Wildlife Ecology
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Lecture – 10
Food chains, Food webs and Trophic levels

[FL]. Today we begin a new module and that is Ecological Energetic.

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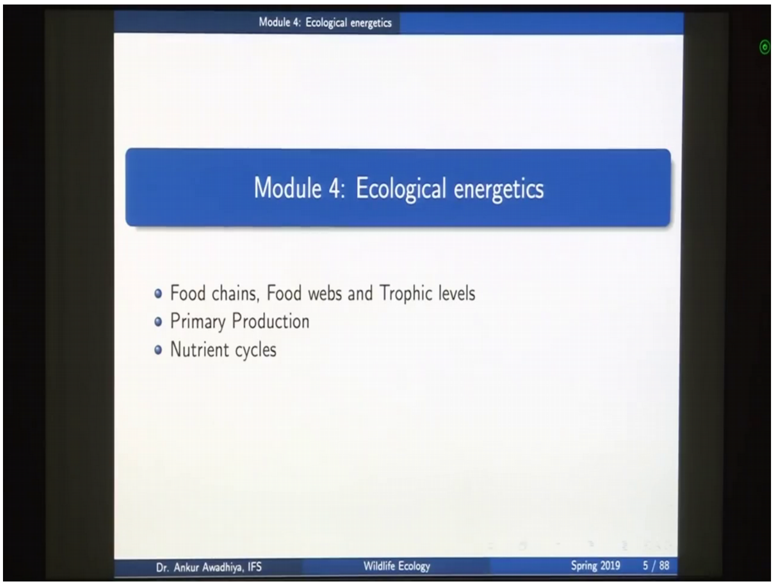

In this module we will have three lectures; Food chains, Food webs and Trophic levels followed by primary production and nutrient cycles.

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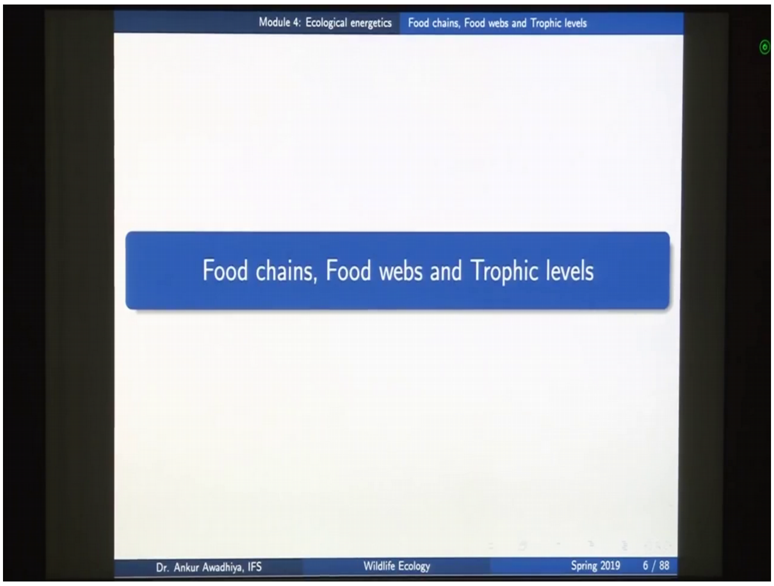

So, let us begin with the first lecture food chains food webs trophic levels.

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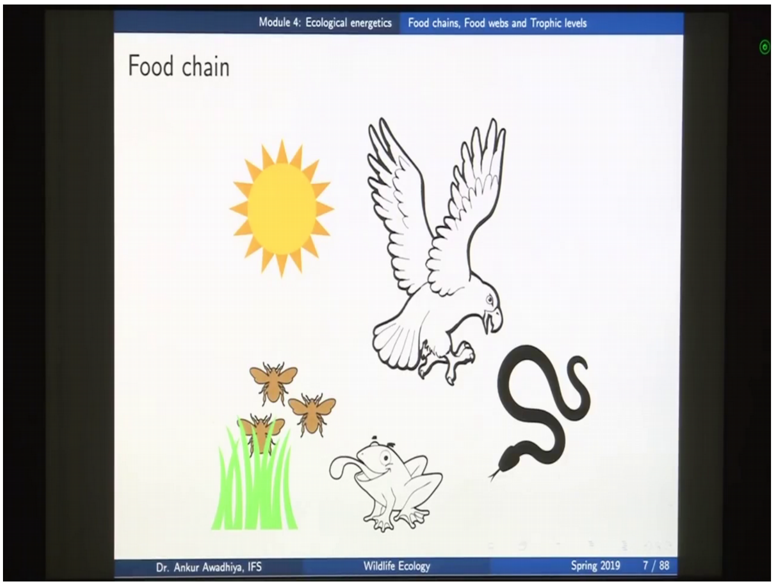

Now this is an image that we all must remember from our school days. So, it says that there is grass and grass is eaten by some insects and then there is a frog that eats these insects, then there is a snake that eats the frog and then there is the hawk or the eagle that eats the snake. And the plants are getting their energy from the sun and this is what essentially a food chain is. Now, in the case of equality we are going to study this food chain in greater detail and also understand what are the kinds of nuances that we observe in different food chains and food webs.

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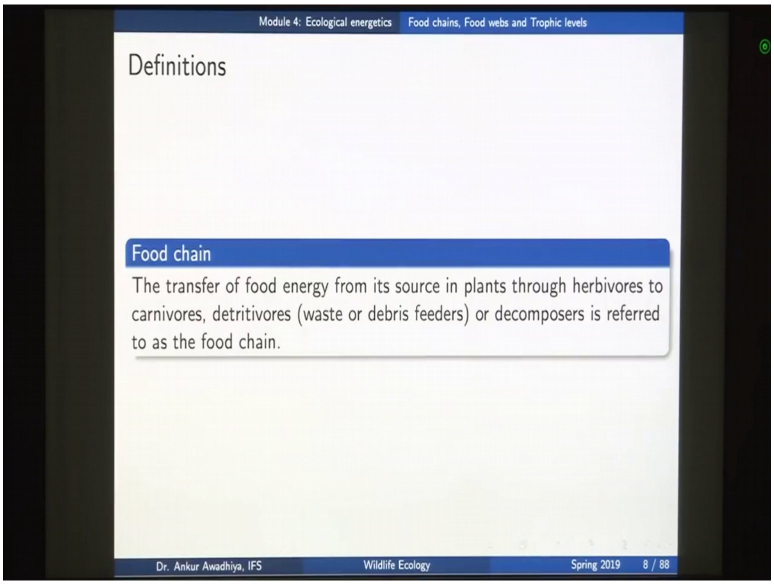

So, let us begin by defining what a food chain is. The transfer of food energy from its source in plants through herbivores to carnivores detritivores or decomposers is referred to as the food chain. So, detritivores or beasts or debris feeders and the food chain has primarily got to do with the transfer of food energy.

So, the sun is providing energy to the plants and that energy is getting stored in the form of carbohydrates and in the form of different organic molecules so that energy the from sunlight is getting converted into chemical energy. And this chemical energy is moving through different organisms in this community in the form of the food chain.

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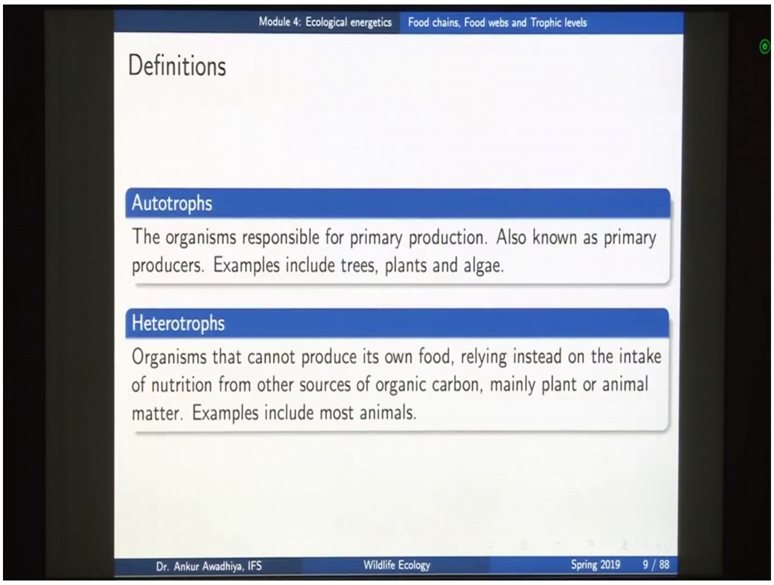

And we also have a number of other definitions that we will use later on. So, autotrophs are organisms responsible for primary production. Also known as primary producers and they include trees, plants and algae. Auto means self, troph means nutrition.

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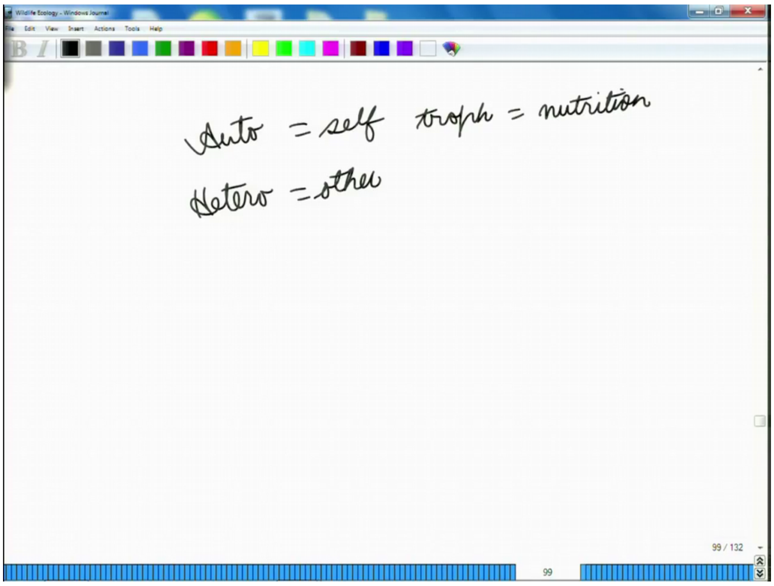

So, auto is self troph is nutrition. So, these are plants that are making nutrition by themselves. On the other hand, hetero is other, so heterotroph is an organism that is using some other organism for its nutrition. So, autotrophs include trees plants and algae and also a number of bacteria that get their energy from chemicals which are known as (Refer Time: 02:45).

Heterotrophs are organisms that cannot produce their own food. So they are organisms like us, they rely instead on the intake of nutrition from other sources of organic carbon mainly plant or animal matter and example includes most animals such as us.

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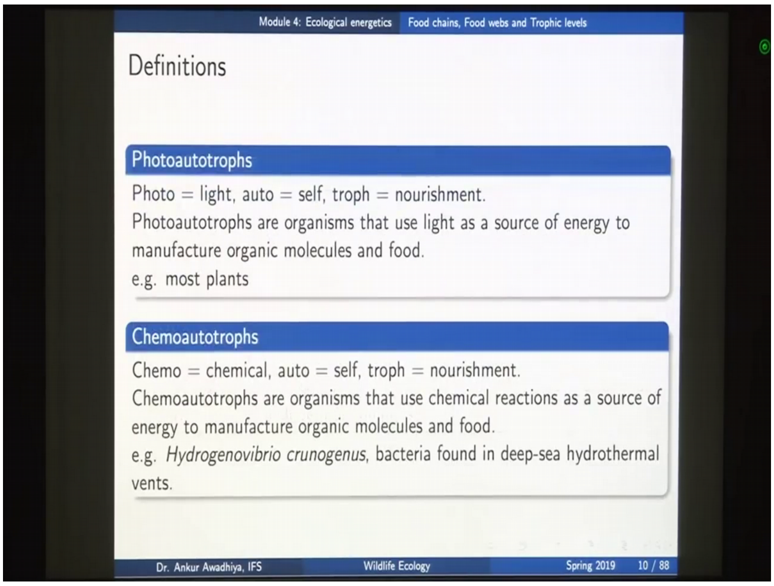

Now autotrophs are divided into photoautotrophs and chemoautotrophs. Photo is light; so photoautotrophs is light self-nourishment or light self-nutrition. So, photoautotrophs are organisms that use light as a source of energy to manufacture organic molecules and food; example most plants. And chemoautotrophs chemo is chemical; so, chemoautotrophs are organisms that use chemical reactions as a source of energy to manufacture organic molecules and food.

So, an example is this bacterium, hydrogenovibrio crunogenus, which is found in deep sea hydrothermal vents. So, hydro is water thermal is heat. So, you have heated water vents that are found inside deep seas, they are both way of a volcanic origin and you have this bacteria that you that utilize this chemical energy to make their own food.

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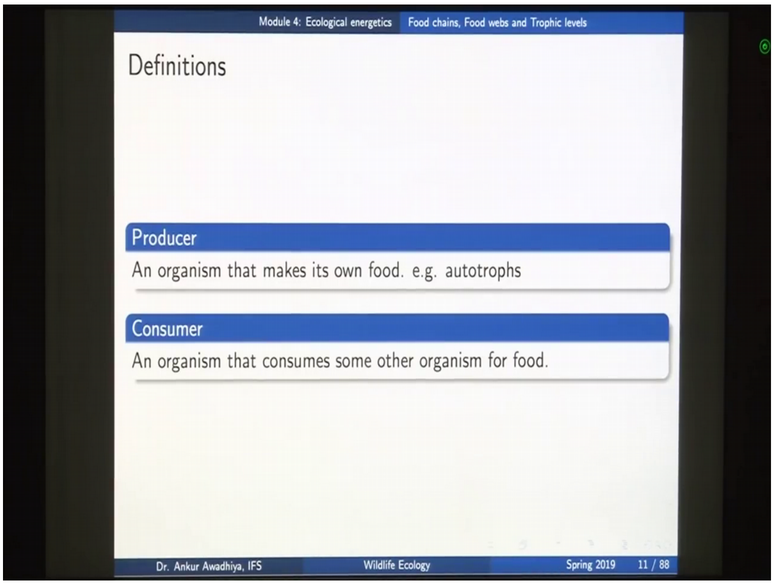

Then when we talk about food chains we can divide all the organisms into producers and consumers. So, producer is an organism that makes its own food which is the autotrophs; including both the photoautotrophs and the chemoautotrophs. Consumer is an organism that consumes some other organism for food; some other organism or some other part of that organism.

