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Ecology

What is studied in ecology?

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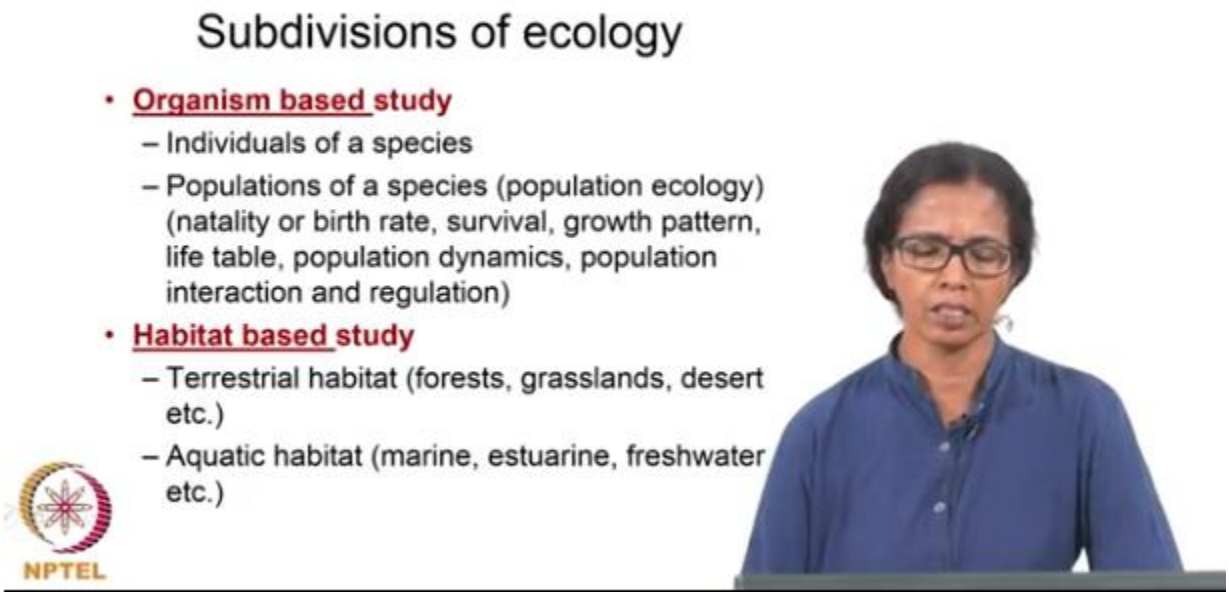


Now we will look at the ecology and how people go about studying ecology. There are various ways in which one can look at ecology, either you can look at the level of organisms, that means individual of a particular species. I can take for example particular tiger from a group of tigers and start looking at it as an organism, as an individual, or I can take you know microbe and start looking at that particular microbe how it is interacting with its surroundings? How it is taking up food? How it is regulating its functions? So, these are the things which are individual based, individual of a particular species one can take and study.

Or one can also study what are known as population of a particular species, which means which is known as population ecology. So, which involves how many of the members of that species is born, that means the birth rate, how many of them are surviving, they do not care about how they, what are the causes of survival, but it is just a count of how many of them are surviving,

