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W11L58_Biodiversity Conservation (Guest Lecture) Dr. Krishnapriya Tamma (Azim Premji University)

Hi, my name is Priya and I am going to be talking about biodiversity conservation as part of the I Think Biology course on the NPTEL platform. We all know that the earth is biodiverse, right. I mean from terrestrial to aquatic marine ecosystem, there is a great number of species that we can see everywhere. And it is always fascinating to think about where this diversity came from.

And biology, specifically ecology and evolution fields, they allow us to kind of peer into these secrets of nature and try and understand where this diversity comes from, what structures are, ecological communities, how do they function? And how will they continue to persist in the future? And this has important implications not just for our understanding of nature, but also for our well being. Because after all, we are also part of these ecosystems.

And these ecosystems are critical for our survival. Think about all the resources that we use, right? Most of them come from the environment, the clean air that we breathe, the water that we drink, the soil that we grow up crops in and everything is part of ecological processes. So we are part of nature, we derive benefits from nature and we also impact nature. And it is important therefore to think about the environment when we think about our own well being.

Because it is not just our well being, but also our livelihoods that are connected to the environment, right. I want to take the example of the interconnections that exist in nature and how change in any one of those connections can actually have profound implications for other parts of that interactions. Think about pollinators, right. We rely on pollinators like bees and butterflies and many other species to actually pollinate our crops, yeah. And if those insects decline, and we know that is happening, for example, pesticides are affecting bees, when those diversity of these pollinators goes down, it not only impacts our agricultural production, but it also impacts all the other species that are dependent on those plants, right? So it ends up

affecting us and the other species as part of the environment. So in that way, having a healthy ecosystem is important for our own survival.

But also think about the time when you go to a park or to a forest, how happy it makes you feel. So having access to nature, having access to these well functioning ecosystems is also important for our own well being. So we know that ecosystems are important. What we want to kind of then ask is, what is threatening these ecosystems? Are there certain things that are threatening the stability of ecosystems? Is that why we need to think about conservation? When we think about the threats to ecosystem, there are many of course, right? And it is possible that you have encountered some of these in a previous lecture. But let me quickly list some of the more important ones.

These include things like habitat loss due to land use change, due to land degradation, there is deforestation, which leads to fragmentation, all of which can also lead to increased human wildlife conflict. There is also the additional problem of invasive species, right, species that are non-native that enter a landscape and then flourish. And of course, the most important thing that is on our minds for a lot of us now, which is climate change, which impacts ecosystems as well. Of course, also other things like illegal wildlife trade and over exploitation, all of which affect our ecosystems and our ecosystems and organisms that live in it are forced to kind of respond to these threats. I want to take the example of maybe three of these to kind of explore what these threats actually do to ecological systems.

Let's start off by thinking about habitat conversion, loss and deforestation. So here's a picture, a satellite image that you can see. And you can see that there are these forests which are in dark green and you have these agricultural landscapes embedded into these forests. Now one of the, the three things that I really want you to take home from this image.

First of all, a contiguous patch of forest has been subdivided into smaller blocks by these agricultural fields, which means that some patches of forest are now isolated from other patches of forest. For instance, take this little block, which is now cut off from the other big patches of forest by this strip of agricultural land. And because of this cutting off, if you were an animal say over here in this patch of forest, it would be incredibly hard for you to make it to the other patch of forest perhaps because this habitat is inhospitable to you.

The second point I want to make is that of these edges. If you look at these edges between the agriculture and the forest, there are so many edges, right and every edge is a point where a wild organism is kind of coming in contact with the human habitation. And this can lead to a lot of problems, you know, human wildlife conflict, but also increased connections or contact between humans and wildlife, which can also lead to increased chance of say disease spillovers.

The third thing that I want us to look at are these roads. These could be roads or railway lines, I

am not entirely sure. But these kinds of linear infrastructure that bisect the landscape. Now, you could imagine you could say, okay, this is very thin strip of road, an animal could potentially cross this. But you can also imagine that when animals are trying to use these linear infrastructures to cross, they can be hit by fast moving vehicles that can eventually cause their mortality.