Now, the consumers which are using some other organisms or parts of the some other organisms as food are further divided into primary, secondary, tertiary and quaternary consumers.

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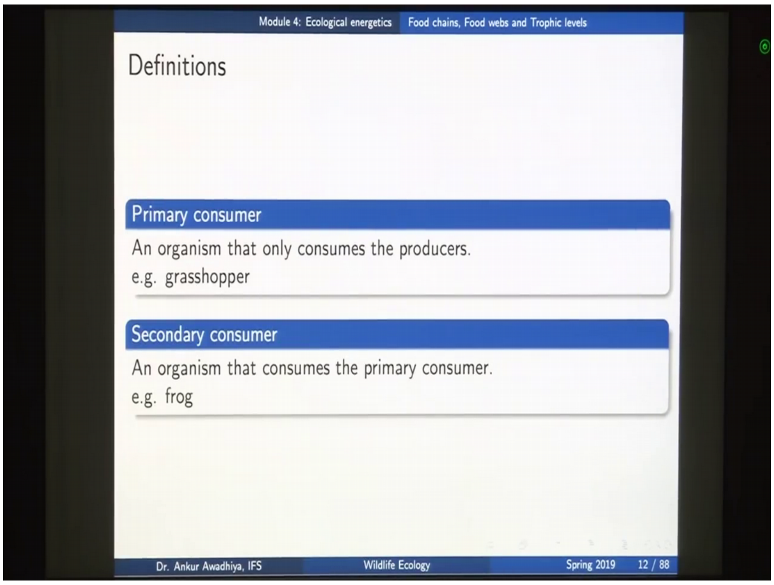

Now, primary consumer is an organism that consumes the producers. That is the this is an organism that consumes the plant matter or the autotrophs. So, example is a grasshopper or another example could be the cow or all the herbivorous animals: cheetahs, sambar, elephant. And most of these organisms are very important, prey species in the ecosystem.

Now these species are eaten up by their consumers, their predators which go by the name of secondary consumers. So, primary consumer is something that is a herbivore and secondary consumer is a carnivore. It could also be an omnivore which is also feeding on the plants, but primarily it is a carnivore. So, it is an organism that consumes the primary consumer. So, that is the frog; so we have the producer.

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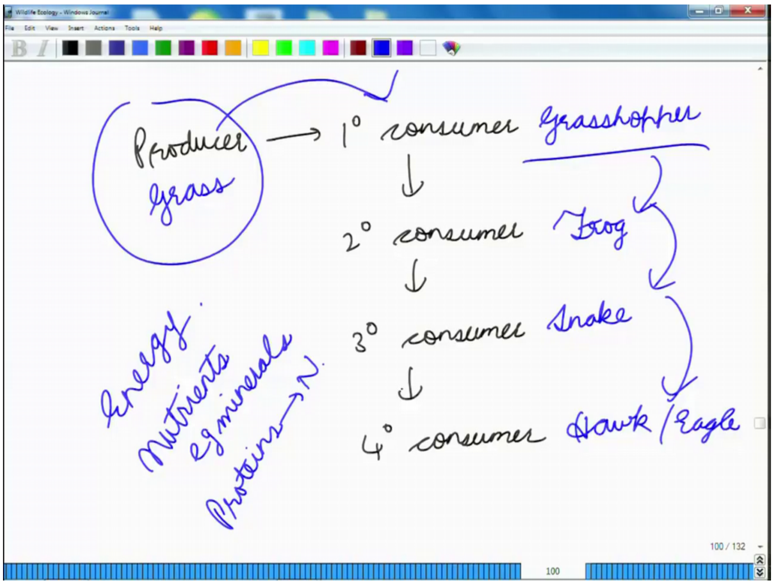

So, you have the producer, that is eaten up by the primary consumer, which is then eaten up by the secondary consumer, which is then eaten up by the tertiary consumer, which is then eaten up by the quaternary consumer and so on. So, tertiary consumer is somebody who eats a secondary consumer.

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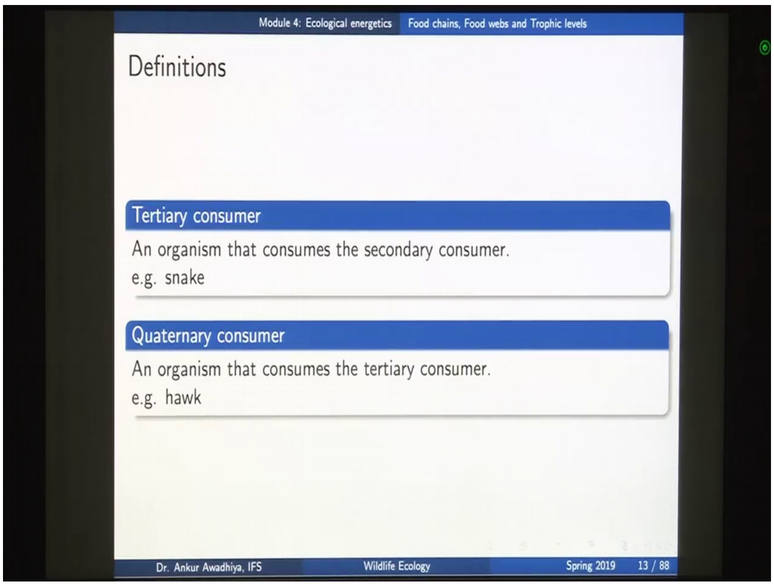

And an organism that consumes the secondary consumer example is a snake. So And quaternary consumer is an organism that consumes the tertiary consumer such as the hawk.

So, in this particular example we are seeing that you have producing in the form of grass, and the primary consumer is a grasshopper, the secondary consumer is a frog, the tertiary consumer is a snake and the quaternary consumer is a hawk; a hawk or maybe an eagle.

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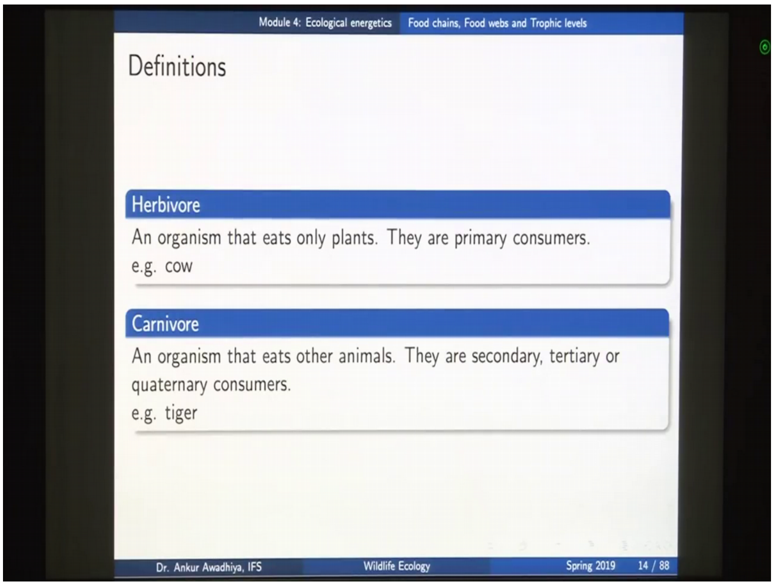

Now, these consumers can be classic can also be classified as herbivores, carnivores, omnivores, detritivores and so on. So, just going through the terms herbivore is an organism that eats only plants, their primary consumers example is a cow. Carnivore is an organism that eats other animals and they can be secondary tertiary or quaternary consumers. So they can be anywhere, but they cannot be the primary consumer and they cannot be the producer. So, an example is the tiger.

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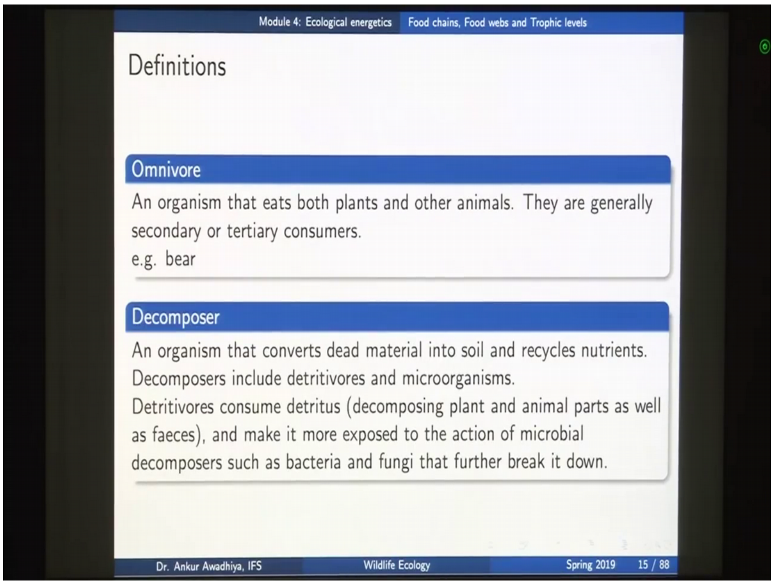

Omnivore is an organism that eats both plants and animals and they are generally second secondary or tertiary consumers example is the bear. So, the bear can eat some insects, it can also eat some amount of flesh, but it also feeds on fruits it also feeds on roots of plants and so on; so, it is an omnivorous.

And, next is a decomposer; a decomposer is an organism that converts dead material into soil and recycles the nutrients. So, when we are talking about any food chain so in this food chain not only is energy getting passed, but also other nutrients such as minerals. So, for instance when we talk about proteins, so proteins have nitrogen in them. So, the plant proteins have nitrogen, from there the nitrogen has moved into the grasshopper, from there to the frog, from there to the snake, from there to the hawk and eagle. But then, if all the nutrients all the inorganic materials and the nutrients if they get locked up in all the organisms, in that case the plants will not be able to get the nutrients.

So, here in comes the role of the decomposers. So, the decomposers break up the bodies of all of these and also of the plants when they have when they are dead and then they release all of these nutrients back into the soil. So, decomposer is an organism that converts dead material into soil and recycles nutrient. Decomposers include detritivores and microorganisms.

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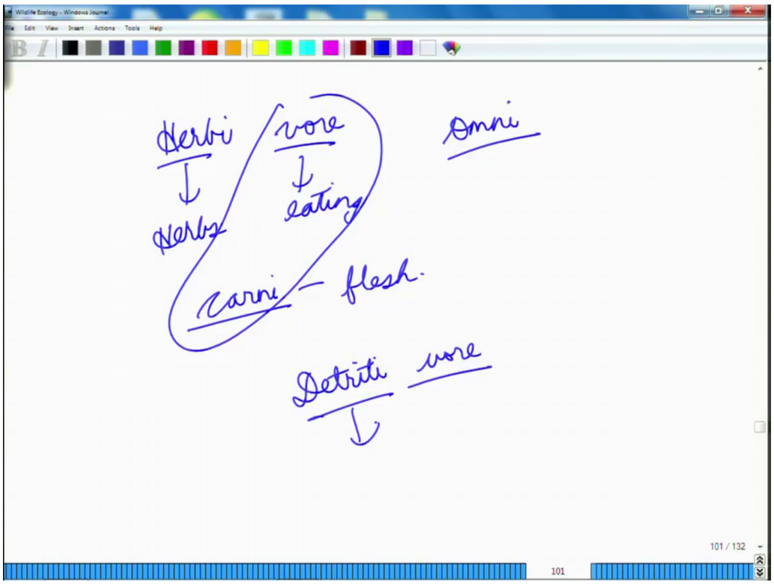

Now detritivore; so when we say herbivore. So herbi vore: vore is eating and herbi is herbs. So, this is an organism that eats herbs or that eats the plants. Carni; carni means flesh. Now this is the same a (Refer Time: 09:05) that is also seen carnival which is a festival of the flesh; that is how the word root goes. So, carnivore is an organism that eats up carni or that eats of the flesh; so, that is a carnivore.

Omni; Omni means both or Omni means all. So, omnivore is something that eats up everything. So, it eats up plants, it also eats up the flesh. When we say detriti vores: so here you have something that eats up the detritus. Now what is a detritus? The detritivores consume detritus which is decomposing plants and animal parts as well as faeces. So, any dead part any decomposing part ah; so the organisms that eat up those are known as in detritivores. And once they eat these up they make it more and more exposed to the action of microbial decomposers such as bacteria and fungi that further break it down. So, a good example of detritivores an earthworm.

So, if you have dead leaves that are there in the soil, the earthworm will eat up those dead leaves. And then it will take out some amount of nutrients from there, but in this process it will also convert those dead leaves into its own fecal matter. And by breaking off the larger tissues into smaller chunks it makes it more and more exposed to the action of the microorganisms, such as bacteria and fungi. Which further break it down to release all the nutrients into the soil. So, that is the rule of the detritivores.

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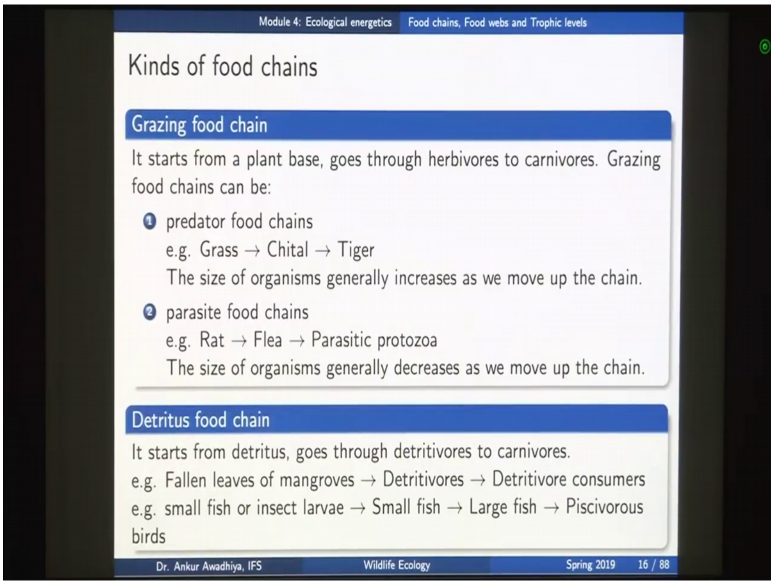

Now, when you talk about food chains there are two kinds of food chains; one is the grazing food chain and the second one is the detritus food chain. Now grazing food chain starts from the plant base. So, it starts from grazing the plant base.

