Geomorphic Processes: Landforms and Landscapes
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Lecture - 3
Introduction to Geomorphic Processes:
Landforms and Landscape
(Part – III)

So welcome back.

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TABLE 13.1 The World's Water Supply (Selected Examples)

Location	Surface Area (km^2)	Water Volume (km^3)	Percentage of Total Water	Estimated Average Residence Time
Oceans	361,000,000	1,230,000,000	97.2	Thousands of years
Atmosphere	510,000,000	12,700	0.001	9 days
Rivers and streams	—	1,200	0.0001	2 weeks
Groundwater; shallow to depth of 0.8 km	130,000,000	4,000,000	0.31	Hundreds to many thousands of years
Lakes (freshwater)	855,000	123,000	0.009	Tens of years
Ice caps and glaciers	28,200,000	28,600,000	2.15	Up to tens of thousands of years and longer

Data from U.S. Geological Survey.

Yesterday in the previous lectures, we were talking about the residence time, estimated average residence time of different locations. We were talking about the ocean, atmosphere, river and streams, groundwater, and finally, we talked about the groundwater, which can remain for hundreds to many thousands of years in the shallow subsurface.

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Estimate of the World Water Balance

Parameter	Surface area (km^2) X 10^6	Volume (km3) X 10^6	Volume %	Equivalent depth (m)	Residence Time
Oceans and seas	361	1370	94	2500	~4000 years
Lakes and reservoirs	1.55	0.13	<0.01	0.25	~10 years
Swamps	<0.1	<0.01	<0.01	0.007	1-10 years
River channels	<0.1	<0.01	<0.01	0.003	~2 weeks
Soil moisture	130	0.07	<0.01	0.13	2 weeks – 1 year
Groundwater	130	60	4	120	2 weeks – 10,000 years
Icecaps and glaciers	17.8	30	2	60	10-1000 years
Atmospheric water	504	0.01	<0.01	0.025	~10 days
Biospheric water	<0.1	<0.01	<0.01	0.001	~1 week

This table also shows some data of residence time.

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Process: Uniformitarianism

- The geomorphic processes varies enormously, it may be as slow as a few centimetre per thousand years to 50 m/s.
- These processes depends upon the region, climate, vegetation, altitude, depth etc.
- It has been suggested that **"geomorphic features are similar to all chemical and physical processes".** Under same set of environmental conditions they have acted in the past, will act in the same pattern in future and are observed as same today – **known as Hutton's principle of uniformity of process** - called **Uniformitarianism**
- The ***present is the key to the past***, called **Uniformitarianism**

Now, further today, we are going to talk about some important aspect of uniformitarianism. Now, this process is basically we partly discussed this in the previous lecture also, that present is the key to the past and whatever the processes which are operating today must have operated in the past also. So, that gives us a clue that the landforms which have been formed are with the processes which are ongoing, similar processes were responsible for sculpturing the landscape in the past also.

So, we say the geomorphic processes vary enormously from place to place and location to location depending on the climatic conditions, depending on the terrain. It may be as slow as few centimeters per thousand years to 50 meter per second. So, it may be fast also, it may be

slow also. So, this is very important the process may vary as I was talking about that depends upon the terrain, depends upon the climate and the region.

So, this process depends upon the region, climate, vegetation, altitude, depth, etc., and based on this or depending on this, the process will vary in terms of its operation, may be fast, it may be slow. Now, it has been suggested that geomorphic process features are similar to all chemical and physical processes and the same set of environmental conditions they have acted in the past will act in the same pattern in future also and are observed as same today.

So, basically this statement talks about that whatever the processes which are ongoing today, all were in the past are more or less similar or same. Now, this statement has been termed as the principle of uniformity of geomorphic processes mainly by Hutton's. So, this is known as Hutton's principle of uniformity of processes called uniformitarianism. So, this you remember, so this part which we talk about that what we call the uniformitarianism is the present is the key to the past.

Now, this helps us understanding the processes which are operating today in the landforms which are formed due to different processes today to similar processes operated in the past and we can correlate the old landscape and try to evaluate that how they were evolved.