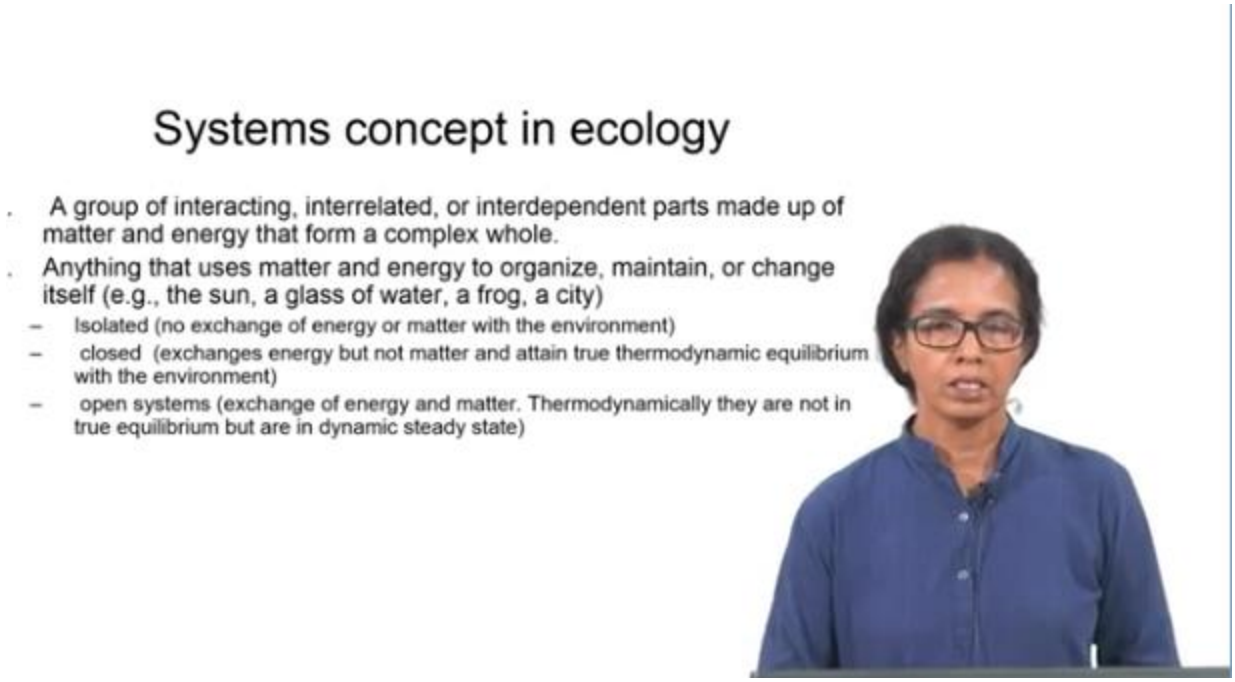
growth pattern. What is meant by the, what is their life table, the population dynamics which is, for example, if you are talking about a population of tiger in a particular national park let us say. And what are the factors that will dictate the population of that species? So, it could be how many tiger cubs are born let us say per year in a particular that habitat, and which can give us what is known as a birth rate per year. And then how many of them have survived, means let us say how many of them have become reached 2 years or 3 years of age, or when we say survival in ecology it defines how many of them have grown to adult age to reproduce and then thrust the next generation into the population. So, then only you can call it as a survival. And then when we say survival of the fittest also is coming in the context of ecology, in terms of saying that how many progenies it could thrust into the next generation.

Similarly, what is the pattern of growth? There are different ways in which you can analyze population dynamics, whether it is you know exponentially growing or whether it is you know linearly growing. So, these are different growth patterns it has, the dynamics of the population. What are the factors that will be affecting the birth rate, the death rate, the survival rate of the population? So, which could be some diseases, or it could be the food availability, the weather patterns, all this can affect the dynamics of the population. And the population interaction and regulation, okay, which means how members of the community or the population or the species is interacting with each other and how it interacts with other species. let us say prey-predator relationships or predator-predator relationships which are all important in the case of population. So, it is not about individual. So, one could as I said they could study either organisms or it could be the, which could be either the individuals or the population of in its particular species.

So, the second way of classification is by looking at habitats, based on habitats. So, habitat itself one classify as terrestrial habitats which is, means terrestrial and aquatic. As you can see from the name itself, terrestrial means which are earthbound which is not water-based. So, but at the same time they also have interactions with water, it is not that they completely are out. So, the particular organism when it spends, most of its life on non-aquatic habitat they are terrestrial organisms, so those are habitats which have you know examples are forest, grasslands, deserts etcetera, so they are not covered by water.

Aquatic habitat could be marine, which means it is an ocean or a sea which is serving as the habitat for different creatures. Estuarine is the place where a river meets ocean. So, this brings in a lot of biogeochemical changes, a river brings let us say freshwater, and the sea brings a saline water. So, the concentration of salinity changes linearly as a function of, as the river is approaching the ocean. So, ocean brings more concentration of salt, and so you can see a gradation of different species that can exist and along let us say the stretch of that estuary. So, you see these estuaries at the river mouths which meets oceans, which has the unique combination of different species that can exist there, or it could be freshwater, means so this is

defined based on the salinity of water mostly, the marine, estuarine and the freshwater systems. So, these are the ways in which subdivisions of ecology is studied.



The other important concept that one has to remember in ecology is systems concept, this is a very, very important concept what we understand by systems, example human body if we take, so it has many, many interacting systems. One is let us say, circulatory system, so it is easy for us to understand human body. And let us say we take you know circulatory system or the nervous system, so it has also different parts in it which dictates it cannot, so it is not working like if I take brain alone it cannot work, so unless if I have to show that my hand is moving, the brain has to give signal, and it has to get transported through various neurons and muscles and other to get the message conveyed to the limb that I am moving, okay.