So, grazing food chain starts from a plant base goes through herbivores to carnivores. And grazing food chains are then further subdivided into predator food chains and parasitic food chains. Now on the other hand a detritus food chain starts from the detritus or the dead end decaying matter and then it goes through detritivores to carnivores.

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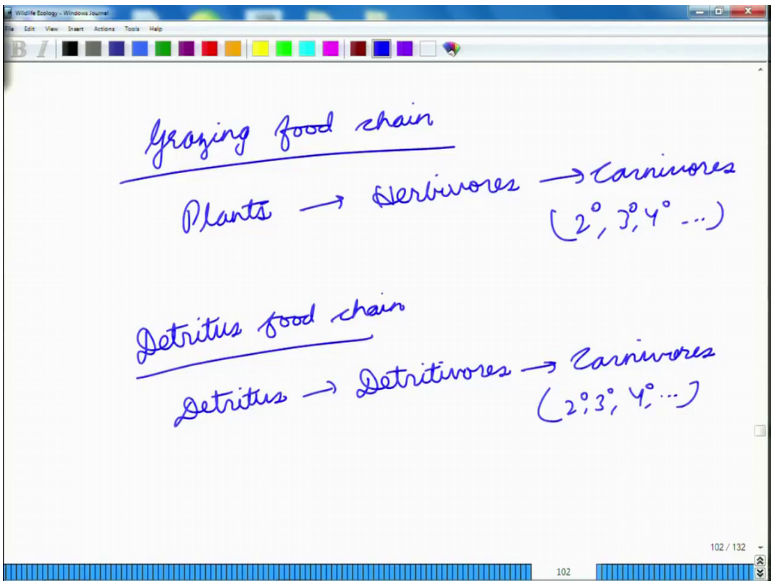

So, essentially in the case of the grazing food chain; so when you have the grazing food chain you have plants followed by herbivores followed by carnivores. And then these carnivores can be; so they can be secondary, tertiary, quaternary and so on.

In the case of detritus food chain you have detritus followed by detritivores and then these are followed by the carnivores. Which can again be secondary tertiary quaternary and so on. Now we will look at some examples.

So, when we see the grazing food chain you have two examples one is the a or two sub types; one is the predator food chains. So, predator food chain a good example is grass that is eaten up by chital and that is eaten up by tiger. All the one that we saw before you have grass that is eaten up by the grasshopper, that is eaten up by the frog, that is eaten up by the snake, and which is eaten up by the hawk. Now when we observe a predator food chain the size of the organisms generally increases as we move up the chain. So, grass is very small, chital is a bit larger its close to around 60-70-80 kg animal and then if you look at a tiger that is a very large animal say around 300 or 400 kgs weight.

So, the size of the organisms increases as we move up the chain. On the other hand when we look at the parasitic food chains, so a parasitic food chain an example is rat flea followed by a parasitic protozoa. So, again in this case the rat will be it will be preceded by the grass or say grains. But, in this case this portion which is the parasitic food chain, so from a grass to rat will be a predator part of the food chain, but this part is a completely parasitic food chain; rat to flea to parasitic protozoa. Now in this case the size of the organisms generally decreases as we move up the chain. So, a flea is very much smaller than a rat and the parasitic protozoa are microorganisms that are living on the flea. So, here the size goes down as we move up.

Now in the case of a detritus food chain you have detritus followed by detritivores followed by carnivores. So, an example is you can have the fallen leaves of mangroves. So, mangroves are plants that grow in the vicinity of this of the sea shores or ocean shores, and when the leaves of these plants when they when they die and when they fall down so they get into the water, and there they are they are consumed by the detritivores.

Now these detritivores are then eaten up by the detritivore consumers. For example, small fish or insect larvae; so, here we had some detritivores some very small organisms that are eating these up and then these organisms are further eaten up by the insect larvae. And from there they get eaten up by small fishes then large fishes, and then piscivorous; pisci is fish vore is eating. So, this is fish eating birds. So, then they are eaten up by the fish-eating birds, so this is a detritus food chain.

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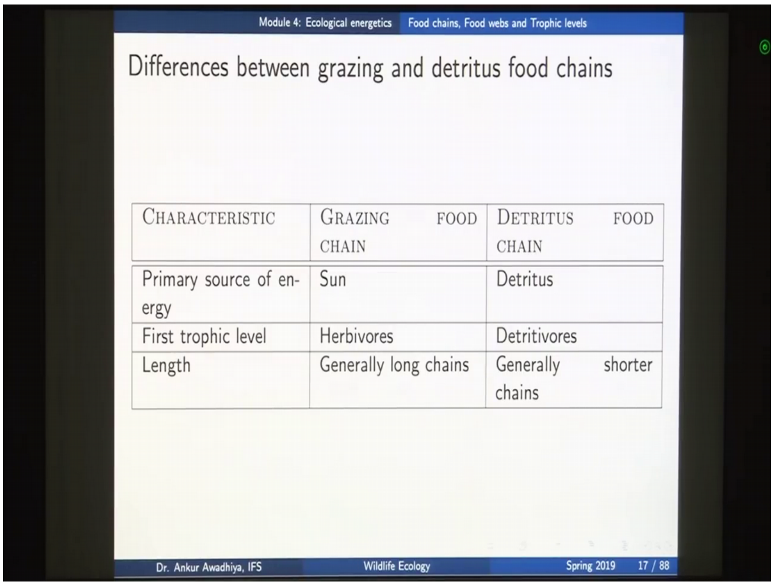

Now, if you look at the differences between both of these food chains we observe that: a in the case of a grazing food chain the primary source of energy is the sun, which is then used up by the plants. In the case of the detritus food chain the primary source of energy is detritus. So, it starts with the detritus or a dead tissue or a dead organism. Then the first trophic level in the case of grazing food chain is herbivores, because they are eating up the plants. In the case of detritus food chain they are ditritivores.

Now the length of grazing food chain is generally longer, and the length of a detritus protein is generally shorter. Now what do we mean by that?

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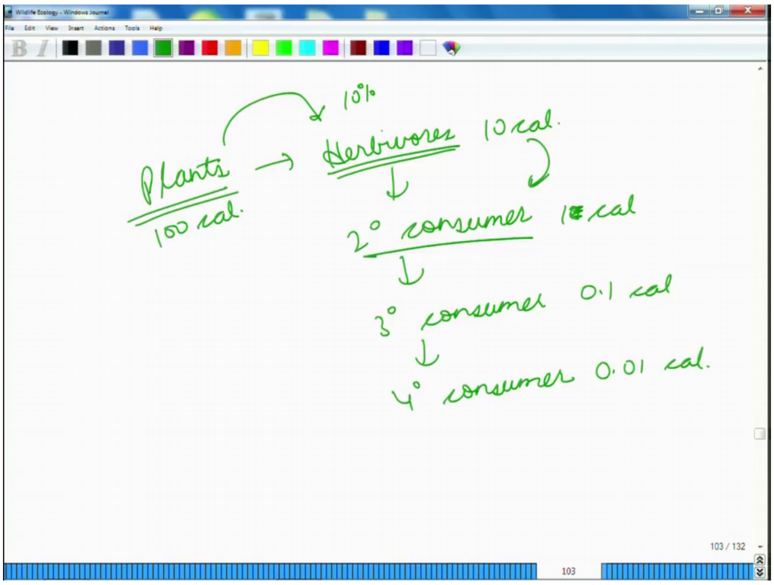

So if you have say plants, then they are eaten up by herbivores, then they are eaten up by the secondary consumer, then they are eaten up by the tertiary consumer, then the quaternary consumer and so on. At each of these stages: so from plants to herbivores plants a suppose they have say 100 calories of energy that is stored in their body tissues, when the herbivores have eaten those they will spend quite a lot of energy to warm up their bodies to ensure that the blood circulation goes on for the movement of their bodies. And so, only about 10 percent of that energy will get stored in the bodies of the herbivores. So, here you only have 10 calories, from here to the next level again it will be 10 percent. So this will have only 1 calorie and then this will have 0.1 calorie and so on 0.01 calorie.

So, the more up you go into the food chain then the lesser is the amount of energy that is available. Now in the case of a grazing food chain, because it starts with the sun, so you have ample amount of energy that is available in the grazing food chain and so it can support longer chains. Whereas, in the case of detritus food chain because the starting material itself is very small it does not have a huge amount of energy. So, it cannot support a very long chain of organisms. So, a detritus food chain is generally shorter in length.

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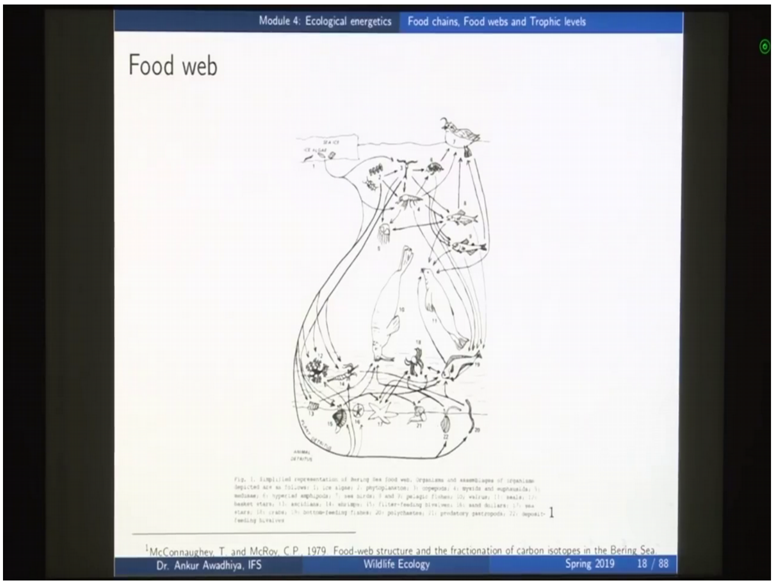

Now that is about the food chains, but then if we look around in the nature we will observe that not a chain is present, but multiple chains that are present and all of these multiple chains make up a food web.

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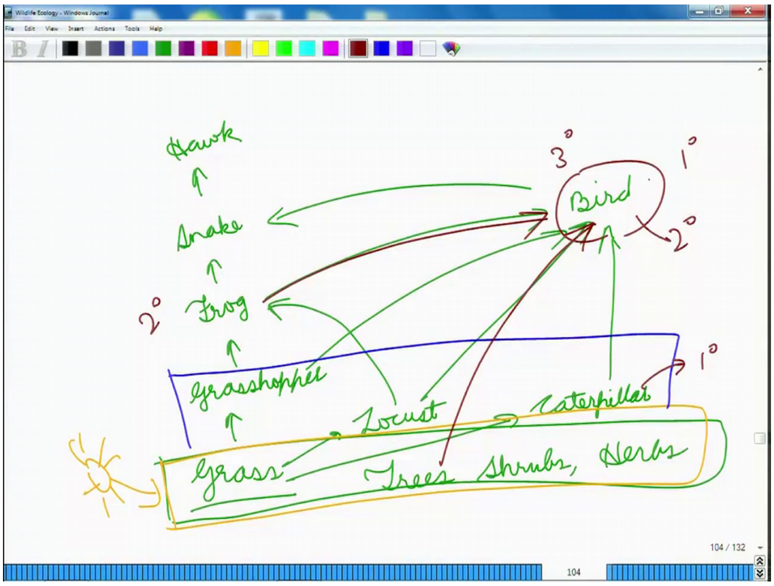

So, for instance when we were talking about our simplest food chain in which we had grass and then this grass was eaten up by the grasshopper, then this was eaten up by a frog, then a snake and then a hawk. But then grass is also eaten up by say a locust and grass is also eaten up by say some other caterpillars. Then a frog will also be eating up a locust and maybe there would be some birds that would directly be eating up a caterpillar or they would also be eating up a locust. And then, you could also have a bird that eats up a grasshopper directly. And then, you can have a snake that maybe feeds on bird eggs or you can have a situation in which there is a frog that is also eaten up by a bird.

So, when we look at these combinations this becomes more and more complex. So, a combination of different food chains that works together goes by the name of a food web.

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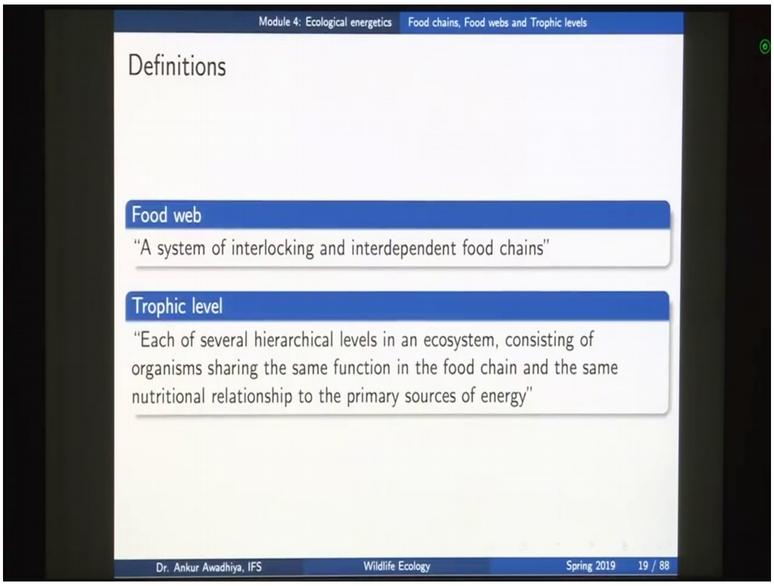

So, we define a food web as a system of interlocking and interdependent food chains. So, all of these different food chains they are linked together, they are interlinking and they are a interlocking and they are interdependent on each other.

