

Hi everyone I hope you're all safe and well and I hope that we can get our online interactive and discussion sessions going soon and over zoom. But in the meantime I'm going to continue to record and upload these lectures and along with some exercises and discussion sessions to blackboard. So hopefully you can download those and continue to work through them until we get the online interactive sessions back up and running.

And so, in the first week we looked at the basics of conservation what it is and why we do it and its history. This week we're going to have a look at what the main causes of biodiversity loss are in the world, and why we need conservation to try and protect the diversity we have on earth.

Slide 2

So when we're looking at the cause of biodiversity loss we need to have a think about the different layers of causes and this kind of progression from an underlying driver up to the unfavorable state of the conservation targets. So that can be an extinction, it can be the decline in numbers of a population. It can be habitat destruction or something like that. And so down here at number one we have that unfavorable state of conservation targets. And so that's kind of the very worst that can be for us is an extinction, so a species completely disappears and but, on the way to that you get population declines.

And then so that's The thing that we can identify as going wrong, and so we're losing that diversity in some way. And then from one to four here you have these kind of different layers of causes. And you have the proximate causes which are the things that are directly causing the extinction so whether or not that's hunting or its habitat loss.

And as you get further away, you get things that become more of the ultimate causes so what it, what is it that is driving people to hunt those animals or to cause that habitat degradation. Is it because it's it gives them money to do so, is it because they work in industry that that makes profit from doing that, or is it some other reason. So it's not quite as simple as saying this species is declining, because of this one thing, you have to think about these different layers of causation So yes, poaching might be driving something towards extinction but why is that poaching happening, we need to think a bit further away from that and think why are people doing that poaching and what is the ultimate cause, because if we're going to try and stop that poaching which will ultimately help that species not decline and hopefully increase in numbers, again we have to tackle all those layers of threats we can't just try and stop the poaching on the ground, we have to think about what's causing it. If we don't tackle the ultimate cause of that poaching or the other threats that could be anything from habitat destruction even climate change if we don't address the ultimate cause of that it will probably continue to happen. And any kind of tackling the proximate causes so that that that poaching is approximate course or the thing that is directly, causing the decline. And that will continue to happen, and it may continue to drive that species towards extinction.

Slide 3

So just as an example of this hierarchy here and we're going to have a look at black rhinos, which is the species that I work on in Kenya. So here the unfavorable state of the conservation targets is the decline of these of this species. So these colored lines on this map of Africa here, show the historical range of four of the subspecies of black rhino. And so, there is the Western the eastern the south central and the southwest subspecies so that there used to be four of them. The Western subspecies is now extinct, so that is an unfavorable state of a conservation target because we don't want these subspecies to go extinct. And the graph at the top left here shows the numbers in different African countries of black rhinos. So as you can see they've gone extinct in a lot of the countries they used to

exist in and that only now in five countries, as opposed to the many that they used to be in. There has now been a reintroduction into Rwanda, so there is now another country that has these animals. But, as you can see that that the range, the size of the range, has decreased, because that whole pink area has now disappeared for black rhinos and also within the countries they still live in they don't live across these whole areas anymore, they just live in quite small relatively small protected areas and they've also gone extinct from lots of these different countries. And it's not just that they've disappeared from some bits of their range and numbers have gone down massively as well. So the y axis on this graph is a logarithmic scale and as you can see it's it goes from one to much higher numbers. The numbers have gone down hugely since the 1970s. It's not just kind of gone down by half it's gone down by an order of magnitude or more so the numbers have gone down massively as well.