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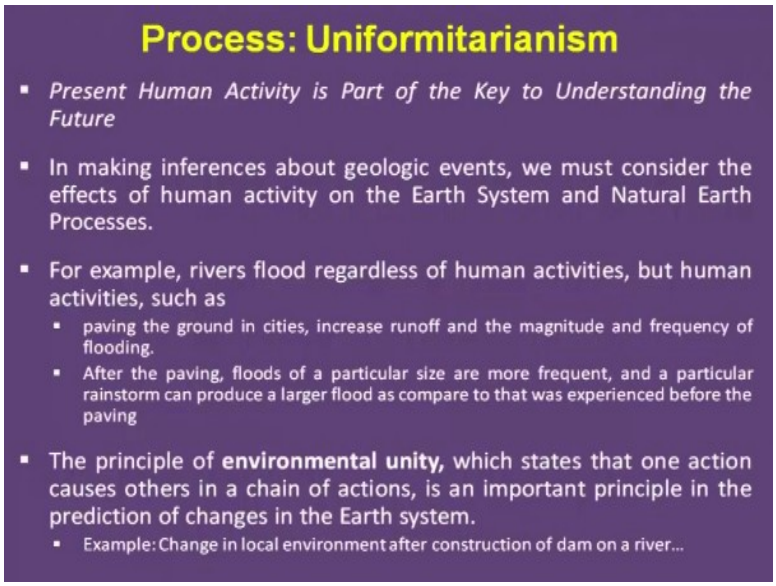

Now, further present human activity is part of the key to understanding the future because whatever the activities that are going on or we can say anthropogenic activity will decide the future. So, we alter something, the result will be different, as we were talking about the

systems within the earth, that if you alters one system, the other will be affected. Similar way, we will be looking at some examples now, which suggest clearly that because of the alteration we have done in the environment, it has affected the other system.

So, in making inferences about geological events, we must consider the effect of human activity on the earth system and natural earth processes. How we are influencing the earth system that is also important and that is also result into the shaping up of the landscape. Now, for example, river floods, regardless of human activities, but human activities such as paving the ground in cities increases runoff and the magnitude and frequency of flooding and this is very commonly we are experiencing in megacities that because of the concrete jungles, the runoff is increased and within no time the city is under flooding conditions.

So, after the paving, floods of a particular size are more frequent and a particular rainstorm can produce a large flood as compared to that was experienced before the paving. So, before paving, things were different and after paving, things are different. So, this is very important and the principle of environmental unity which states that one action causes others in a chain of actions. So, this is what we were talking about, I mean, a while ago that if you are trying to disturb one system, then you are going to also affect the another one and this is an important principle in prediction of changes on the earth system.

So, this is important in terms of that, how we are influencing the system, and of course, we have touched upon some point, not in so much of details, but yes of course the population is going to affect our earth system. So, example, change in local environment of reconstruction of dam on the river can change or affect the local ecosystem as well as the areas which are sitting in the downstream region.

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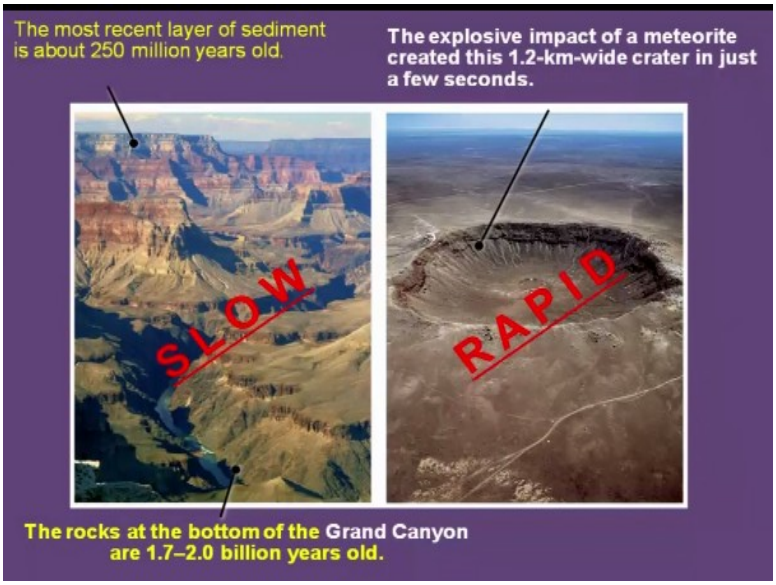

Further, if you look at the examples in terms of the process which we are talking about, that the processes can be fast, process can be slow. So, this is a best example which talks about the processes and the landscape, the fast process and the slow process. These 2 pictures are one is of great Canyon, another is of crater that is an impact created by meteoritic impact. So process comparisons, slow versus rapid.