So a landscape, and because of various human activities can get fragmented, can get degraded, the quality of the habitat may go down, all of which kind of put stress on the animals. And like I said, the other thing that emerges from this is increased possibilities of human wildlife conflict, right. So humans and wildlife come into contact with each other. And most often than not, not always, but often, it is in a negative interaction, right. It can result either in death or in loss of property. Animals often have to move out of their habitats, because the habitats are shrinking, the habitats are degraded, they may not get good enough food. So when they come out of their habitats, they encounter human property, human beings, and they can cause damage, right. And often, these kinds of conflicts can lead to loss of life, both in animals and in humans.

The last thing that I want to kind of think about is the spread of invasive, right, a non-native species. This is Lantana Camara. It is a plant that you will see all around India, right. It is an invasive species, it spreads quite rapidly. You might wonder what is the harm in having a few non-native species. Now, invasive species are particularly problematic because they have very high growth rates, they are able to take over landscapes, and they prevent the growth of native flora and fauna. Especially, Lantana has been quite a bit of a problem in India.

Here is a report from Bandipur Tiger Reserve, where they show that almost 75% of Bandipur Tiger Reserve has some amount of Lantana in it. And in some places, the density of Lantana goes up to 80%. So 80% of that patch can just be Lantana. For those of you who have seen Lantana or have interacted with Lantana, you might know, and if you haven't, go and look at a Lantana plant. Lantana is actually quite thorny, and it can grow in this really bushy way.

And it is very hard to penetrate, right. So when you have a lot of Lantana growing in the landscape, it is difficult for animals to move through. So not only is it suppressing and competing with native plants and preventing them from growing, it also has effects on the way animals move and use the landscape, right. One thing I want to point out is that although we look at these threats as individual threats, they are not occurring in isolation. Often two or more of these threats are happening simultaneously, right.

The landscape can be degraded, it can undergo deforestation and fragmentation. And there can be a lot of invasive species that are spreading the landscape, along with human wildlife conflict, right, and many other things. So how an ecosystem or how a habitat responds to these multiple threats can be quite complex. And we need a systematic approach that can allow us to kind of look at how these things impact ecosystems and how they are responding to these different

impacts simultaneously. And this is where biological sciences can really help us, right, especially ecology can really help us in trying to understand how ecosystems are responding to the changes and how best we can, you know, take action to mitigate or to reduce the impact of some of these stresses.

And that brings me to the next part of the conversation, where I want us to examine ways in which biology and as biologists, how can we actually obtain information about these organisms or ecosystems, the threats that they face, and how they respond to these changes, yeah. And I want to kind of explore three approaches that biologists often use to understand ecosystems and the threats that they faced that can aid in conservation.

The first one and one which more scientists are involved in is in estimating and monitoring populations, right. So you can have a population of an animal, it could be a bird, it could be an elephant, tiger, whatever. And you could use various scientific methods to count the number of individuals perhaps to kind of estimate population size, you could look at the number of males and females, the number of juveniles, you could estimate survival rates, how many of them are surviving from one generation to another. And all of these kinds of things provide us crucial baseline data that allows us to understand is a population increasing? Is it declining? Right. And if there is a conservation intervention is that actually working to increase the population size of the animal and so on, yeah.

Here is a picture of a researcher who is kind of counting the number of birds that visit a certain kind of habitat in a certain time. And by doing this in different habitat types, he will get an idea of how many species or how many individuals are using different types of habitats. And from that, he can potentially design certain kind of land use strategies that can help support more biodiversity. So this is one major way in which biologists can contribute to collecting data that can be useful for conservation.

Another thing that we often do is to map landscapes and habitats. Here is a picture and often that is done using satellite and remotely sensed data. And here is a picture that you can see. It's a satellite imagery from Idaho in United States of America. And you can see these forest fires, one of which is big and still burning. There are some smaller ones that are burning here as well. And it's easily visible to us that there have been large swathes of the forest that have been burnt out. So we can use satellite imagery to kind of get this very large scale spatial data, which is otherwise impossible to get if you were to do this by foot.