Slide 4

And so what is causing this unfavorable state of our conservation targets? Well as I was using as an example, before. It is primarily due to poaching. It's not just poaching and there's been issues with habitat loss and other things with like rhinos but especially since 2008. Well, the first kind of big wave of poaching for rhinos happened in the 1970s in the 1980s, and that was the primary cause for that big decline, we saw on that on that scale just a minute ago. And then poaching started again in about 2008 well it had always been going on at low levels, but it's it started up again very, very it was increased massively again from about 2008. So poaching is the main threat to black rhinos and it has been since about the 1970s. So this graph here just shows the big increase in the poaching of African rhinos from to almost the present day, so there has been a decline recently. This isn't just black rhino is by the way this is white rhinos as well which are the two African species of rhino, and so there has been a decline recently. But there's still a high number of rhinos that are being poached every year, so this direct killing is the main threatening mechanism which was number two on our hierarchy of causes behind the decline of rhinos across Africa.

Slide 5

So why are these animals being poached or the source of the threatening mechanism, which is number three on the hierarchy and is the demand for their horn. And earlier in this century, so when the big increase started again was for two reasons, it was for East Asian traditional medicine or Chinese traditional Chinese medicine, which is often abbreviated to tcm and and also for dagger handles in the Yemen. So in Yemen, when met when males when male humans, when people become a become a man as part of that process, traditionally, they are presented with a with a special dagger And the most expensive of these had a rhino horn handle so that was where the demand used to be for rhino horn. And due to the really dreadful humanitarian crisis in Yemen, the demand for Horn from there has gone down, but the demand for rhino horn for traditional Chinese medicine has gone up massively in China, and also in Vietnam since. So the demand for this Horn for those uses is number three the source of that threatening mechanism.

Slide 6

And then the underlying driver, which was number four sorry there's a mistake on the slide there at number three should be number four so that that ultimate cause the one that was furthest away from the the unfavorable state of our conservation targets at least in the last 10 years or so, has been or one of them has been the growth in the the population of affluent people in China. And so rhino horn is expensive very expensive, so you need to be fairly wealthy to afford it. And this graph here shows the a big growth in the number of affluent households in China since. So the scale here is

in millions, so this is 50 million urban households, 100 million households, etc, and as you can see the light blue section of the bar shows the number of affluent urban households in China and, as you can see from 2013 to 2020 it has grown a lot and it's projected to grow even further in the future. So one of these underlying drivers for this poaching, is that there are more people in China it's not just China, this does happen in other countries as well, and there's a big growth in the number of people that can afford this rhino horn. So therefore there's a bigger demand for it, so therefore more poaching happens. So this is one of the underlying drivers for why rhinos are declining in Africa or have declined in Africa, so if we just tackle poaching by using security and rangers and things like that and don't tackle this underlying driver, which is the demand for the rhino horn from these affluent people and then we're not going to let them will it will struggle in the long term to protect the rhinos. Now what i'm not saying is that we need to stop these people becoming more affluent that's not what i'm saying at all it's not that in order to protect rhinos, we have to have more poor people in China or we need to try and prevent people becoming more affluent because obviously that clashes with social goals to you know, to lift people out of poverty and have more people having better lives. So the solution here isn't we need few affluent people in China, the solution is, we need to try and persuade those newly affluent people that rhino horn isn't a medicine. There's no evidence at all that rhino horn is effective as a medicine for any ailment or disease. And we need to persuade them that rhino horns are better on the rhinos on living rhinos rather than used as a medicine. And so that's where the challenge lies the challenge lies in tackling this underlying driver by stopping the demand for rhino horn completely. So this is just showing you that it's not just as simple as this species is declining, because of this cause, we need to think behind that cause and think what is driving it so that we can tackle it at the at the source of the problem, if you will.

Slide 7

So these are the primary threats for by diversity around the world, and so, even though i've just been using a poaching example direct killing and poaching doesn't feature in this in these biggest threats facing biodiversity around the world, and this takes in to account and not just vertebrates. But it looks at all freshwater and terrestrial biodiversity, including animals, plants and microbes. So the direct killing is going to be affecting large vertebrates mostly and, but when you look at all, biodiversity and other threats become more important.