So, and similarly, that same limb when I am touching somewhere, I know that I have touched something because it is conveying back that message. So, in the process, there are various parts that are involved and then through which it is get conveying the message.

Similarly, if you take ecosystems it is not a single individual or an organism, it is actually as I said you know different organisms of different species coexisting and interacting with each other. So, these interactions are very important for the well-being and the health of the ecosystem. So, we can call it as a group of interacting, interrelated or interdependent parts made up of matter and energy, you know in a broader sense we can define that way, that form a complex hall, so that is what is an ecosystem.

So this may be looking very little elusive in its definition, so there are, so if we have to expand it, so in other words it also as a system which is self-organizing system, okay, ecosystems are self-organizing, you know we do not go and play a role and so if you take a human created systems, artificial systems we call them, there for example, we may have to put energy, we may have to put a battery there. Let us say an example is an automobile it is a system, right, so if it has to work, we have to put you know fuel there, and it has to have an ignition, so there are various things which are controlled by an external agency like human being, especially in the form of energy driven devices.

Whereas in the case of ecosystems they are known as self-organizing you know systems with the flow of matter and energy through the system, so they maintain and organize themselves, and they can change themselves.

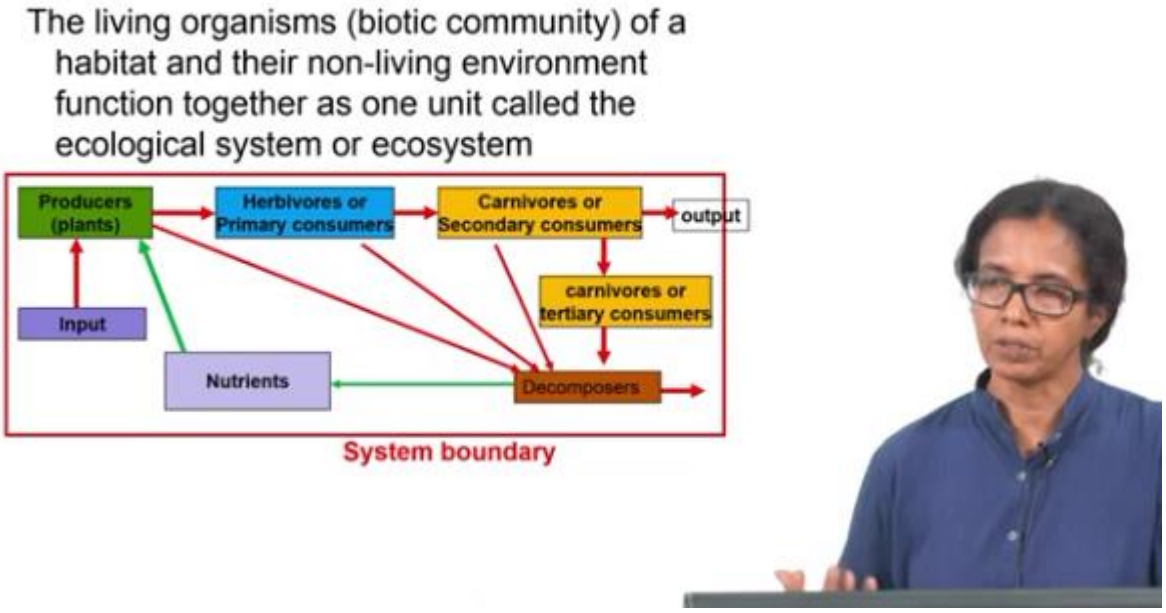
Examples of this is given let us say you know sun, a glass of water, a frog, a city, these are examples of system, okay, when I take a glass of water why is it a system is question right? So, in thermodynamics, for example, we define system with a you know system which may be either a closed system or an open system. So, in the case of ecology too, the systems have to be classified based on thermodynamic principles, and they work on the principle of thermodynamics. The minute you say energy and material is flowing in the system you can imagine that it is dictated by the laws of thermodynamics.

So, what we call a system here? System can be called an isolated system that means there is no exchange of energy or matter with the environment, which is very very difficult many times, right. I mean if you have to see an example of a system which may not be exchanging anything, so it may not be, it has to be you know exist that is almost impossible for ecosystems to be in that isolated you know condition.

The second class is what is known as closed systems, that is exchanges energy but not matter, and attain true thermodynamic equilibrium with the environment. So, so basically if you look at a glass of water for example, it is actually thing that is exchanging matter because constantly there is evaporation of water molecules and going back and there is exchange of energy which is you know the surrounding temperature is changing and fluctuating. And that is what is dictating, so both are happening that is why it is a system level, and you can say that it is an open system which is you know, which is exchanging these things.