Then we also define a trophic level. A trophic level is each of several hierarchical levels in an ecosystem consisting of organisms sharing the same function in the food chain and the same nutritional relationship to the primary source of energy. So, when we look at this food web, so here you have grass you may also have some trees, you may also have some shrubs, you can also have some herbs and so on.

And all of these if you look at this definition, all of these organisms share the same function in the food chain that is all of them are producers, and the same nutritional relationship to the primary sources of energy. So, all of these are using the energy of the sun. So, all of these are using the energy of the sun and then they are passing it on to the a primary consumers or the herbivores.

So, all of these together will form a trophic level. Similarly all of these together the grasshopper the locust, the caterpillars that are eating or that are feeding on these on these organisms the grass trees shrubs herbs and so on they will form another trophic level. So, when we look at a food web we can define different trophic levels, we can define organisms that are producers, that are primary consumers secondary consumers, tertiary consumers and so on. Although, it looks much more simpler in theory than it looks in practice.

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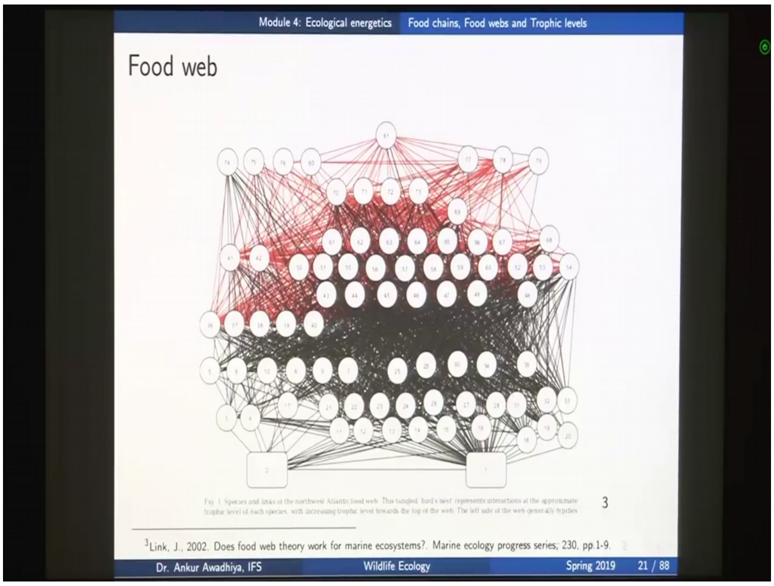

So, for instance this is a food web that is found in the Atlantic Ocean. And as we can observe here there are so many interrelationships, so many who its who relationship here that it becomes a bit difficult. But then, it is also possible that one organism may a be a part of several different trophic levels.

So, for instance here we have a situation in which you have a bird that is eating up caterpillars. So, when this bird is eating up caterpillars; so you have caterpillar as the primary consumer, so the bird becomes a secondary consumer. But then if this bird eats up a frog, so, in this case the frog is a secondary consumer; so, here the bird will also become a tertiary consumer work or if this bird eats up say some fruits from the trees, so it will also become a primary consumer.

So, essentially any organism in a food web may occupy more than one of those trophic levels. So now, we can understand the level of complexity that is involved here. You have so many relationships and every organism or many organisms can occupy different trophic levels at the same time. So, to reduce this complexity we make use of some tools.

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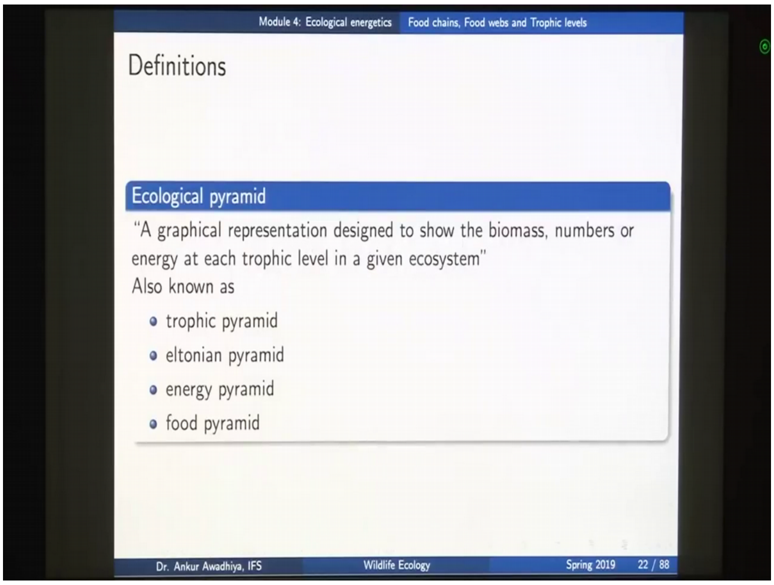

And one such tool goes by the name of an ecological pyramid. Now, an ecological pyramid is a graphical representation designed to show the biomass, numbers or energy at each trophic level in a given ecosystem. It is a graphical representation that is designed to show biomass. Biomass is the total amount of mass that is formed out of the biological entities that are present at in at each trophic level or the number of organisms that are there at each trophic level or the energy that is there in each trophic level.

And these ecological pyramids also go by the name of trophic pyramid, eltonian pyramid, energy pyramid, food pyramid and so on. Now we will look at some different kinds of pyramids.

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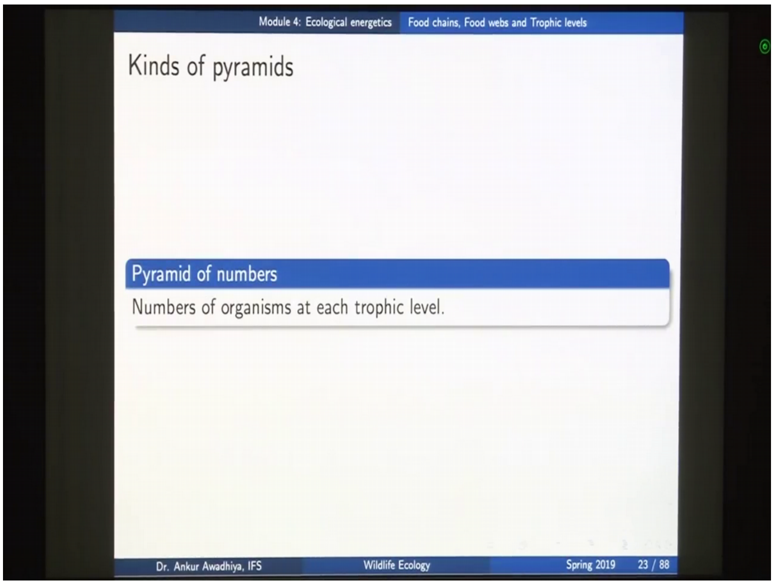

So, the first pyramid is the pyramid of numbers. So, pyramid of numbers shows you the number of organisms that are present at each trophic level. So, what do we mean by that?

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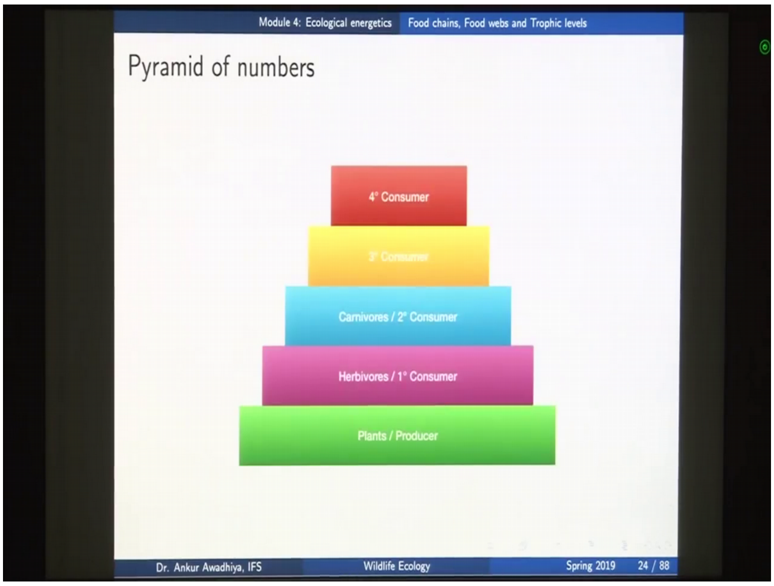

So, this is one pyramid of numbers. So, in the case of the first trophic level which is the plants or the producers will go into the field and will count how many plants are there; how many individual grasses are there. And when we total up all of them all the trees, all the herbs, all the shrubs, all the grasses that are there together will come up with a number. And this number will be depicted by this particular portion of the pyramid.

So, the area of this pyramid or the area of this particular block is proportional to the number of entities that we have at this trophic level. And all of these different slabs are showing different profit levels. So, this is the trophic level of the producers, this is the trophic level of the primary consumer, this is the trophic level of secondary consumer, this is for the tertiary consumer, this is for the quaternary consumer and so on. So, this pyramid will show us the number of individuals that we have at each trophic level.

So for instance, if there is an ecosystem in which you have tigers and you have leopards and both of these are apex predators or both of these are quaternary consumers. So, this particular block will tell you how many tigers are there plus how many leopards are there, you put both the numbers together and you reach to this level.

Now generally it is observed that the number of individuals will go down as we move up the trophic level. Because, for instance in a tiger reserve like the (Refer Time: 24:50) tiger reserve you will have say around 30-40 tigers. So, that will form this upper block. So, you will have say 40 tigers, but then if you look at the number of their prey species. So, if you look at the number of chital or the number of sambars they might go up into several hundreds or maybe even several thousands. So, as we move down the size would increase.

If you look at say the number of grasses that are there then that might even go up into millions. So, as we move up a pyramid the number decreases as you move down a pyramid the number increases. So, you have a larger size base and you have an out narrower top. Now this is something that is intuitively expected.

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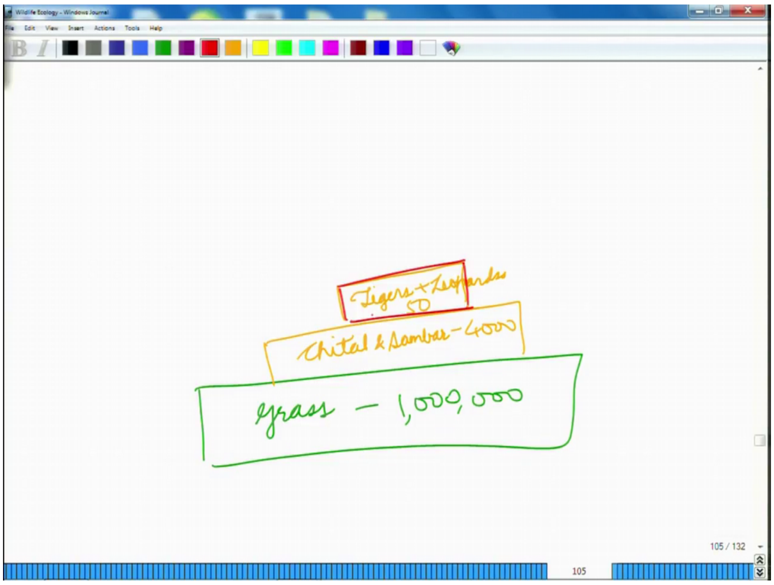

So, in this case you will have say grass and you have say 1 million individuals of grass. And then you have these 1 million individuals of grass are supporting say chital and sambar, and their number is say 4000. And then this number would be supporting say around tigers plus leopards say around 50 individuals.

So, we see that as we are moving up in the trophic levels, as we are moving up in the pyramid the number is going down. But then you can also have an inverted pyramid of numbers.

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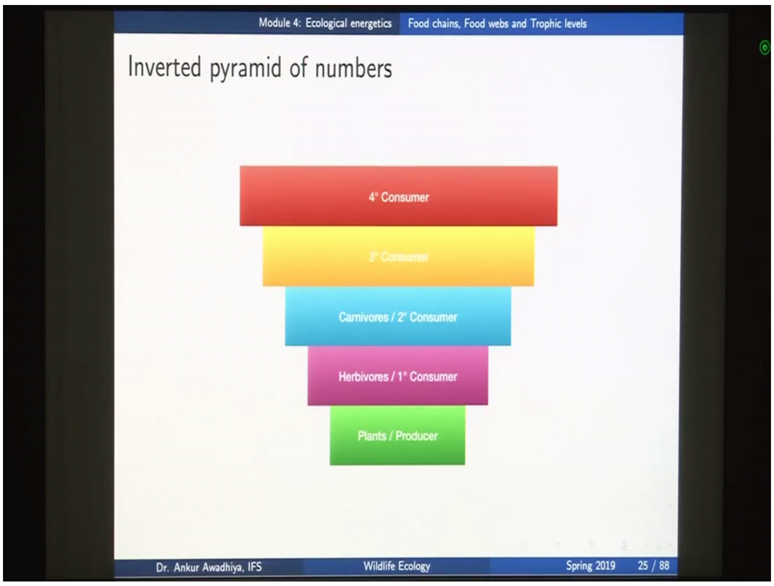

So, in an inverted pyramid of numbers you will have a situation in which the number of quaternary is much greater than that of the tertiary consumers, which is greater than the number of secondary consumers, which is greater than the number of primary consumers, which is greater than the number of the of the producers.