So, as you can see here the relative effect of these drivers of biodiversity loss, the most important is land use change, so this is when habitat is changed, mostly for farming so say area of rain forest is cleared so that cows can graze it and for human food production. The second most important is climate change, which we will talk about a bit later on, and then we have nitrogen deposition a lot of this is in fresh water ecosystems where fertilizers and other chemicals run off the land into fresh water which we talked a bit about in the first lecture. And then that affects those freshwater organisms, such as fish and amphibians. Biotic exchange is invasive species and so again, we talked about that a bit last week with the brown tree snake on guam, and so this is when a species is introduced to a new area and its effects impact those the native species that live there and causes them to decline. And finally, the last one is increasing atmospheric CO₂, so this is related to climate change, and it has other impacts, as well as just kind of global warming and it causes acidification of water courses and other things like that. So these are the primary threats that the world faces or the world's biodiversity faces, this is the main things that are causing the decline of biodiversity around the world.

Slide 8

And now you're going to have a quick look at some of these most some of these important drivers, in turn, and so the first one is land use change and which we will talk about a bit now, so this is a map that shows what the vegetation type should be around the world, and so we have things such as tropical forests around the equator in the tropics. So that is your rain forests, which includes Myanmar. We have temperate forests, which are a bit further away from the equator so that's where I am now in the in the UK and in Europe. We have savannas which are the light green which you get large areas of in Africa which aren't desert and aren't in the Congo rain forest are savannah. Then we have other types of which are a bit smaller are grassland and shrubland. And so we have that in the steps of Central Asia and in parts of the USA and then tundra and Boreal forests, which are in the far northern reaches of the planet where it's very cold. And then, large areas of the planet are also covered in desert semi desert so without human impacts, this is what the vegetation types or the items that we talked a bit about in the first lecture would be around the world.

And a lot of the land, what the land would look like and lots of places before humans started had an impact it now looks very different.

Slide 9

So, before I get on to how land use change has progressed and we're going to have a quick think about why that's happening, and to do that we're going to have a think about the costs of conservation. So the cost of converting an area of land, the cost of conserving an area. And so, and so, think about an area of land in a rain forest. And it hasn't been affected by humans and it's still sort of a pristine rain forest and it's got very high biodiversity. Rain forests have the highest amounts of biodiversity of any biome. And it's it's great for conservation, for it to be there, however it's not really giving any humans any economic value. And there's lots of ways of valuing biodiversity and valuing land which we will talk about a little bit, and I think Kathy has mentioned. I'm not saying at all that this land doesn't have any value, but no one is getting kind of a direct cash payout from this land at the moment because it's, you know, no one is farming it, no one is using it for any economic activities. It's definitely valuable, I definitely believe that all of that is valuable, but it's not giving anyone any direct cash payouts. So, to protect that land for conservation, there are five types of costs. There is acquisition, which is just the money that you pay for buying that area buying that property. There's management, which is the ongoing cost of maintaining it so whether or not that fences whether or not that security or not that's paying employees. So that's the management costs which are ongoing. So acquisition is usually a one off cost you just buy the land and then it's yours, management is an ongoing cost. You have transactions which are negotiating an economic exchange and so that's searching for the people that own the land it's negotiating with them and then it's obtaining approval for the buying land from an authority. So there are costs involved with that process. So it's not just the price of the land it's the money that you have to pay to make sure that you can acquire it. And there are damaged costs which are damages to economic activities arising from conservation programs. So this can be human wildlife conflict so say in India, there are some problems with elephants coming out of the forest and damaging villages, damaging tea plantations,. So there are costs associated with that it's not just human wildlife conflict but that's one of the best examples where large animals can come out of those protected areas and can damage people's livelihood. And the last one, which is why i'm talking about the cost of conservation in the context of land use change is the opportunity costs of conservation. And this one is kind of the most difficult to to understand because the other ones are either costs you're paying directly to buy and manage the land or costs of damages because of that this one is that see you protect that area of rain forest. You

can't then use that rain forest that area for farming generally or another economic activity, if you want to preserve it without any human impact, then you can't use it for another economic activity.