Now let us say you have closed the glass and not allow any exchange of matter, it will still will have its energy in terms of it, its existence there but at the same time the exchange of matter with the surroundings can be stopped that is what is a closed system.

Similarly, open systems, that is where both matter and energy can exchange with the surroundings. Thermodynamically they are not in true equilibrium but are in dynamic steady state because if you take, let us say any ecosystems, an example let us say, pond or a lake, okay. So basically what kind of you know changes are happening there is very, very difficult to monitor because each individual or organism of different species are contributing in different ways in terms of you know generating matter, making use of energy which is coming from solar system and then converting it into various forms of energy. So, this is essentially the function of ecosystem and which is exchanging constantly with its surroundings, so if I take let us say a pond as an ecosystem it is getting inputs from various sources that are surrounding it which will be exchanging let us say nutrients from the surrounding.



So, let us say there is water which is flowing into the pond which brings nutrients from its surroundings, so which is not a very controlled way that it will be bringing, it depends upon the flow velocity, how much rain it is receiving, what is a kind of transformation that is happening in the pond.

So, at any given time, point of time determining the exact amount of nutrients that is available in the pond is not a constant, it is constantly fluctuating or changing, so which feeds back into, for example, so the living organisms or the biotic community of a habitat. So, this is now let us call this as an ecosystem, let us say there is a system boundary that is defined here. So the inside the ecosystem we all know that what is known as energy flow happens through what is known as food web, the nutrients are taken up by the primary producers or the plants and various other inputs are also like water or temperature and another external factors will be there which controls the production of the plants. So, plants produce biomass, and this biomass is taken up by primary consumers or what we call the herbivores.

So, in this case let us say if I am taking a pond it could be you know phytoplankton and zooplankton which will be there in the water and there could be even some fish which may be eating some of the plants which could be surviving, plant-eating fish, herbivores fish.

So, these red arrows are indicating the flow of matter and energy from in the system from one level to the other. So, this levels in the food web are what is dictating the number of individuals in each species and the number of species that will be coexisting in the total system. So, there could be possibility of different types of primary producers or plants possible in a particular ecosystem because each of it will be utilizing what is known as the particular adaptation for living in a particular environment. So, the definition that is coming in here is adaptation because you will not find the same type of plants that you will see in a pond and let us say in India you will not see that in let us say in Siberia. So, this will be different because of the temperature that may be existing there, then the type of nutrients that is flowing there, so all these are dictating the type of species that can survive there and what can adapt to that particular climatic condition or the weather conditions existing there.

So, these primary producers are eaten by as we know, the herbivores or the primary consumers, so the primary consumers in the food web will be, so the food web as we all know that the energy and the matter is flowing, and they function with certain what is known as efficiency, so how much? When we say that there are plants or primary producers in this first level, the questions that is coming to us are the efficiency of this producers, efficiency to do what? Efficiency to produce biomass, let us say you plant something, how much will it grow? Is a question in terms of let us say I can weigh at the end of the growth of that plant and see how much mass it has produced which is known as the biomass.

So, what is that biomass constituted of or constituting of? That biomass is nothing but the nutrients and the other inputs that is taken up from the atmosphere in terms of water, for example, plants grow by just the process of using water and carbon-dioxide, $H_2O + CO_2$ giving you the molecule. So, basically it is in the sizes through the photosynthesis process, the food that is required and grows in size, so the biomass is added by the addition of this molecules that are available there, and so with some efficiency only these plants can work like any other synthetic system that we talk about or the. For example, if I take a machine I define what is known as efficiency, efficiency is defined as the ratio of the output to the input, how much it is you know leaving, giving up so here output is nothing but the biomass at a given point of time.