The third way in which scientists can, you know, add to our understanding of populations is by using something called conservation genetics. Some of you may have already encountered genetics as part of previous lectures. And I want to kind of draw the analogy. It's not a perfect analogy, but an analogy to maybe your favorite murder mystery show, where you would see a detective who would collect hair or would collect blood and they would get information about say either the victim or the person who committed the crime.

And from that they are able to say something about the person. In the same way, you can imagine scientists also getting genetic data from say animals and being able to say something about the individual or about the population from which it comes. And this field called conservation genetics has proved to be quite useful for us to kind of get secrets of populations that we really can't get by just observing them.

For instance, in this map here, you see this is a map of India and these red polygons that you see correspond to tiger reserves. And what scientists have done is by using conservation genetics, by using genetic data of individuals from each of these populations, they've tried to look at whether there is evidence for movement or migration between these different populations.

And if there is, they've then gone on to identify the corridors that these animals use to move from one population to the other. And those are then protected as corridors for conservation. So conservation genetics as well can provide very important clues about how populations are structured, especially over large spatial scales.

Great. So now that we understand a little bit about the threats that biodiversity and ecosystems face, we've looked at how scientists can kind of collect information that can aid in conservation.

I want to just quickly give you a brief outline of the history of biodiversity conservation in India and the various initiatives that the country has taken to conserve wildlife. And we'll start off in the colonial times. So this picture shows you a bunch of British people sitting in front of some carcasses of tigers. The British took to hunting in India, a lot of hunting happened. Hunting also happened before the British came, right. A lot of our kings also indulged in hunting, but mostly as a sport and not really as a means to exterminate or to kill off a species.

On the other hand, the British, they hunted, but they also took it up as a way to exterminate a species, especially large carnivores like tigers and to some extent leopards as well. And this is called bounty hunting, where you basically reward people for bringing in, say the carcass of an animal or a head of an animal. So the British wanted to exterminate tigers because they thought of them as vermin, as pests, as beasts that were not worthy of being in the landscape. And so they actually wanted to wipe out the species as a policy. And that really led to a lot of decline in tiger populations in the country.

It is thought that from a population size of 100,000 individuals, tiger populations crashed to about a few thousand in a relatively short period of time because of these measures. While they were hunting tigers, there was also a parallel destruction of forest, right. There was a lot of tree felling and forest loss in many parts of India, specifically in central India, as timber became very valuable and there was large scale cutting of forests to use timber for railways. Remember, there was the increasing rail network across India to make coal and also to convert the landscapes for

agriculture, yeah. So tigers at this time are facing not just decrease in population size because of direct mortality, but they are also seeing a loss in their habitat because of forest loss.

Of course, after the British left, a young India also took certain decisions that you know, that saw developmental projects being implemented across the country. So all of this together brought a lot of species and ecosystems to a point of vulnerability. And many naturalists and environmentalists like Salim Ali, Krishnan and others, they started sounding the alarm bell saying that there are a lot of species that are declining in their numbers, right? And we need to kind of talk about this and we need to do something about this. This alarm that a lot of people were feeling when they saw the state of the natural world around them in India, kind of mirrored what was happening globally, right. And that was growing concern for environmental degradation. There were movements across the world demanding clean air, clean water, and an increased consciousness about environmental degradation.

By the 1960s, 1970s, it was clear that many species like the tiger, the gharial and other populations of other species also began to decline quite precipitously. And there was pressure put on the then government led by Indira Gandhi to do something about this, right. And she was willing to consider nature protection, as she was also a nature enthusiast herself. At the same time, there were also these mass movements, right, people's movements that kind of shaped attitudes towards biodiversity conservation in India. And a lot of these stemmed from movements around rights and livelihoods, rights over forests and the livelihoods of people who depended on these forests. Two of the most famous such movements, quite different in character, but that happened in a similar timeframe are the Chipko movement and the Silent Valley movement.

