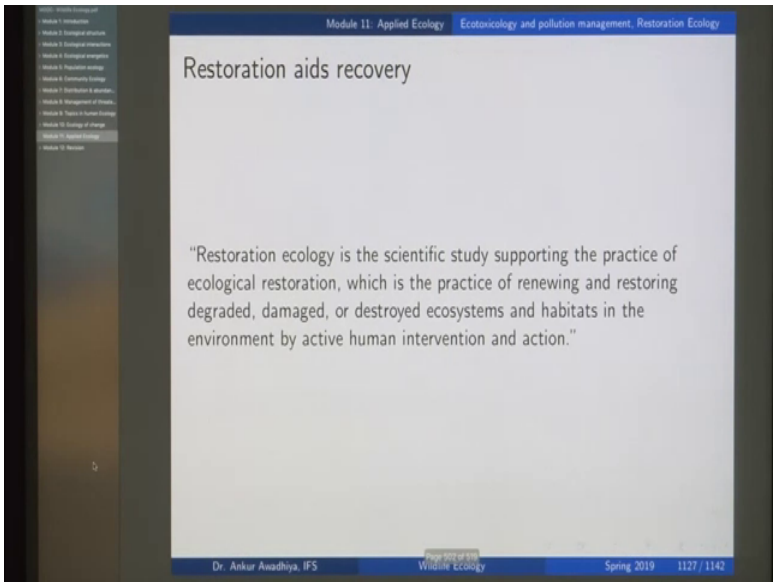

So, a number of communities a number of populations resilient and if we want to help in that recovery, we can bring in restoration. So, restoration is there to aid the recovery and restoration ecology is the scientific study supporting the practice of ecological restoration, which is the practice of renewing and restoring degraded, damaged or destroyed ecosystems and habitats in the environment by active human intervention and action.

So, there are 4 principles you need to maintain, ecological integrity it has to be an informed choice informed by the past and future, it has to benefit an engage with the society, especially the local community and it has to maintain long term sustainability. So, if all these 4 things are met, then we say that it is a good example of an ecological restoration. Then we looked at certain degrading and restoration actions and whenever, we are talking about restoration of natural communities it is the function of the local constraints and it is the function of the regional constraints especially the connectivity.

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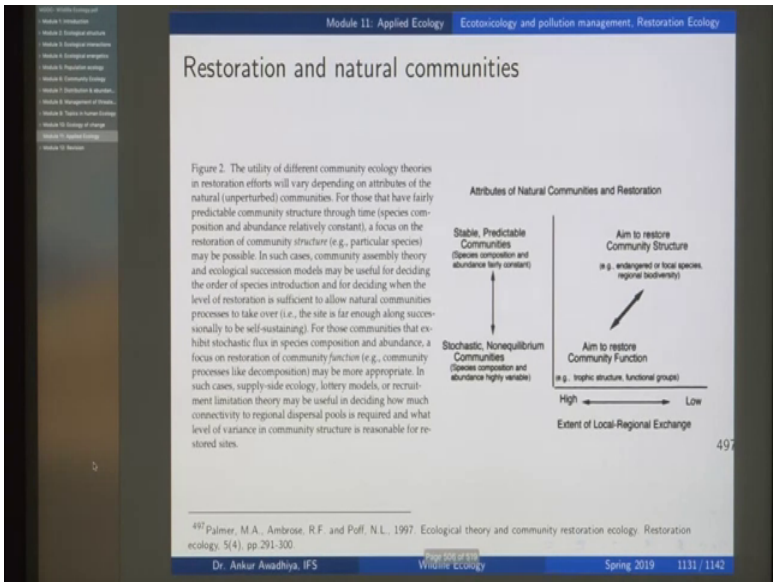

And then we saw, that if there are communities that are not yet it equilibrium and they are very highly connected to the surroundings. So, in that case, if we aim to restore community function, that will be good enough, because the organisms will be able to move from the surroundings and maintain the structure of the community by themselves. But if you are talking about climates communities and they do not have good amount of exchange with your locality in that case we will have to aim to restore the community structure itself.

Because in that case, you will have to bring in all the organisms that will be a part of the community structure, because they will not be able to come by themselves, because there is less amount of exchange that is possible in the regions. Then we looked at examples of mine restoration. So, the causes of degradation here are deforestation soil erosion, water pollution and a heavy metal release and the images of restoration includes flattening of the waste dumps and landfills to prevent erosion.

You fill up the dug pits, you cover it with a layer of clay to prevent access to rain and oxygen, then cover it with a layer of topsoil and then grow plants, there and in the case of the tailings dams you go for evaporation of those tailing dams so, that the heavy metal to get concentrated and then they can be removed from the area.

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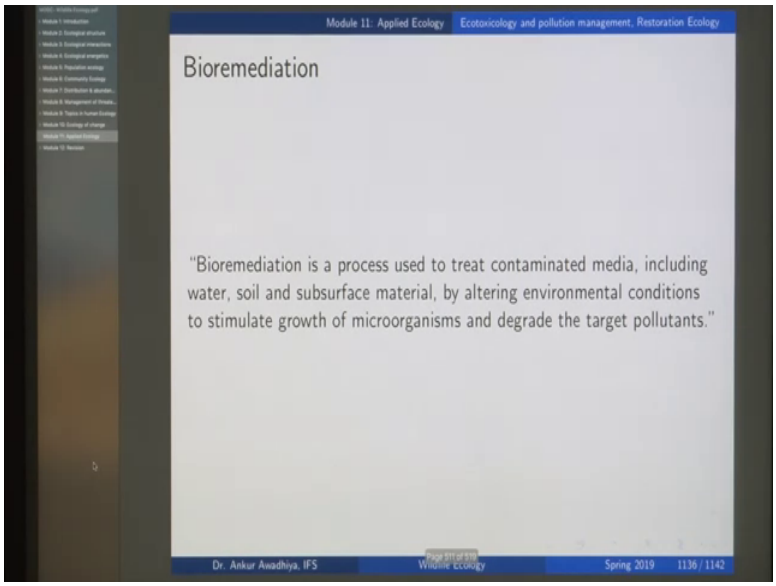

Similarly in the case of riparian zone, you also have the restoration measures. Next we looked at bioremediation, which is the process that is used to treat contaminated media including water soil and subsurface material by altering the environmental conditions to stimulate the growth of microorganisms and degrade the target pollutants.

So, in this case, you are trying to increase the number of microorganisms and those microorganism field can act on the contaminants and degrade them to a level that it is no longer toxic. And we could even go for phytoremediation as in the case of this plant there is fragmentise. So, you make your sewage water go through a sedimentation tank whatever remains it is passed with the root zones, where redox reactions occur there is a huge quantity of microbes that are available.

And they are able to treat the waste, they are able to reduce the biological oxygen demand, they are able to reduce the total suspended solids that are there in the water. But then whenever we are talking about restoration, we have to be prudent it should not be taken to the extreme situations.

So, that is all we wanted to discuss in this particular course. So, I hope you enjoyed the course do well in the examinations, do well in life good luck and [FL].