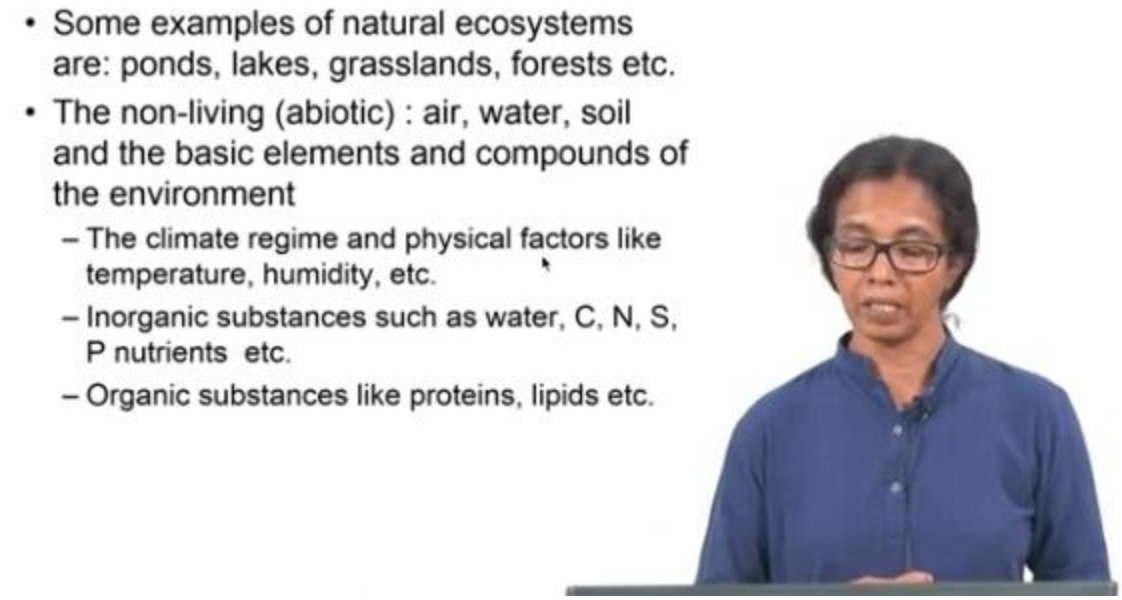
So, as you can also see that the biomass is also not a constant, the plant is continuously growing, so at any growing stage if you look at, you know on day 1 it will have one biomass, day 30 it will have another biomass, let us say 100 years down it will have a different biomass. So, it is a constantly assimilating biomass and also leaving some amount of biomass in terms of

degradation or decay into the environment. So basically, you can see that all these components also have one connection to what is known as decomposers.

So, if you take producers, herbivores, carnivores, or secondary or tertiary consumers, they all decompose by the operation of microbes, and then some amount of you know nutrients are given back to the system itself. So, it is a kind of interconnected chain that we are talking about, and each level is defined by what is known as efficiency. How much is the output or the living biomass or the standing you know crop is what is called, the term for describing what is the mass of that particular individual or the organism or a group of organisms in a particular ecosystem at a given point of time.

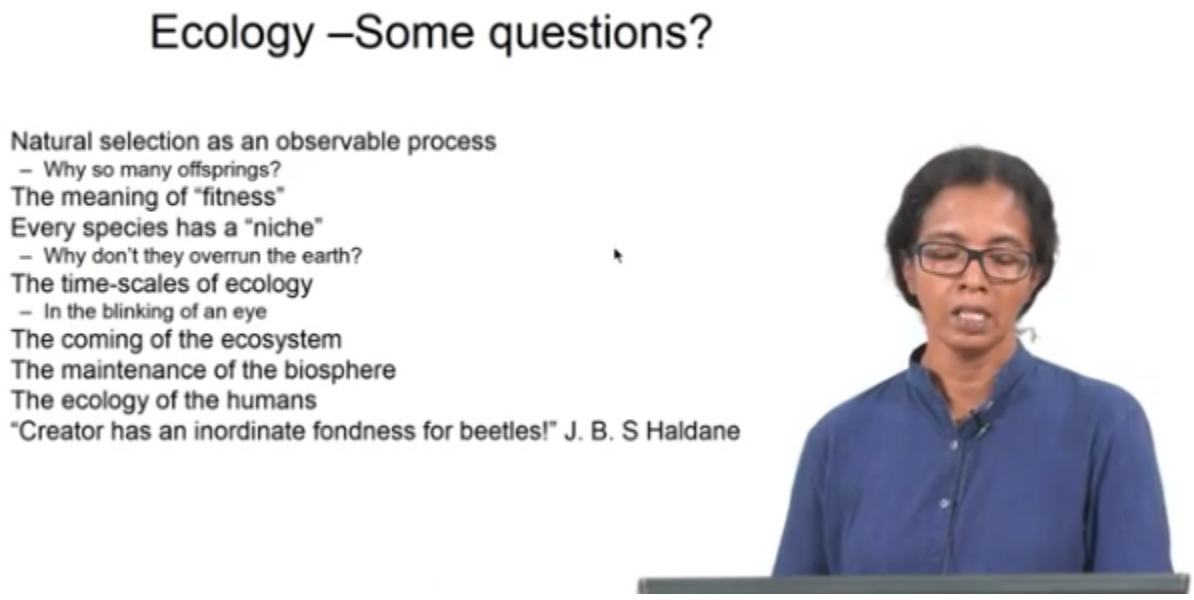
So, as I said it is a dynamic quantity, it can keep varying and depending upon various external factors and the efficiency is defined based on these factors to calculate the efficiency of transfer of energy from one level to another. So primary producers or plants have certain efficiency with which they operate, from the plants when an animal is eating that plant it transfers energy or material to the primary consumer.