Many of you might be very familiar with this famous photograph of women who hugged trees as a means to protect them from extraction. And with this movement, the environmental movement, and the pressure from naturalists and from environmentalists, the government then decided to kind of put in some laws to protect the environment. And that gave birth to the Wildlife Protection Act of 1972 in response to the declines that we saw in populations of many species, including the tiger, the great Indian bustard among others. I just want to kind of point out, I have a screenshot of the first paragraph of the Wildlife Act and I want to just read it out to you. It says this is an act to provide for the conservation, protection and management of wildlife and for matters connected therewith or ancillary or incidental there to with a view to ensuring the ecological and environmental security of the country.

And that is very important. When we often think of security, we think of a military security, right. But the ecological and environmental security of the country is equally important because that is what nourishes us, right? That is what keeps us going. And so this act aimed to ensuring ecological and environmental security of the country.

One of the things was the outcome of this act was also the creation of a protected area in India, right. So many protected areas were being created. These are areas or these areas were envisioned as being places where there would be minimal human activities. There are many different types of protected areas in India, including national parks, wildlife, sanctuary, conservation reserves, community reserves, marine protected areas and so on.

And they all differ in the level of protection that is given to them and how much access is given to humans. Yeah, apart from these protected areas, there are also other sites of conservation importance including RAMSAR sites and all of that. So the act and a lot of the things that we have put in place so far, basically aim to protect the landscapes that are already there, be it forests, grasslands, scrublands, you know, to protect these different types of habitats from further degradation.

But what about landscapes that are degraded, right? There's also a parallel effort to kind of restore and reforest habitats, right? Restoration basically involves going back looking at how the landscape was before it got degraded and trying to get that landscape to that point again. And in this kind of restoration efforts as well, ecological data becomes crucially important, right? Knowing what is the community of animals and plants that were there, in what proportions they were found is important for restoration efforts.

Having done all of this for conservation, what do we have? We do have some successes, right. For example, if we just take the project tiger as an example, we know that there has been tremendous progress that's been made. For example, there are about 3,682 tigers that are reported as of a recent report from 2023. And that's phenomenal increase, you know, from about 1,500 individuals in the 1970s to almost 4,000 individuals is a success, right. And today, India boasts of the largest population of wild tigers in the world.

Remember those three ways in which I said biologists or scientists can contribute to conservation. Let's kind of look at whether those have been used here. And that is true, right. For example, using either camera traps or genetic methods, we have a very accurate estimation of population sizes for tiger, right. We also have used remotely sensed data to map changes in tiger habitats to come up with better conservation plans to look at corridors to look at movement and so on. Yeah. Third, conservation genetic studies have also helped us understand how these different populations are connected to each other to help us identify corridors where animals are moving and protect them as well to make sure that the different populations remain connected to each other.

While tigers can be considered a success, you know, the conservation of tigers to some extent, there are many challenges ahead, right. There are still species like the great Indian bustard whose populations are declining. Yeah, forest loss continues to happen for various reasons. Another important threat on the horizon, or something that is already affecting our ecosystems is climate change. And so in order to kind of work around all these different threats and to kind of protect

the functioning ecosystems that we have, we have to work with local communities, we have to work with various people in the society to bring about biodiversity conservation.

In this lecture so far, we have explored how biodiversity is important for our own well-being. We have looked at how biology can help us understand the natural world, what kind of techniques and approaches we can do, and how actually that information can be used to drive conservation goals in India, right. And how we have to work with various different stakeholders to bring about this conservation. And we have to do it because it is important for us. A planet that is diverse, that has clean environments will result in a healthier human population. And biology, specifically the study of ecosystems and wildlife has tremendous implications for our own well-being.

And biological conservation requires us to apply the knowledge that we have of ecological systems to ensure their long term assistance, right. And as scientists and biologists, our work can provide this crucial data. With that, I'd like to thank you all for your patience.