So, this is the photograph on the left hand side is of great Canyon which shows that the bottom of the section which has been marked by dot, the rocks at the bottom of the great Canyon are 1.7 to 2 billion years old and the most recent layer of the sediment is about 250 million years old. So, the top is 250 million and the bottom is around 2.0 million years old. So, you can understand the process where the incision process took so much of time to produce this fascinating landscape, whereas on the other hand, the explosive impact of a meteorite creates this 1.2 kilometer wide crater in just few seconds.

So, this is what is the irony that one process is very fast and another process is very slow. So, this is a slow process, sand rapid process. So you can now link with the part which will be talking about the slow process and rapid process which can result into the shaping up of the landscape.

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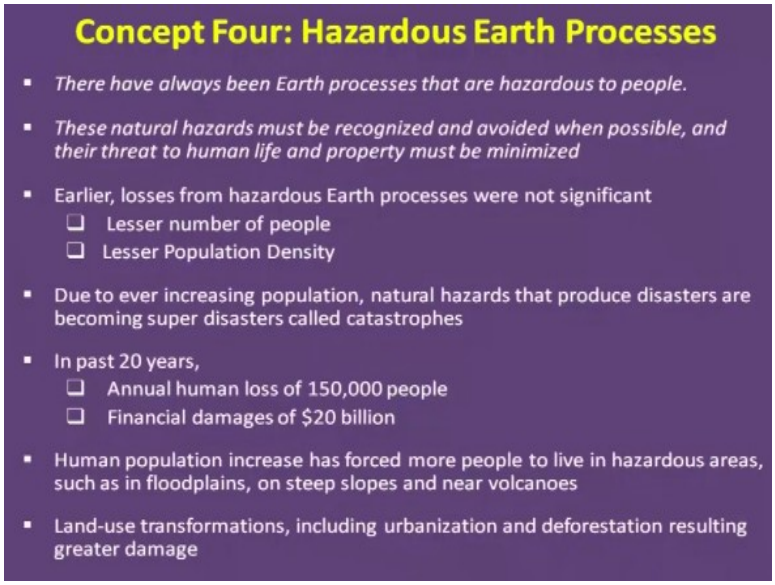

Now concept 4. As we were talking about different kinds, 5 concepts we talked in the previous lectures, out of which 3 we are going to cover. So concept 4 is hazardous earth processes. There have always been earth processes that are hazardous to people. These natural hazards must be recognized and avoided when possible and their threat to human life and property must be minimized. So, this should be our first aim that we understand the hazards which are related to earth processes and we should minimize its effects on human and property.

Earlier losses from hazardous earth processes were not significant, and this one of the reason was that the population, so lesser number of people were there, lesser population density, and further due to ever increasing population, natural hazards that produces disaster are becoming super disasters called catastrophes. Now, the reason is that more and more people are getting into, there is a population increase and we are being forced to get into the hazardous areas.

So, in last 20 years, annual human loss of 150,000 people in different type of natural hazards, financial damage up to 20 billion dollars. Human population increase has forced more people to live in hazardous regions. A few examples are floodplains. So, we are forced to go to floodplains and occupy the areas because it would not have enough land available, that may be one of the reasons, another is that we are close to the resources. People staying in steep slopes, are gone to steep slopes and near volcanoes.

So all these 3 examples which have been given will result into a hazard and this is one of the reasons that because of the increase in population, humans are forced to go and stay in the

hazardous areas, and this is one of the reasons where the evens are becoming catastrophe because more and more people are exposed to the hazard. So, land-use transformations, including urbanization and deforestation resulting great damage. So, this is another important point which one should keep in mind in concept four, hazardous earth processes.

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So, this figure, it shows different anthropogenic activity as well as natural hazards and mainly the geohazards. So if you are talking about fuel extraction, of course, in sometime in future, like we cannot say that in few years, but in geological time scale, this will become extinct. So, we are also exposed to other hazards like earthquakes, floods, landslides, sinkholes, hurricanes, volcanic eruption, tsunamis, and then climatic effects, desertification.

We also keep putting the waste, and based on the waste disposal, we are having groundwater pollutions, and then recent example of Amazon, which we are experiencing of the forest fire, then we have pollution which is has contributed, definitely which will result into the contamination of the groundwater, and then sea level change, this is related to the climate, but warning example I will show you of the sea level, not exactly, it is not the eustatic sea level, but local sea level change which has occurred, it is not an ocean, but a small huge lake which has been transformed because of the human activities.