So say someone comes along and wants to cut down the trees and turn it into a cow ranch or a cattle ranch. The money that they would get from doing that is not being seen is not being realized because it's being conserved for its biodiversity. Therefore, that the potential profit that someone would make from setting up that cattle ranch is an opportunity cost it's not a direct costs, because no one is actually paying any money for that cost but it's a potential loss of income, so we could make more money by farming it than protecting it, so the difference between the money we are making to protect it and the different and the money we would make to farm, it is an opportunity cost. So I have that written here is conserving a particular area, it means that land cannot be used for other activities that may create more profit may create more income.

There's other things, to think about here, which is conservation does have economic benefits, often not considered as well, so it's not as simple as we are not a farming this place, therefore, we are seeing the benefits from it that's not true at all so by protecting that area. You are not only preserving the biodiversity for its own sake, but you are likely conserving the water cycle. And so there are big problems potential problems with the Amazon being cut down in effecting rainfall patterns. You are conserving genetic diversity that might be useful in the future for and finding new medicines or finding new products that may be useful for humans, and so you there are a lot of economic benefits from conservation that aren't often thought about. And, which is worth considering here and but we'll have a but the point I want to get is that one of the costs of conservation is not using areas of land for other economic activities.

Slide 10

So this figure is from a paper that shows the opportunity costs of conservation for a forest reserve in Paraguay. So the costs here in US dollars or the opportunity costs per hectare for conserving this forest so as you can see it varies from place to place. So certain areas might be more suitable for farming or mining or other economic activities than others. So the darker and area is the larger the opportunity cost of concerning that place. The middle sort of grey hatch area is where a protected area already is so if we were going to expand this Protected Area there's variations in the opportunity cost of doing so, depending on where you expand it to you.

Slide 10

So if we go back to a pre human world and we have all this all the land is in the state that it could potentially be in so all of this different types of vegetation. So if we were to be dropped on the earth now with those biomes. There has been no human activity on the earth whatsoever but a bunch of humans are dropped on the earth. By conserving it there are big opportunity costs because we could be instigating other activities that would make us money, whether that's farming or other things. And so there are different opportunity costs by conserving those different places.

And so i'm going to show you a few maps, now that show how land use change has progressed. And so, as you can see lots of areas of the world have been converted from that potential vegetation type to cropland. So there's very heavy conversion to cropland in India in East Asia in lots of Europe, especially Central Europe and the very Western side of Asia and lots of the USA and Canada, so those potential vegetation types, which would have had a lot of biodiversity, and you know lots of also plant species lots of mammal species and everything else are being converted into croplands which will have lower biodiversity.

Slide 12

There are different parts of the world that have been converted into pastures or rangelands. So these are often areas that aren't suitable to grow crops so they're there to dry or we're usually there to dry. And so, whereas these areas are growing crops such as wheat or rice or anything else, these areas are raising animals to be used for human consumption. And these are generally areas that are too dry to grow crops, so, as you can see, northern Australia is one of those places lots and lots of pasture and range land, not many crops, because it's too dry.

Slide 13

And, and this is just an example of how this land use change from that potential vegetation type which here is a rain forest on the hill on the left of this slide to a cropland which here is oil palm plantations which you get a lot of in Southeast Asia. And this conversion massively simplifies the habitats. So when you have a very complex, very biodiversity rich rain forest you get a much more simple monoculture so these palm oil plantations are completely dominated by this one tree species, which is economically valuable for humans. So it's, not to say that there's no other biodiversity these plantations, but there is much, much less than it is in that rain forest you see on the hill there. So say we were dropped in this landscape pre human impact, it would be dominated by that very by diverse rain forest. And by protecting that rain forest into the future, there is a huge opportunity cost, because we could convert it into this oil palm plantation and make lots of money from selling the oil, the resulting oil. And so there would be economic benefits of protecting the rainforest but potentially there's we can make a much quicker and much bigger profit in the short term by converting it into oil palm. But when we do that we simplify the landscape and we destroy quite a lot of the biodiversity that was associated with that rain forest. So that's why I was talking about opportunity cost and middle there was because a large part of why conservation is often less valued or not prioritized is because of the big opportunity costs of protecting landscape, so if we can make more profit in the short term by converting it into a crop or range land, then that that kind of monetary incentive, often in lots of people's minds takes precedence, and so they will convert the land for farming, instead of protecting it for conservation, so that is why land use change is one of the big or is the biggest threats to biodiversity on.