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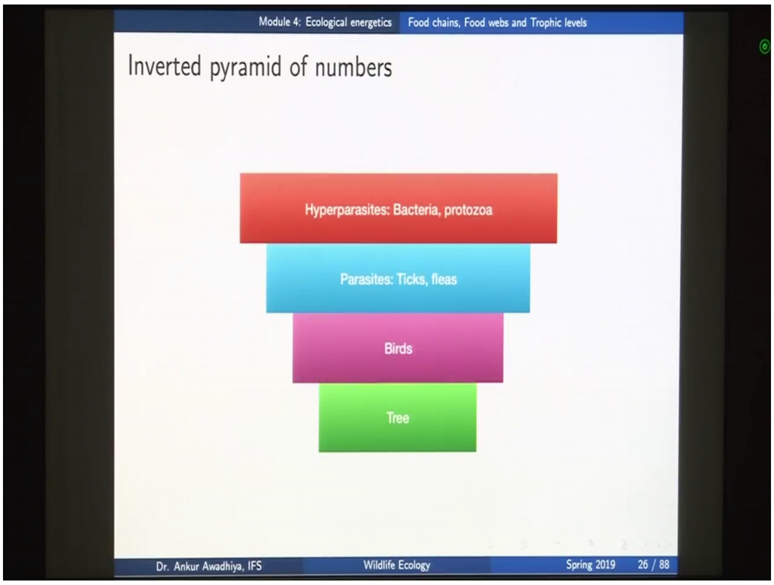

Now, one such example is given by the tree ecosystem. Now in the case of a tree a tree might be supporting some number of birds. Now because a tree is such a large organism so it might support a number of birds. So, let us say that there are 100 birds that are being supported by one tree; so here you have one and here you have 100. Now if we consider any parasites that live on the birds each bird would be supporting say around 50-60 parasites. And each of those parasites such as a flea would be supporting a number of hyper parasites say such as bacteria protozoa.

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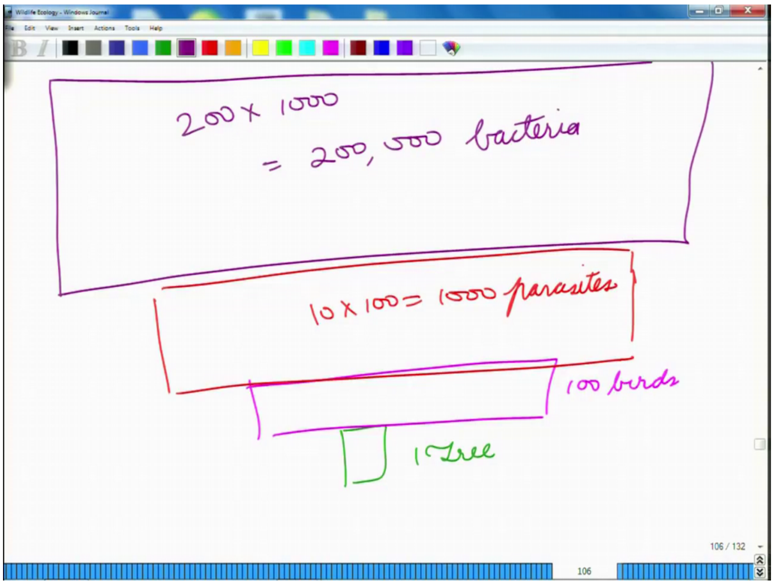

So, in this case what we are observing is that you have one tree that is supporting say 50 birds or let us say 100 birds. Now each of those birds is supporting say 10 parasites. So, if each of those supports 10 parasites, so this particular block would become 10 into 100 is fleas 1000 fleas or 1000 parasites.

Now if each of these parasites is supporting say 200 bacteria. So, in that case the number of bacteria that will come on the top here would be very large, because each parasite is supporting 200 bacteria and you have 1000 parasite. So, you have 200000 or 200000 bacteria. So, this is a pyramid of numbers that is inverted, because you have a smaller sized bottom and a larger sized top.

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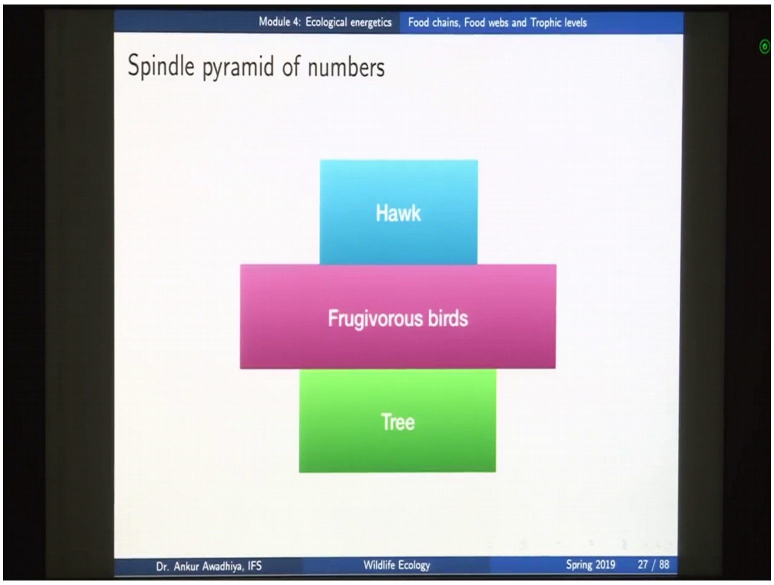

You can also have other shapes such as a spindle. Now in the case of a spindle you have a middle range that is larger and then that is followed by a smaller portion. So, for instance, in place of having these parasites, so, we remove the parasites and the hyper parasites that were there in our example and now you only have these birds that are supporting a population of hawks.

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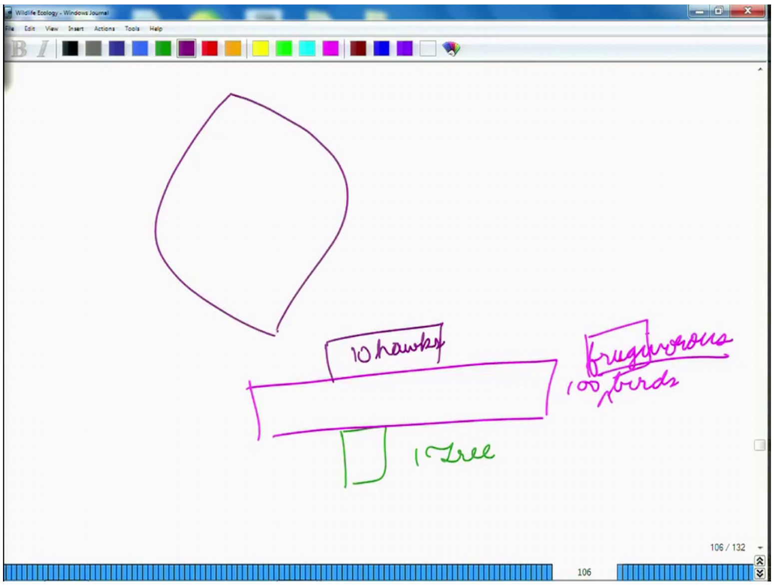

And these are say frugivorous birds. Now frugivorous means that these birds are living on fruits frugi is fruit; vore is eating and they are supporting say 10 hawks. So, here we have a pyramid of numbers that looks like a spindle which is this shape. Another such example could be from a one of the lakes or maybe from the seas.

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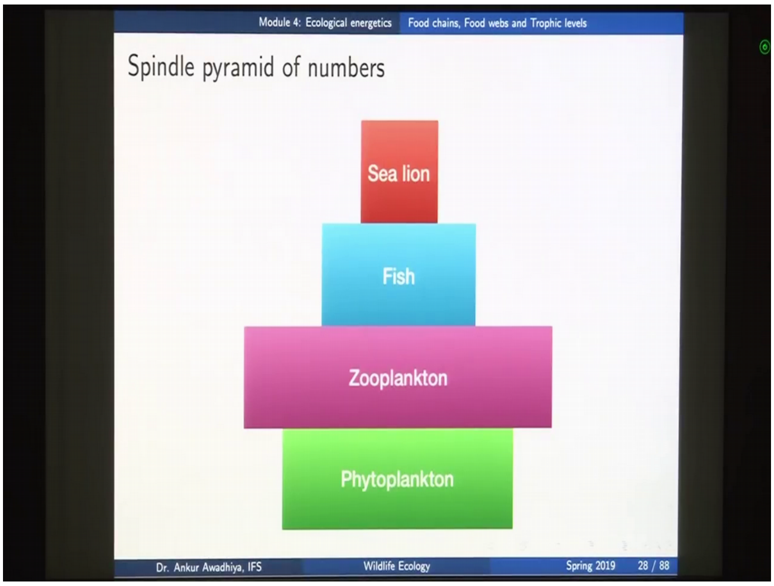

So, now in the oceans what we have is we have the phytoplanktons. Now a phytoplanktons are microscopic organisms that are able to sequester carbon. So, they perform photosynthesis and they act as the producers in this case. So now, these phytoplanktons support the zooplanktons. Now zooplanktons are again microscopic organisms and these are animals. So, these are microscopic animals that are feeding on the phytoplankton. So, these are microscopic plants and these are microscopic animals

Now it is possible that a in a certain situation where the rate of reproduction of the phytoplankton is very high. So, you have phytoplanktons that are able to multiply themselves very quickly. So, they multiply themselves and then they also get eaten by the zooplanktons. Now these zooplanktons are getting a sufficient source of food, because of the phytoplankton. So, you have a large number of zooplanktons, but you can have a situation in which the phytoplanktons are much lesser. Why much lesser? Because they are able to reproduce very fast; so, even though you have a very small number.

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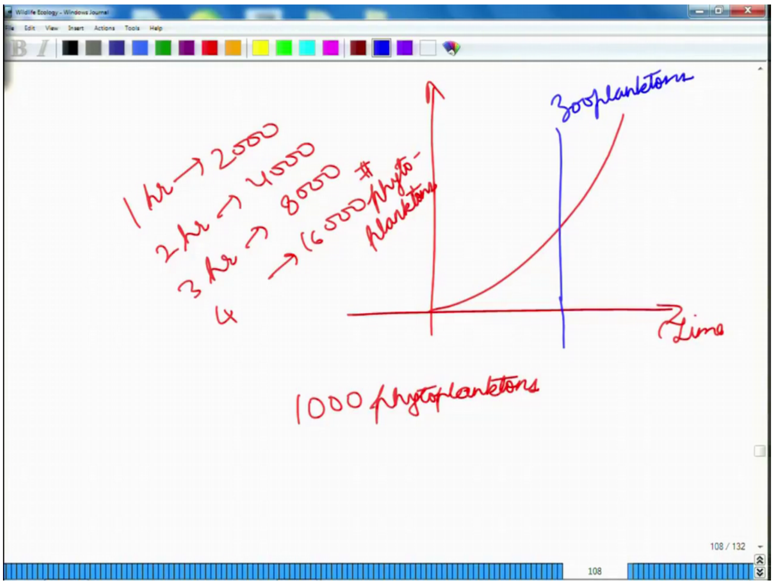

So, in this case suppose you have 1000 phytoplanktons and suppose they are able to duplicate themselves every hour. So, in that case in 1 hour from 1000 they will become 2000, if in 2 hours from 2000 they become 4000, in 3 hours from 4000 they become 8000, in 4 hours they become 16000 and so on.

Now if this is the rate of propagation, we will find a situation in which the population increases exponentially. So, here you have the number of phytoplanktons and this is the time. Now because nature is not able to support such a huge rate of growth; so, it is possible that at this level their population is being consumed by those zooplanktons. So, even though you have a lesser number of phytoplankton they are able to multiply themselves very fast and then they multiply themselves fast they become much more. When they become much more they are eaten up by the zooplanktons. In that case the number of phytoplanktons are again goes down and the number of zooplanktons increases.

So, when you look at a snapshot of this ecosystem we will find that you have less number of phytoplanktons more number of zooplankton. And then these zooplanktons have been eaten up by the fish. So, the number of fishes is less and then suppose these fishes are eaten up by a sea lion then that gives the number of sea lion is also less. So, here again we are observing a pyramid of numbers that is looking of this shape, so, this is the shape of a spindle.

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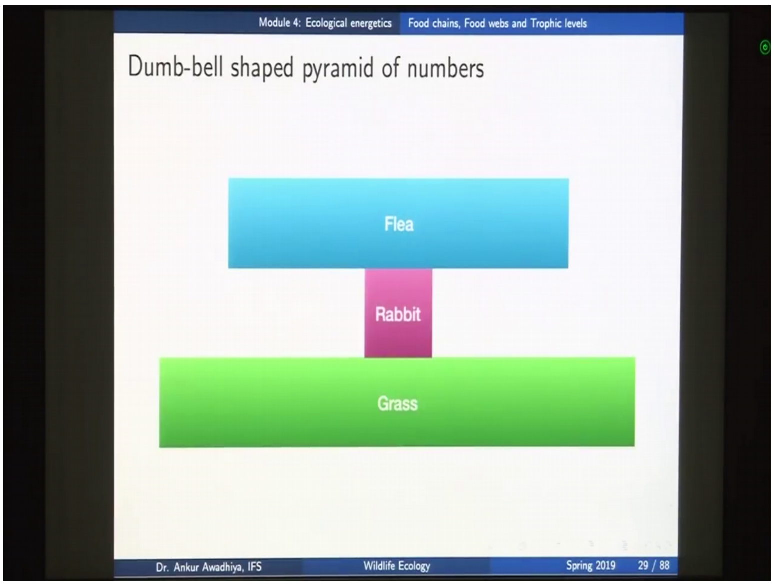

Or we can even have a pyramid of numbers that looks like a dumbbell. So, one such example is grass, rabbit, flea. So, you have grasses, so there are quite a number of grasses in your ecosystem, that is and those grasses are supporting a small number of rabbits. But then because each rabbit can support a multiple or a large number of a these parasitic fleas. So, the total number of fleas that will be found in this ecosystem will be greater than the number of rabbits. And in that case the pyramid of numbers will look like a dumbbell.

Another pyramid is the pyramid of energy. So, we looked at the pyramid of numbers in which each trophic level is showing how many individuals of are present at that particular trophic level. In the case of pyramid of energy we look at the energy that is contained in organisms at each trophic level. And in this case the energy generally looks like this. So, you have a pyramid that is a flatter or wider at the bottom and that goes on tapering to the top. So, the amount of energy that is present at each trophic level goes on decreasing as we move up the food chain of the food web.

The third kind of a pyramid is the pyramid of biomass which is the biomass of organisms that is present at each trophic level. So, here as well in most situations we observe a pyramid of biomass that looks like this. So, it wider at the bottom and it goes on tapering as we move to the top.