I will show the example in the next coming slide. Damming of the river can also result into the change in the environment in the upstream as well as downstream. So, these are all examples of geohazards, which you can see here actually, and definitely these all geohazards which we are talking are having the impact on humans at least.

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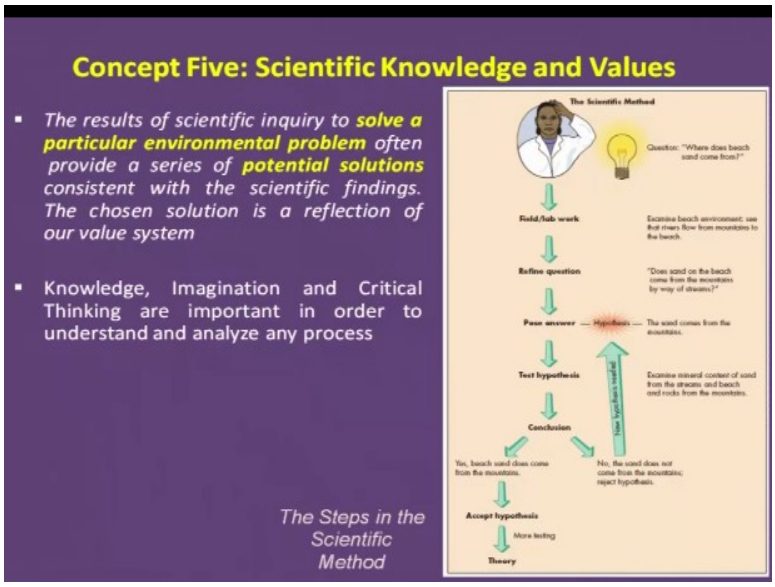

Concept 5 is scientific knowledge and values. So, unless and until you do not study the complete scenario of any process or you do not take into the details which are available of any particular process, you will not be able to understand the overall evolution of the landscape. So, what it says here is that the result of scientific inquiry to solve a particular environmental problem often provides a series of potential solutions consistent with the scientific findings. The chosen solution is a reflection of our own value system.

So, initially, you need to examine and try to study the problems in detail with several questions in mind and that in thought process and then finally that poses an answer and the answers could be through hypothesis and these hypothesis can be tested and finally the conclusion. So, any process or the problem can be taken into consideration for detailed scientific knowledge and value through knowledge, imagination, and critical thinking. So, this is what we say in the thought process.

Now, these 3, knowledge, imagination and critical thinking are important in order to understand and analyze any process.

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So, earth's environmental system, if you take the earth's environment has a complex network of system interlinked with one another.

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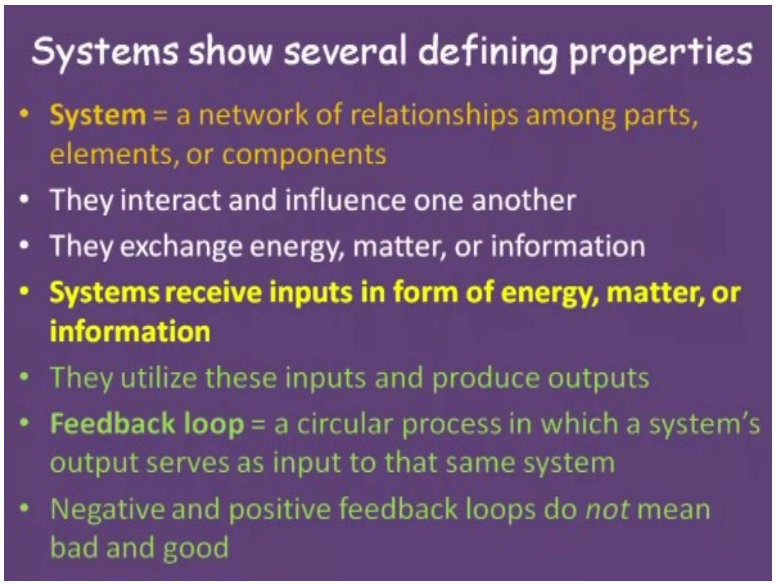

System shows several defining properties. Our system if you define, a network of relationship amongst part, elements and components. They interact and influence one another. They exchange energy, matter, and information System receives input in form of energy, matter, or information. They utilize this input and produces output. Feedback loop, a circular process in which a system output serves as input to that same system. So, this feedback system is extremely important. So, if you basically, that is an interaction between the systems.