So, with certain efficiency again the primary consumer is going to operate, so the primary consumer is going to, even whatever is taken up it will use for various body functions, one is growth, second is like it may have to like move around, for example, mobility, so that requires some energy expenditure. So, some amount of the biomass will be getting converted to this activities, and so it will be losing some of the biomass, so the biomass that at a given point of time is net result of the food that it has taken up. How much if it is ingested, how much of it is assimilated, how much of it is you know what you call ejected from its body in terms of various the food digestion process. So, that happens in all the stages, and the efficiency of each level is dictating how each of them will be interacting with one another. So, this is what we study in school as what is known as food web, but in just it is nothing but an energy flow paradigm, and this brings us to various questions also to you know ask in terms of understanding ecosystems.



And in all these aspects the nonliving or the abiotic has a major role in controlling the, for example, air, water, and soil, and the basic elements and compounds of the environment they control the climate regime and the physical factors like temperature, humidity, inorganic substances such as the availability of water, carbon, nitrogen, sulphur, phosphorous, nutrients etcetera, and also the synthesis of organic substances like proteins, lipids. So, these are the constituents of this nonliving or the abiotic part as an example in the system, but they are the part, they are part of the ecosystem itself.

So, you cannot take out one part, let us say I can take out proteins, or lipids from a living organism and say that you know that can be isolated and can be standalone thing which can make the system work, no they are all just a cog in the wheel of this whole operation.



So, some of the questions that comes up is in ecology are natural selection as an observable process, is it visible to us you know what we all hear that you know there is what is known as a natural selection process. So, the question is many creatures why they have so many offsprings or how many of them, for example insects or if you take you know microbes, they have large number of you know production rate is. Reproduction rate is very high, and certain animals, for example, can multiple, have multiple off springs, why do they have you know multiple offsprings? Okay, for example, if you take many predator animals or primary carnivore, you will see that you know their number of offsprings are very high, in nature you will see that you know bird may have you know 5 or 10 offsprings, do they all make it? The question is like you know how many of them live up to the next stage where they reproduce and thrust the progeny into the next generation.

And so that is where the question of what is known as fitness comes in, so fitness is not in terms of our definition of fitness, ecological fitness is another term that we need to understand, so many times we misconstrue this us, the physical fitness of the organism which is not the meaning of fitness in ecology. It means how the progeny is being thrusted by you know sexual process or asexual process into the next generation. So how many of them can transfer the gene from one generation to another, is the only question of fitness here, successfully means the next generation is surviving.

And every species similarly has niche, okay so the niche is the term that comes in ecology again as a definition, so this is to say that you know when we say species, what is a species is a definition. So, species is a group of animals which, group of animals or organisms which practices a particular trade, okay, so it is like you know saying group of teachers, okay, so they

teach that is their profession. So, they had, they are equipped with the mechanism to teach. So similarly, so here niche is something that a particular trade that they are practicing, and that species has a particular adaptation to make use of that particular habitat.

So, an example we take you know a sunbird, sunbird you might be knowing that a sunbird feeds on nectar from plants. So, it has a unique, so what we call a sunbird have a unique adaptation called long beaks which again is suited to take nectar from flowers with long stalks, not any flat flowers, so that is a unique combination of flowers with long stalks and sunbirds which have the unique feature of having the long beaks.

Now, let us say this all the plants which produce this long stalks or flowers, flowers disappear from earth. So it is an immediate consequence is that so tomorrow onwards you know sunbirds cannot be changing the beak length and then start adapting. So that beak length adaptation is something which has happened over you know thousands or millions of years of selection process, so that that makes it to trademark for or they just adapt themselves to take the nectar from long stalk plants, and that is their niche.

And then in that particular community itself when I say sunbirds, there may be multiple some subspecies or different species which are coexisting there, so how do they, what is their niche again? So, the niche is they again may have special adaptation, one may have a little longer beak, another may have a shorter beak, one may have a little-curved beak, so these are all adaptations, if you look at you know birds are very good examples for learning this different kinds of adaptation if you look at water birds, you know, if you look at them you will see that many of them may have, some of them may have long legs, some of them may have long beaks, some of them may have short beaks, so these are length scales where for example they may forage in the water at different depths. So, some of the long beak means it can go deeper into the water and forage food, so that particular trade is being, so now if I say pelicans means all the pelicans will practice a particular way of feeding themselves in a particular habitat, so that is they have a niche.