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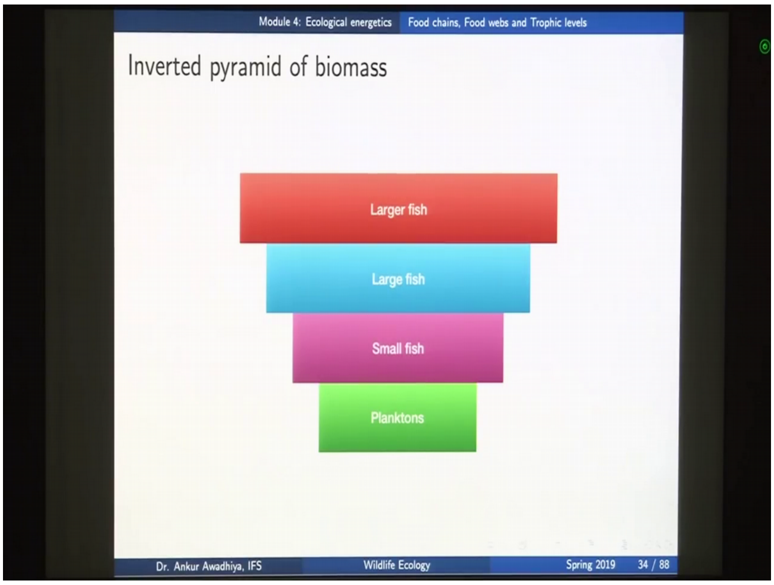

But another example is that of an inverted pyramid of biomass. So, an inverted pyramid of biomass for example, can be the example of these a of again an oceanic ecosystem. So here again you have planktons and these planktons are supporting small fishes. But then, because these planktons have a faster rate of reproduction or a faster rate of multiplication, so a smaller number of planktons can support a larger number of fishes. And because those fishes each of those fishes is having the large amount of biomass, so if you look at the amount of biomass that is being supported by the planktons though it will be less than the biomass that is there in the fishes.

And then from a small fish to a larger fish to an even larger fish. So, for instance if we look at a large sized shark. So, a shark will be having a huge amount of biomass that is stored in its body and that might be much greater than the total biomass that is present in its prey species. So, we can have a situation in which we have an inverted pyramid of biomass.

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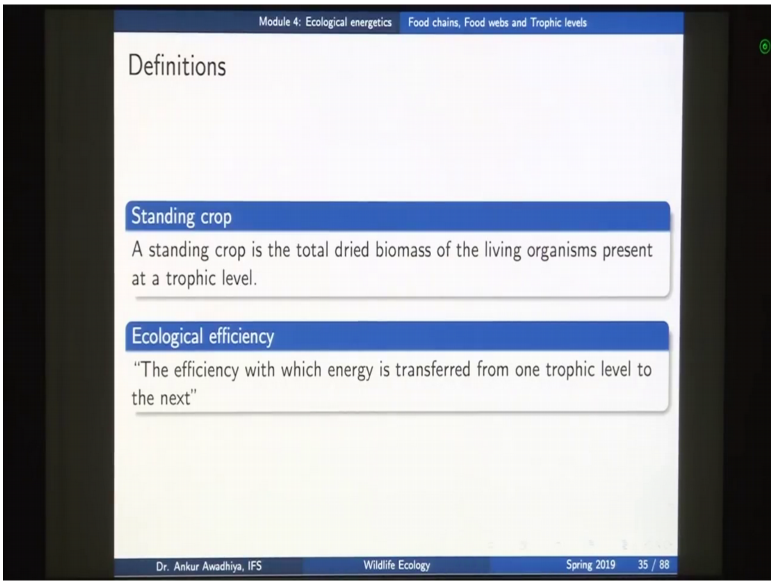

Now, in these pyramids we can also define the standing crop. Now a standing crop is the total dried biomass of the living organisms that are presented each trophic level. So, in this case we are looking at the dried-out biomass. So, for instance in the earlier situation we were looking at a total amount of biomass that was present in the grasses for instance. So, let us say that we had 1 million tons of biomass and that was the green biomass. In the case of standing crop we will look at the dried out biomass after removing all the water.

The next concept is that of ecological efficiency. Ecological efficiency is the efficiency with which energy is transferred from one trophic level to the next. So, when we are looking at any pyramid.

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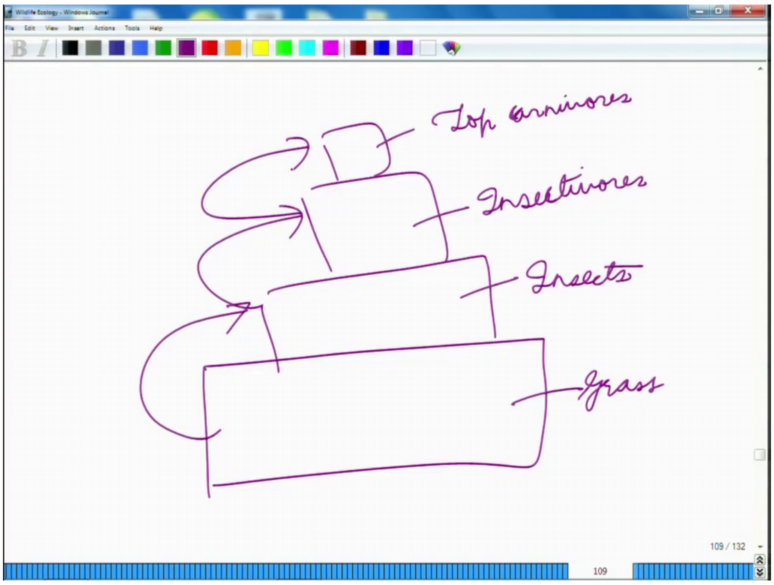

So, here we have a pyramid, and here we have grass that is eaten up by insects, that is eaten up by insectivorous organisms, and that is eaten up by the top carnivores. Now in the case of ecological efficiency we are asking the question; when energy is being transferred from one trophic level to the next how much amount of energy is getting transferred and how much amount of energy is getting lost. Now why do we see a loss of energy?

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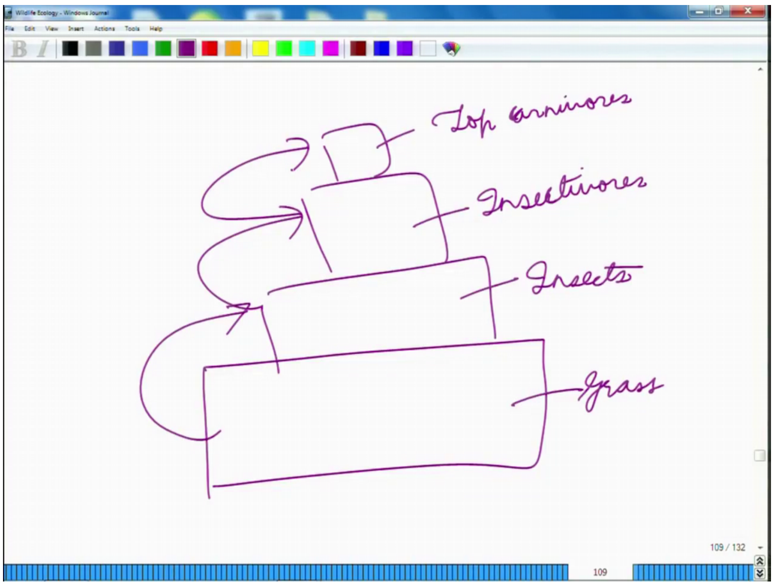

Because if we have any organism say a human being that is eating food. Now if we eat up say 1 kg of food, we will not increase our mass by 1 kg. So, if we are eating 1 kg of food it does not mean that our weight will go up by 1 kg. Why because, we are using that energy for movement both outside and also for moments inside the body, such as the moment of blood inside our blood vessels the moment of the heart and so on.

We are also with that using that energy for respiration and in that process of respiration we are also releasing quite a lot of energy in the form of heat. Then that food is not completely getting digested, because for instance if we are eating a plant based material if you are eating see carrots so some portion of that carrots gets digested and absorbed and assimilated into our body. But then we also lose quite a lot amount of those carrots in our faeces, because it contains a number of plant materials such as the cell walls, cellulose that is not digested.

So, all of that bio-material is getting lost from getting lost in this process of being moved from one trophic level to the next trophic level. Then we will also use some amount of energy in getting the food. So, there are a number of processes in which we are losing the energy. And ecological efficiency asks the question; what is the efficiency with which energy is getting transferred from one profit level to the next. So, how do we compute that?

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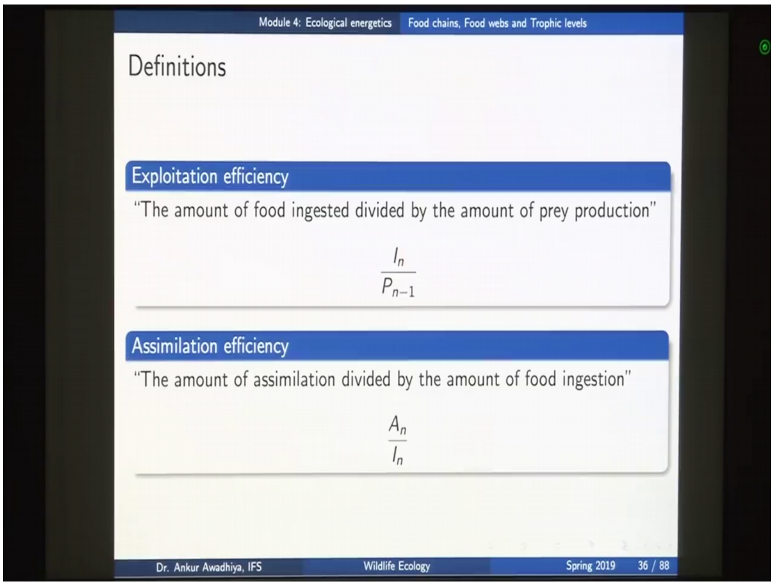

We first define some sub parts of this ecological efficiency. So, the first one is the exploitation efficiency. Exploitation efficiency is the amount of food ingested divided by the amount of prey production. So, for instance if you go to (Refer Time: 39:27) and if you have say 10000 kg of biomass that is available in the form of chital. And in a year out of that 10000 kg of biomass that is being that is being produced by the chitals if our tiger is eating up say 100 kgs. So, the amount of food that is ingested that is 100 kg divided by the amount of being of food that is being produced in the pray that is 10000 kg will give us a certain amount of efficiency which goes by the name of exploitation efficiency.

So, I in this case is showing the amount that is ingested at the n-th trophic level. So, we can define it at any trophic level we can even define it for the grasshoppers that are feeding on the grass, when that case how much amount of biomass is being is being eaten up by the grasshoppers divided by the amount of biomass that has been produced in the previous trophic level. So, which is why we have n minus 1 and P is the rate of production that is the exploitation efficiency how much of the biomass are you able to exploit.

Now once you have exploited that biomass, you now need to assimilate that biomass into your own body. So, in that case we define the assimilation efficiency which is the amount of assimilation divided by the amount of food ingestion. So, in case you have eaten say 1 kg of food, how much of that food gets assimilated into your body. So, it is A n divided by I n which is the assimilation efficiency.

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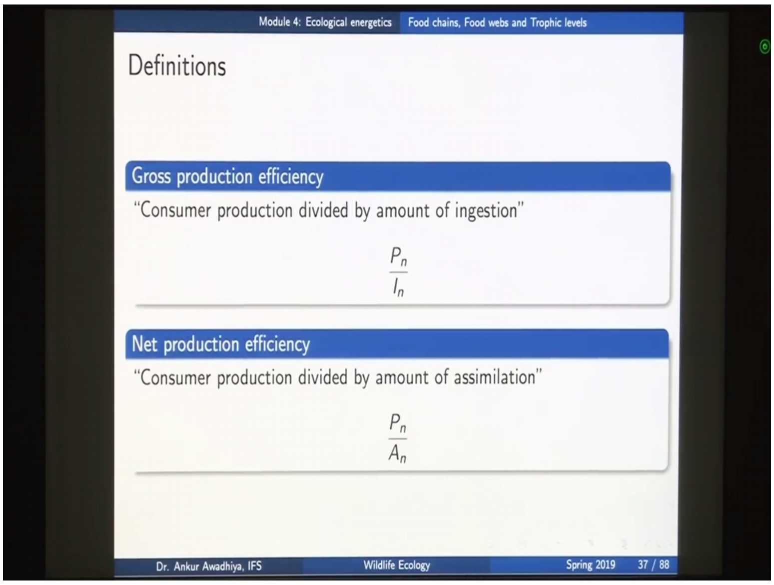

Next we have the gross production efficiency. Gross production efficiency is the consumer production divided by the amount of ingestion. So, let us first look at the net production efficiency. Net production efficiency is the consumer production divided by the amount of assimilation. So, once you have assimilated say 100 grams out of the 1 kg that you had; that you had ingested. So, out of that 100 grams how much is the amount that you are using it for production in your own body. So, that production could be in the form of increase in the weight of your own body or in the form of more number of off springs and their increase in weight.

So, that is P n divided by A n the amount of production at the n-th trophic level divided by the amount of ingestion at the n-th trophic level. And that is the net production efficiency. And in if we use I n the amount ingested at the n-th trophic level in place of the assimilation then we have the gross production efficiency.