The interaction will also influence the system. So, one system will influence another system depending on what kind of interaction it has and it will exchange the energy, matter, and

information and final outcome of any particular system is what we will be talking about the feedback system. So, it may be positive, it may be negative. So, this feedback loop is very much important.

So, it may be negative, it may be positive, but the feedback which we talk about the negative and positive, it does not mean that one is good and one is bad actually, it depends that what was available with the system and what does happen in future and what is the present situation? So, based on, sometime some system gains something, sometimes some system loses. So, this depends on the interaction and final feedback, may be negative or positive. Let us see some examples of this one.

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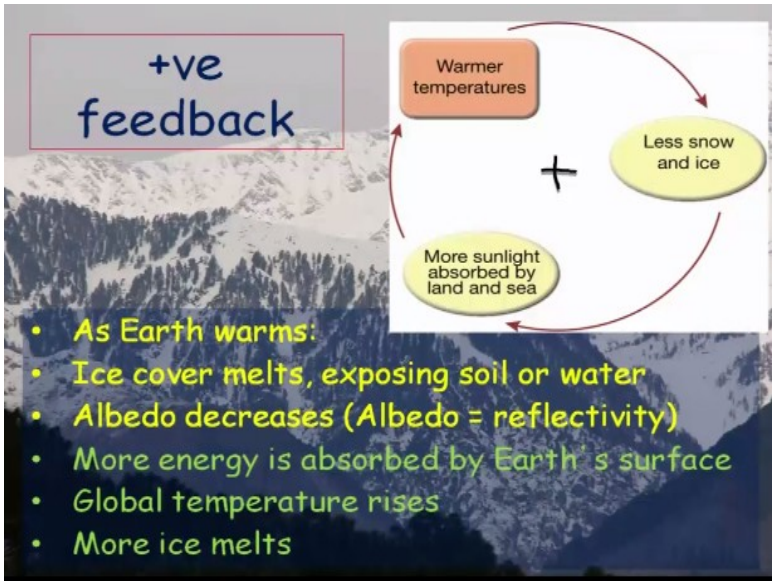

So, positive feedback for example, this is the process, but this will also affect the landscape evolution. So, one has to keep in mind whatever we are talking about is having direct relevance to the geomorphology. So for example, as earth warms and what will happen? The backdrop picture is of snow covered piece from Himalaya. So, if you warm the earth, what will happen, is covers will melt, exposes soil and water. So, basically the soil in the areas like Himalayas for example, and water in the Antarctic, say it will expose soil and waters, albedo decreases.

Alberto is the reflectivity of the sunlight falling on the earth's surface. So, if you have less white area, then the albedo decreases, the reflectivity is less because it will start absorbing, so absorption will result into also warming up of the earth's surface, so more energy is absorbed by the earth's surface, global temperature rises. This is basically more ice melt, something is

added into the system. So, global temperature rises, more ice is melted. So, this is basically the positive system or positive feedback we say. So, warmer temperature, less snow and ice, more sunlight absorbed by land and sea, this is a positive feedback system.

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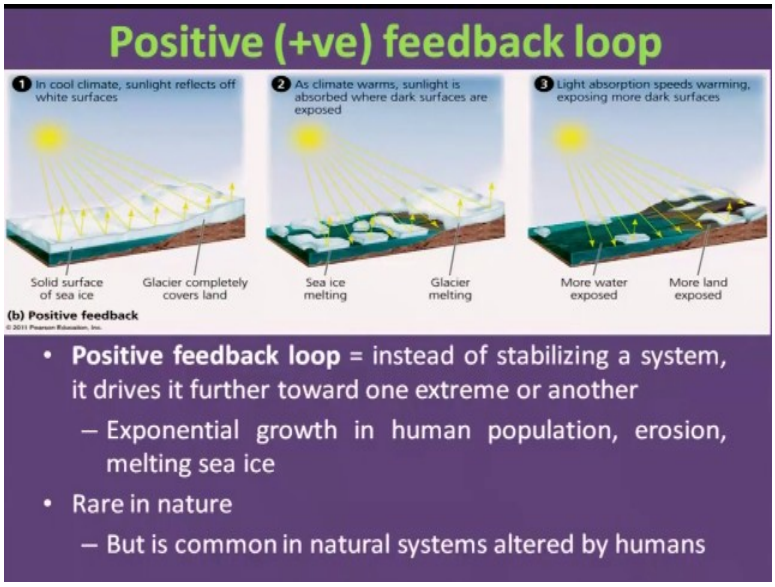

Another positive feedback is the same which we are talking about. So positive feedback loop, instead of stabilizing a system, it drives it further towards one extreme or another. The exponential growth in human population, erosion, melting sea ice will drive the system from one to another extreme. Rare in nature, but is common in natural system altered by humans. So, this may be possible. So, this is another example, the upper one which has been shown is a similar which we are talking about in the previous one.