And at the same time, they are not over running the earth, so they are controlled, the population is controlled, so that has this interaction between different species and with the intra species and interspecies competitions that are coming into the picture there which controls the population.

Then time scales of ecology is very important here, so this is not the, so in the blinking of an eye I have written here, so in the blinking of an eye for our purpose of understanding microbe may multiply 100 times when in the blinking of an eye. But at the same time we will not be able to see any other transformation of let us say you know an adaptation by you know or mutation by some other you know animal which may get adapted to, let us say the sunbird which I was describing, the adaptation that would have happened, would not happen in a timescale which we

will understand at all, okay, that will be very very small changes that will contribute to the changes.

Similarly, if you look at the changes in the ecosystem, it is very very difficult to estimate the changes that is happening with the timescales you may see. The one of the contexts in which this is discussed here is the what is known as ecological succession, so what is meant by ecological succession is if you let us say we cut down a forest, a particular area and then leave it as such, then you will see gradually the changes that is happening and there are examples in you know in the the pacific ocean there are some island region were completely destroyed by volcanoes, and so eventually over a time period now it is completely covered by plants, so which is a timescale over which colonization by different organisms, so initially it will be microbes, it will be smaller organisms which will you know control the processes that is going on in that ecosystem, and then eventually takes over in the case of that volcano destroyed island.

Whereas in the case of natural forest and other grasslands or other places which may be let us say a fire has eaten up by grassland, and then how long will it take to get back to maybe the previous state or some other evolved state. So, the ecosystem also has different states or dynamic states to which it is reaching, depending upon what are the kind of species that may exist there, that may come and colonize there, and that is interacting. So now the grassland is destroyed, how will it grow back? What is the reason for it growing back because there may be grass seeds which are embedded in the soils and grass seeds are known to be very stable against fire. So, basically they will germinate when the next time when the rain happens and then first it will be the seeds which may have survived the fire onslaught. So which is actually a little bit of a selection process that is indirectly happening, so the seeds which could survive the fire could survive the fire will be the ones which are germinating in the habitat, and they will colonize there.

And next it will be the interaction, let us say some bird comes there and eats the seeds and then it will interact with the surrounding, and it may be bringing some other seeds from some other neighborhood you know grasslands, so it will introduce some species. So, there are multiple exchanges that is possible and ecosystem as I said this, not a closed system, it is constantly interacting with let us say bird flying in and out. It is actually bringing materials or it will be taking materials out from the system or there may be an insect which is pollinating here, and it may be going in the neighborhood, so this will also be bringing different kinds of interactions possible in the system in addition to the other natural factors like water or air and climate.

So in that context there are few questions that is in terms of how the ecosystems are maintaining the biosphere and also as I said it is the larger, so it is not the ecosystem working in isolation, ecosystems combined together and form the larger context of biosphere and the global you know environment is controlled or dictated by the interaction between different ecosystems, and

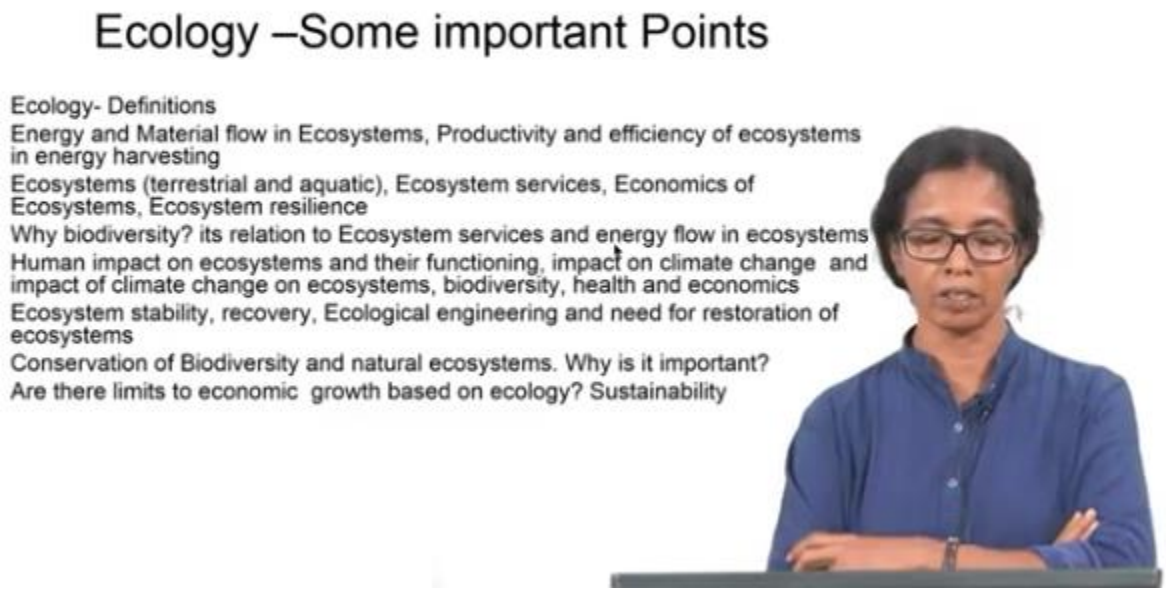
different bio geo regions that is evolved based on the presence of different ecosystems in these regions.