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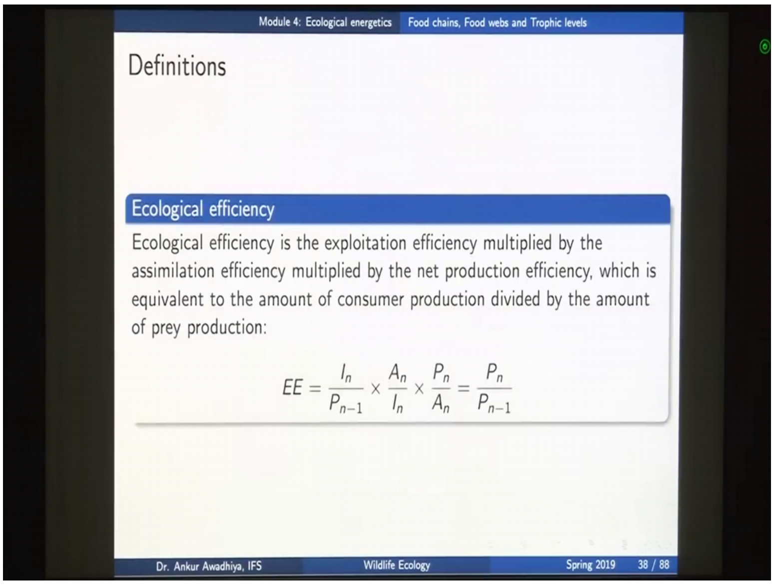

And from all of these we come to the ecological efficiency. Now, ecological efficiency is the exploitation efficiency that is I n divided by P n minus 1; that is the amount that was produced in the previous trophic level and here I n is the amount that is ingested at this trophic level. You multiply that by the assimilation efficiency which is the amount assimilated divided by the amount ingested, you multiply that by the net production efficiency which is P n divided by A n and you get to this amount of P n divided by P n minus 1.

Which is the amount that is being produced at the previous trophic level and you have the amount that is being produce at this trophic level. So, the amount that is being produced at current trophic level divided by the amount that has been produced in the previous trophic level gives you the its logical efficiency.

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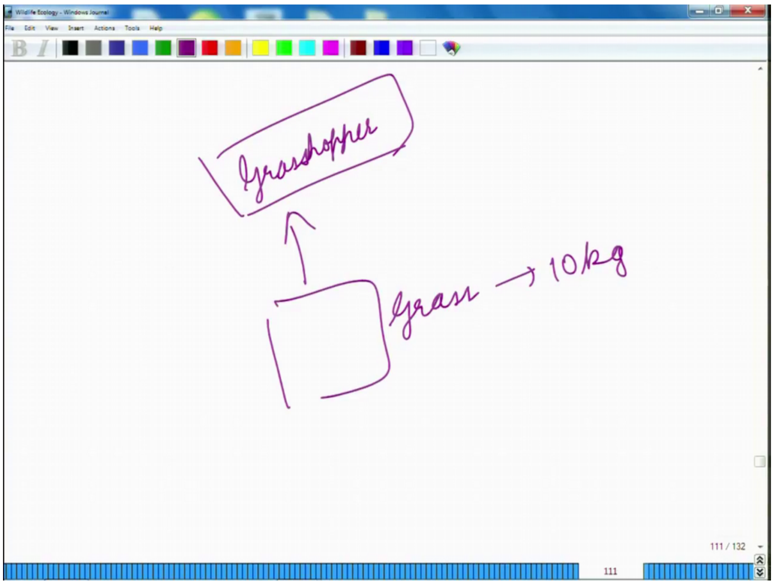

So, essentially if you have grass that is being fed by grasshopper. So, if grasses increase in weight by say 10 kg how much is the increase in the weight at this trophic level of the grasshoppers; grasshoppers and the other primary produce; primary consumers is what the ecological efficiency would be asking.

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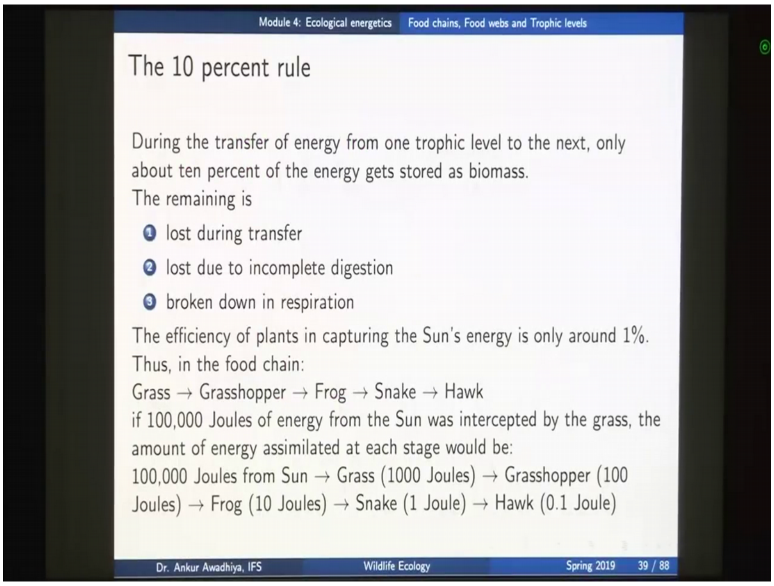

And we have a rule of thumb in this case which goes by the name of the 10 percent rule. Now 10 percent rule says that during the transfer of energy from one trophic level to the next only about 10 percent of the energy gets stored as biomass. So, that is the ecological efficiency is close to about 10 percent, the remaining is getting lost during transfer, loss during incomplete digestion and broken down in respiration.

Now the to give an example: the efficiency of plants in capturing the suns energy is only about 1 percent. Now this is not 10 percent this thing needs to be remembered; the plants efficiency is close to about 1 percent. So, if you have say a 1000 calories of energy that is being absorbed from the plant or from the sun, so out of that 1000 calories only 1 percent that is 10 calories will get assimilated or will be used in the production of the grass.

So, in this food chain grass to grasshopper to frog to snake to hawk if 100000 joules of energy from the sun was intercepted by the grass the amount of energy assimilated at each stage would be: so, you have 100000 joules from the sun, out of that only 1 percent that is 1000 joules will be made of level at the level of the grass. And then we have 10 percent rule from all of these trophic levels.

So, if you have 1000 joules that is available at this trophic level at the next trophic level we will have only 10 percent of that of level which is 100 joules. From that, you move on to the next trophic level and you again have 10 percent that is 10 joules. Then snake the a snake trophic level will only have 1 joule and the hawks trophic level we will only have 0.1 joule. Which also gives us an indication why these chains cannot be very long, because the more is the length of these chains the lesser is the amount of energy that is available at the apex predator level trophic level. And that small amount of energy may not be sufficient to for the survival of those species at that level.

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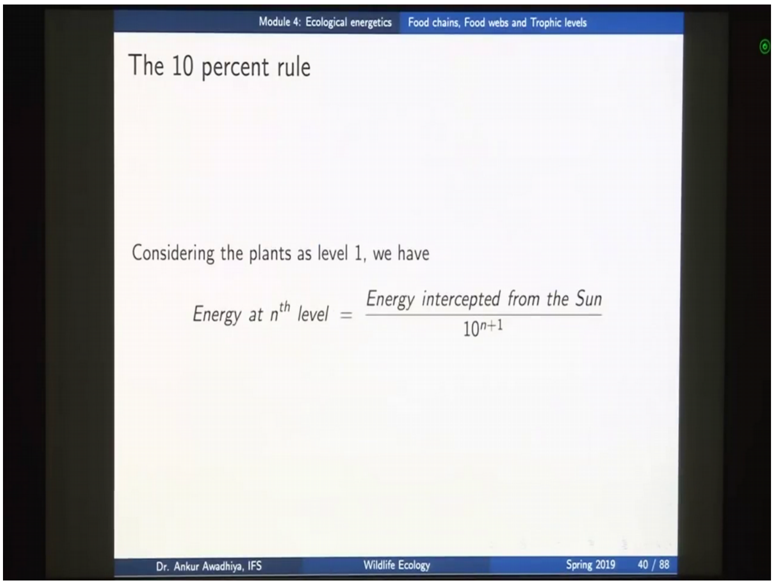

We can also a say that this 10 percent rule in the term of an equation. So, if we consider plants at level 1, we have energy at the n-th level is given by energy intercepted from the sun divided by 10 to the power n plus 1. So, if you have plants as 1, so at the level of the plants that is at the level of the producers you will have energy intercepted by the sun divided by 10 to the power 1 plus 1 which is 10 to the power 2 which is 100. So, you have one hundredth of the energy or 1 percent of the energy that is being intercepted from the sun is made available at the level of the producers. And from the next trophic level onwards you have only 10 percent of that energy that is available.

So, this is about the ecological engergetics. But one other rule of understanding this trophic levels is the case of the trophic cascades.

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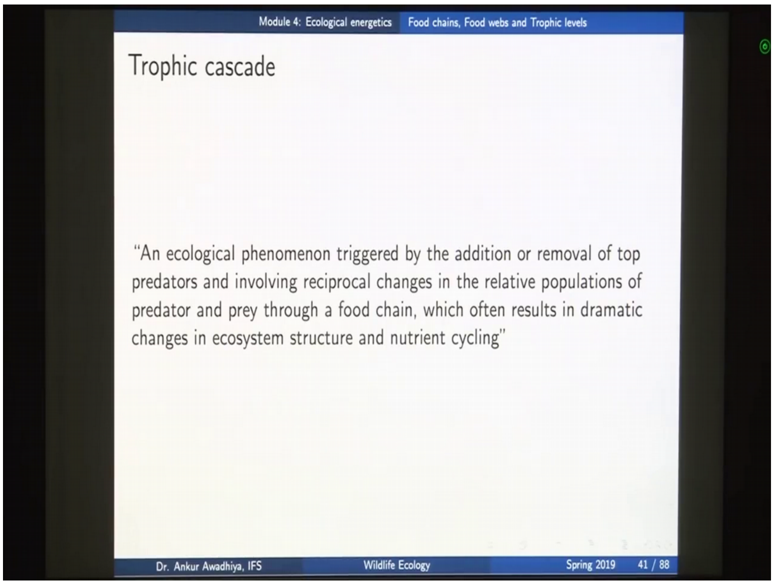

Now what is a trophic cascade? It is an ecological phenomenon that is triggered by the addition or removal of top predators and involving reciprocal changes in the relative populations of predator and prey through a food chain, which often results in dramatic changes in ecosystem structure and nutrient cycling. So, you have this ecological phenomenon that is occurring because of the addition or removal of the top predators.

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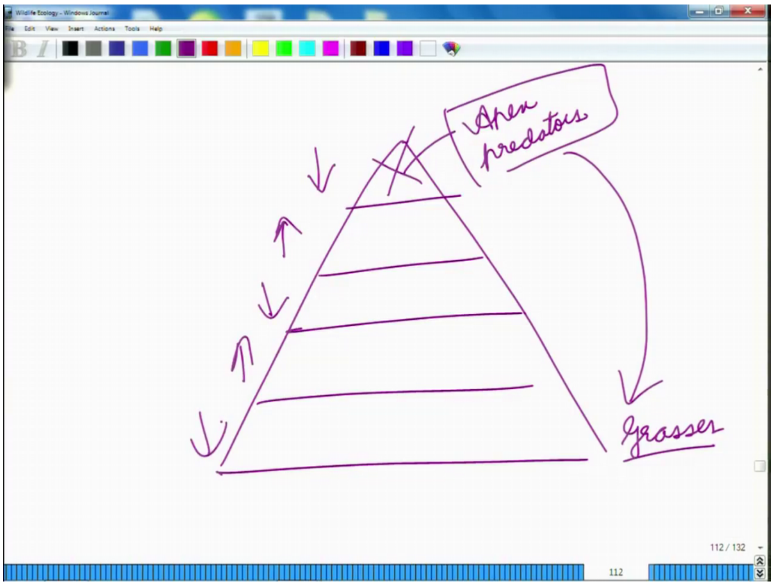

So, if we have this ecological pyramid and you have different trophic levels; you have producers, primary consumer, secondary consumer and so on and here you have the apex predators. Now if you remove the apex predators; so for instance if you have a forest in which you have tigers and tigers are the only apex predators that available there and you have chitals and you have the grasses. Now if you remove tigers from this ecosystem what will happen is you will have a very less amount of predatory pressure on the chitals. So, with the with these tigers gone there will be nothing to regulate the or the population explosion of the chitals.

So, the population size of the chitals would increase, when that happens they will be eating up much more of the grass and even though the smaller saplings of the of different trees that are available. And so the impact of removal of the predators would come down as a cascading effect to the bottom of this food web. So, in this case by a removal of tigers you will have the removal of grasses.

So, coming back to the definition; “an ecological phenomenon triggered by the addition or removal of top predators”. Now we looked at removal of top predators similarly if you do not have any top predators if you add those top predators you will also find a very different impact. And involving the reciprocal changes in the relative populations of predator and prey through a food chain. Why reciprocal changes? Because you are removing one predator that leads to an increase in the number of their preys which leads to a decrease in the number of their preys and so on. So, you have a reciprocal relationship.

So, if this portion reduces, this would increase, this would increase; so this would decrease, so this would increase, so this would decrease and so on. So, you have reciprocal relationships and which often results in dramatic changes in the ecosystem structure and nutrient cycling. So, we will look at one such example.

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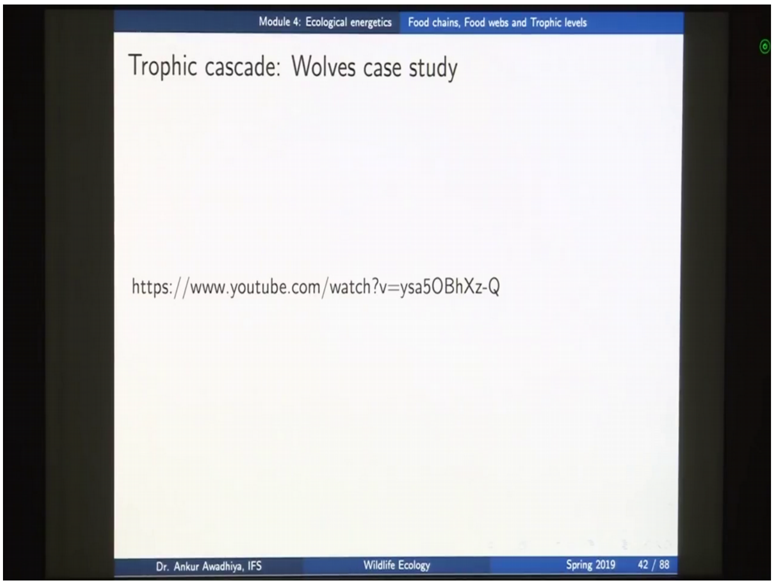

So, this is the case study of a wolves which is which I have taken from a video from YouTube: it is from sustainable human and now we will look at that video.