So, warmer climate will reduce the ice, expose more waters and soil, so albedo will reduce. The sun rays is absorbed by the land surface and water surface making the earth surface warmer, and finally, we reduces the ice caps. This may also result into the sea level rise.

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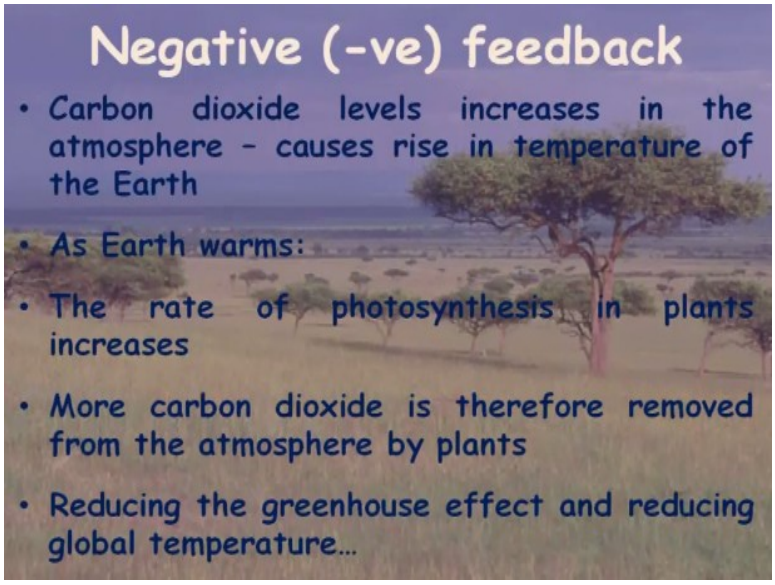

Negative system. Now, this is an example which has been given as carbon dioxide levels increases in the atmosphere causes rise in temperature of earth. As earth warms, the rate of photosynthesis in the plant increases, more carbon dioxide is therefore removed from the atmosphere by plants reducing the greenhouse effect and reducing global temperatures. So, this has become a negative feedback because it has reduced the global temperature.

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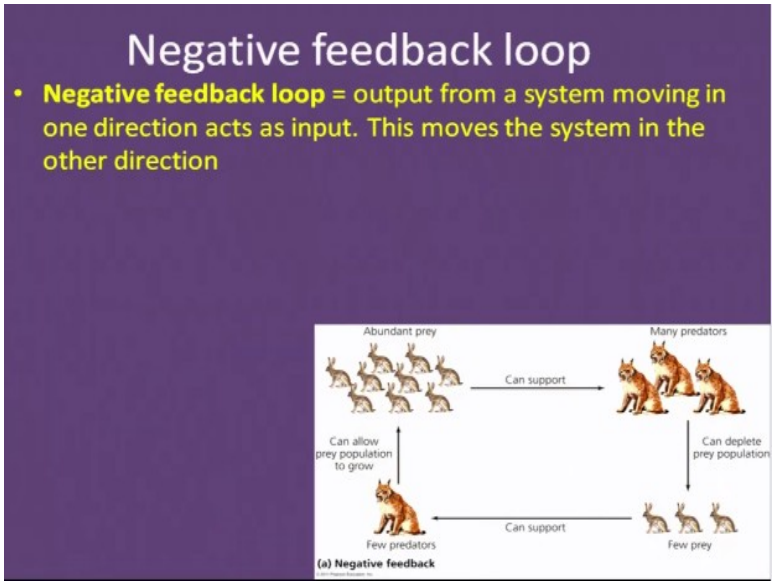

Negative feedback about the abundant prey and the predator. So negative impact output from a system moving in one direction acts as an input. This moves the system in another direction or other direction. So, what has happened what has been shown here is one is there are a lot many numbers of preys are available and that can support many predators, many predators can deplete the prey population and very few preys are left out, and now few preys can support few predators.

So this is overall system as they can negative, initially it is looks like positive, but overall, final feedback is negative. So we will stop here and we will continue in the next lecture. Thank you very much.