And as I said earlier the ecology of the humans in this is also separate entity altogether because as a species we are not only, so if you take any other species let us say, they use the ecosystems only for basic functions, let us say if I take a frog in a pond, what is its function there? So basically it uses you know the food from that is available to it from the pond and then defecates and then maybe breath, so in this process it has only few exchanges that is that is happening which is, you know, it is not creating a cloth, it is not creating a vehicle, it is not polluting externally. So, these are things which we earned as a species when you consider. Let us say you put a frog versus a human, or a you know deer versus a human or a you know any other animal versus human, so all the wild creatures or the other natural systems that if you look at they are using only the ecosystem services for the minimum existence that is food and maintenance and refuge and then raring their young ones.

And where if you look at humans, we have done lot of modifications to the system in harnessing this energy in various forms and also appropriating this energy, I would say the word appropriating because we are appropriating the energy that is available for other organisms to increase our numbers. So, there are some other equations coming in here, and if you one of the questions that I ask here is, where do you put human beings in this food web? Should we consider us a you know in terms of the energy that we are harvesting, can we place ourselves in in the link whereas a primary consumer or a herbivore or can we put as a carnivore or whether an omnivore, where do we place ourselves, is that is sufficient for you know placing us in the energy flow paradigm. So, because we are also using energy for other purposes like transportation energy, material energy for you know various functions that we are using, so we take away lot of other energy that is not taken by living systems that we find in the natural ecosystems.

So, ecology of humans is something that is to be studied little separate, but at the same time, we influence the ecosystems drastically due to this. So, this is an emerging area where we need to look at in a with the point of view that our energy consumption how it can affect the existence of the biosphere itself.

So, certain questions we will be addressing in the next few classes would be the definitions, as I said some of the definitions we have done already and energy and material flow in ecosystems, what is meant by productivity and efficiency of ecosystems in harvesting this energy coming from sun. How ecosystems like terrestrial and aquatic ecosystems function, services again we have already listed, then what is the economics of this ecosystems, okay how do we translate that in a very loose fashion, we may not be able to dwell detail, but it is important for us to appreciate the economics part of it.



The resilience of ecosystems, how is it defined? How easily the perturbed systems can go back. Why biodiversity? Okay, so every time we hear ecology, we immediately correlate something to biodiversity, so why biodiversity? What is its relation to ecosystem services and energy flow in ecosystems? So, as I said human impact on ecosystems their functioning, impact on climate change and as I said it is the back and forth loop, we affect the climate, and climate affects us, so climate affect the ecosystems and health and economics.

Similarly, stability of ecosystems, recovery and is it possible to heal the systems which are disturbed? So, there are novel approaches in which one can look at restoration of disturbed ecosystems because as I said ecosystem services are disturbed, it is affecting human well-being and other well-being of other organisms on earth, so is it possible to you know restore or bring back the ecosystems to a functioning ecosystem.

Similarly, our conservation of biodiversity and natural ecosystems, why is it important as a question, are there limits to economic growth based on ecology? So, this is a question that we need to address because as I said ecosystem service and functions are important for all operations on earth, so we cannot have an overriding factors that we will get rid of all the natural ecosystems, and we will run the all systems on an artificial scale. So that is why there is a limit that is set by for economic growth when we define, many times we are not taking into account the ecosystems services and the functions that is served, and unless we account for that, we will never be able to define economic growth. So, that is where sustainability definitions will come in. And you will have another module on what is sustainability.

Thank you