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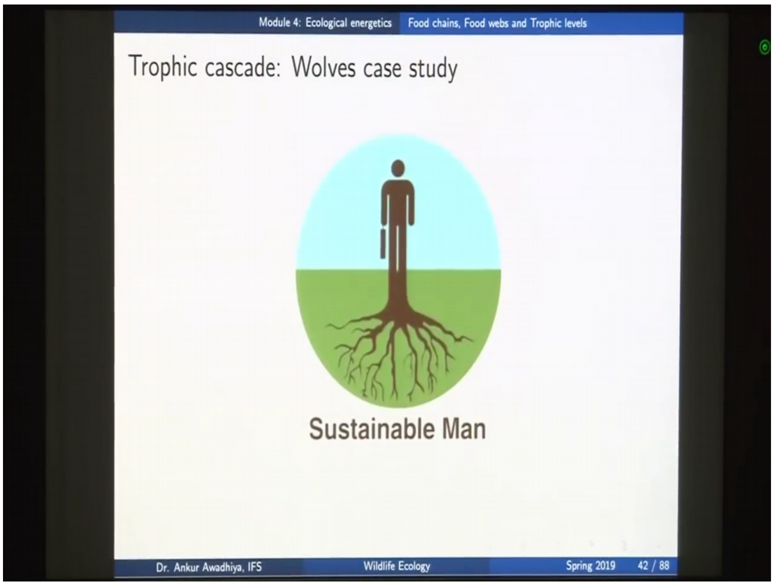

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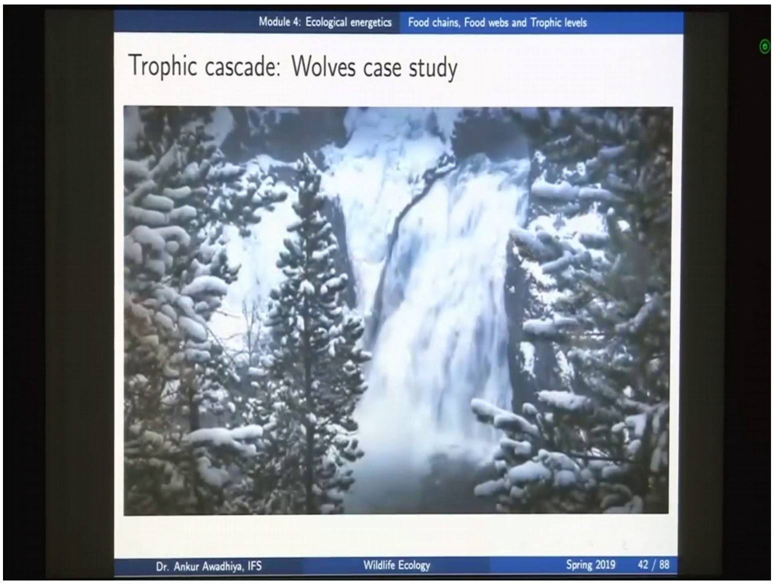

One of the most exciting scientific findings of the past half century has been the discovery of widespread trophic cascades. A trophic cascade is an ecological process which starts at the top of the food chain and tumbles all the way down to the bottom.

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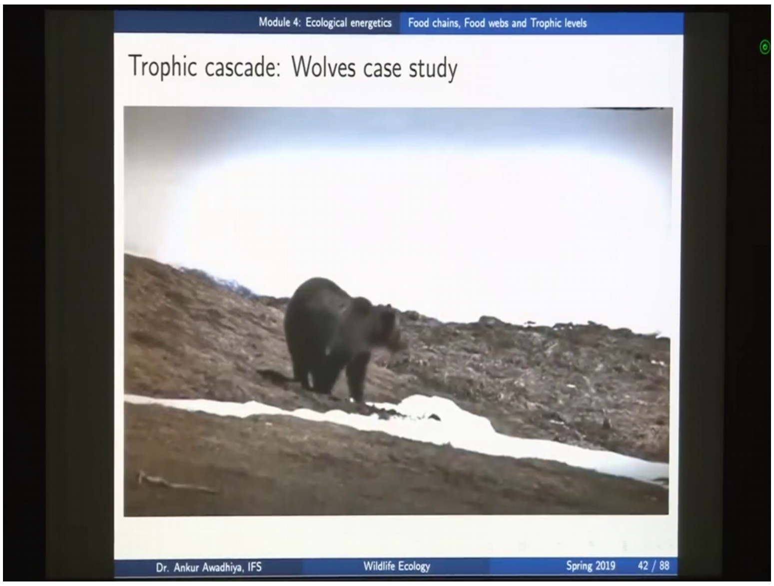

And the classic example is what happened in the Yellow Stone National Park in the United States when wolves were reintroduced in 1995. Now, we all know that wolves kill various species of animals, but perhaps slightly less aware that they give life to many others. Before the wolves turned up they are been absent for 70 years that the numbers of deer, because there were nothing to hunt them had built up and built up in the Yellow Stone Park and despite efforts by humans to control them that managed to reduce much of the vegetation there to almost nothing there just grazed it away.

But as soon as the wolves arrived even though there were few in number, they started to have the most remarkable offense. First of course they killed some of the deer, but that was not the major thing, much more significantly they radically changed the behavior of the deer. The deer started avoiding certain parts of the park the places where they could be trapped most easily; particularly the valleys and the gorges and immediately those places started to regenerate. In some areas the height of the trees quintupled in just 6 years. Bear valley sides quickly became forests of aspen and willow and cottonwood.

As soon as that happened the bird started moving in, the number of songbirds of migratory birds started to increase greatly, the number of beavers started to increase; because beavers like to eat to the trees and beavers like wolves ecosystem engineers, they create niches for other species. And the dams they built in the rivers are provided habitats for otters, and muskrats and ducks, and fish, and reptiles, and amphibians. The wolves killed coyotes.

And as a result of that the number of rabbits and mice began to rise which meant more hawks, more weasels, more foxes, more badgers, ravens and bald eagles came down to feed on the carrion that the wolves have left. Bears felling it too and their population began to rise as well partly also, because there were more berries growing on the regenerating shrubs. And the bears reinforce the impact of the wolves by killing some of the calves of the deer. But here is where it gets really interesting.

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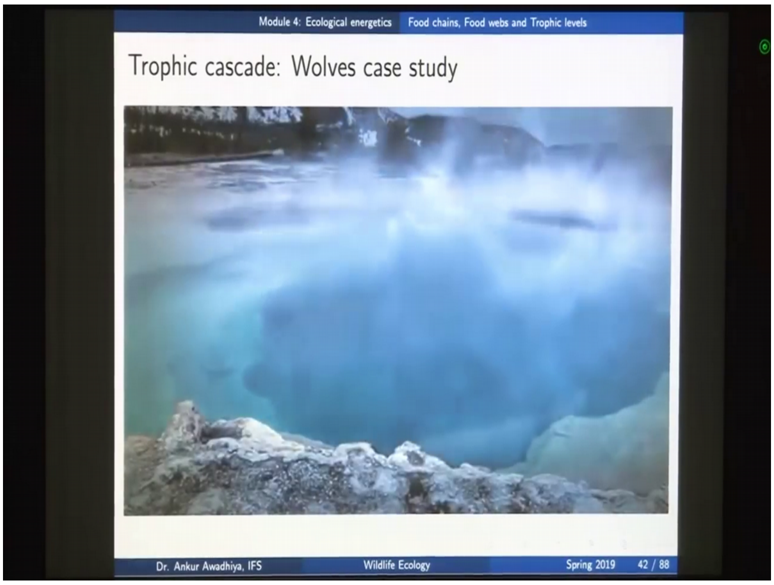

The wolves changed the behavior of the rivers. They began to meander less, there is less erosion the channels narrowed more pools formed more riffle sections all of which were great for wildlife habitats; the rivers changed in response to the wolves. And the reason was that the regenerating forests stabilized the banks so that they collapse less often, so that the rivers became more fixed in their course.

Similarly, by driving the deer to some places and the vegetation recovering on the valley sites there is a soil erosion, because the vegetation stabilized that as well. So, the wolves small in number, transform not just the ecosystem of the Yellow Stone National Park this huge area of land, but also its physical geography.

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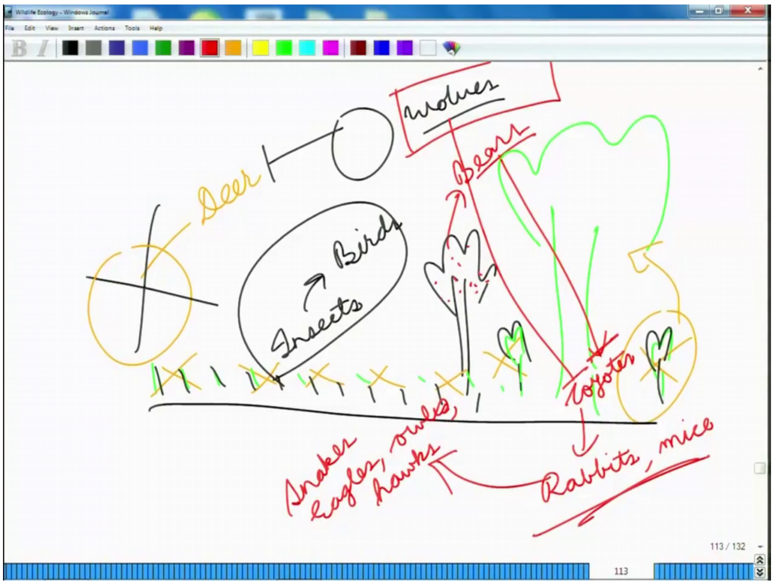

Now, in this example what we are observing is that earlier we had a patch of forest that had some grasses and that had some trees. Now if you do not have any herbivores here, so these plants would be able to survive. But then if you only have some herbivores in the form of deer and you have and you do not have anything to control the population of deer what would that deer do is they would eat up all the grass and also any of the small saplings that are coming up because of these trees; so, these all get eaten up. So, once that happens the regeneration of the forest stops, because you do not have any new saplings that will later on become trees.

Now in the case of Yellow Stone National Park what had happened was that these wolves had been cleared off they had been hunted away. So, in that case there was nothing to stop the deer's and they were eating up everything and so in this situation the amount of biodiversity had reduced to a very great extent, because you only had these barren lands and you only had these forests that were not regenerating themselves.

Now in this situation when you bring wolves into the system and even though these wolves are small in number, but once they once they create a negative impact on the deer's by killing of these deer's and by a by changing their behaviors so that they avoid certain locations. In those locations now these saplings have a chance to grow. So, now, you have these saplings that are coming up. Now you have these grasses that are coming up.

Once that happens now these grasses and these saplings can now support more number of organisms. So, for instance when say you have these grasses you will also have a number of insects that will feed on these grasses which will also support a number of birds that will feed on these insects. So, by bringing in wolves you are increasing the population of insects and birds. Similarly, once you have these saplings and once these saplings grow to a certain stage they would support some other organisms. So, for instance earlier because we did not have any shrubs, so there were no berries.

Now, because these shrubs are able to survive so you have berries that are growing up on a number of shrubs. And these berries are then supporting bears. So, just by having and then these bears would also have some other impacts, because they would be killing off some other organisms like the coyotes; the bears and the wolves kill off the coyotes. So, when the when these coyotes are killed off that increases the population of rabbits. Because rabbits were being eaten up by coyotes, so when once you reduce the population of coyotes the population of rabbits would go up. Rabbits and mice would increase; once rabbits and mice population increases that would further increase the population of those organisms that feed on these animals.

So, things such as snakes would increase or things such as eagles would increase or wolves would increase or hawks would increase and so on. So, just one organism, just one top predator that can produce so much of impacts on the ecosystem and this is what is known as trophic cascade.

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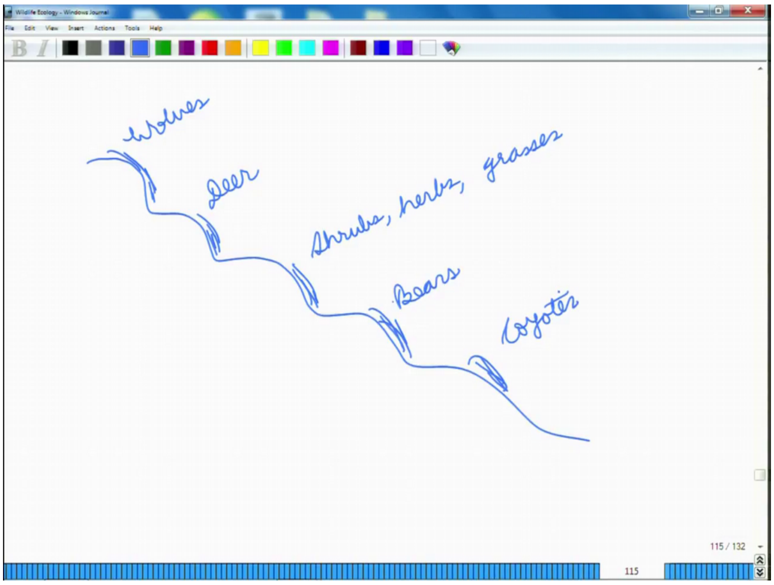

Why is it called a trophic cascade, because if we look at a river a cascade is a series of small waterfalls. So, each of these small waterfalls will be called a cascade. So, in this case the wolves are impacting some other organism they impacted the deer, which then impacted the shrubs and the herbs of that area and the grasses of that area, which then impacted the bears in that area, which then also impacted something else the coyotes in that area and so on. So, the impacts are moving up and down in the food web. So, which is why we call these as profit cascades and they play an extremely important role not only in the ecology, but also in the geography of the region.

So, in this lecture we looked at food chains, food webs. We looked at different trophic levels we looked at different pyramids and how do we make sense of this data; and why is that important in the case of ecology. And a very important implication of understanding of these food chains food webs and trophic levels is the knowledge about the trophic cascades, what is the impact of a top predator in any ecosystem.

So that is all for today, thank you for your attention [FL].