Slide 14

And again this just shows next to each other how you have these potential vegetation types. These areas are being converted to what the authors of this paper called anthromes so you can have dense settlements, villages, croplands, rangelands. So this potential vegetation type at the top, is being converted to these human dominated landscapes at the bottom here. And then the big areas of wild lands left are the Amazon, the Sahara and that's just mostly because it's too dry really to grow anything or to try to raise animals and the very cold parts of the far north which are the boreal forest and the tundra. So the areas that haven't been converted aren't undergoing land use change are the areas that are least economically valuable for humans to do so. So we can't really grow anything in those very cold places in the deserts we can't really raise animals there so they're still they've still been left fairly wild because it's not valuable for humans to do so, there is a very low opportunity cost of conserving those places because there aren't really any at the moment there aren't really any highly profitable industries that can be set up there. That may change in the future, and also it's quite unfortunate because those are places that yes, they do have amazing species and they do have good biodiversity, but they are much less diverse than the tropics and which, as you can see, by this map have been converted from that potential vegetation types, to a much greater extent.

Slide 15

So the most anthropogenic transformation has happened in tropical and temperate deciduous forests and grasslands and tundra, why is this important why just mentioned it, then those, especially the tropical forest, very biodiverse. And so we are losing our biodiversity by converting those places also there are different species in all of these places so by converting a lot of the temperate deciduous forests we've lost a lot of the biodiversity that only exists in that biome. So because we haven't converted many deserts there will still be lots of desert biodiversity around, even though the level of biodiversity in desert generally is much lower than in tropical forest say. We still have a lot of kind of wild land in deserts whereas temperate deciduous forests tropical forests we're losing by diverse in those places much more quickly, because they're being converted there's much more land use change happening in those places.

Slide 16

The second threats i'm going to talk about is climate change which i'm sure you've all heard about, so this is caused by human industrial activity and other things releasing greenhouse gases into the atmosphere these greenhouse gases trap some of the solar radiation comes in, to our atmosphere from the sun. And so the more greenhouse gases, we have in the atmosphere, the more the planet will warm up because we're trapping some of that radiation in the atmosphere.

Slide 17

So why is that important for conservation well it's changing the distribution species, we have, and it changes the suitability of habitat for different species. So this example i'm using here is the Gray long-eared bat in Europe. So what studies like this do is they look at the range of a species in the present day, they predict the future, how environmental conditions including temperature and rainfall and other things will change into the future. Based on climate models and so here the future they're looking at. The environmental conditions in Europe will change because of climate change and the colors on the graphs at the top here are the red and yellow those are highly suitable for this species and the blue is less suitable. So, as you can see, as the earth warms the suitability of habitat for this back will shift northwards so much more of the UK will be suitable habitat for it, more of Sweden and Norway and in southern side of Europe, and there is more blue in the scenario than in the present so some of southern Europe would likely become too hot, so it will be shifting to the north. And at the bottom here, and this the green areas are places where the bat will be able to migrate to move more in the future, which is based on landscape resistance. So landscape resistance is how much it's been converted by humans so lots of species may not be able to move through human dominated landscapes, because you know, there are no, there are a few trees is fewer water sources things like that. So, in the present day, and the bat migrates around Spain quite a lot from different habitats centers which will be the little white dots in the future, and due to both climate change and human land use change. So this links into the land use change. The bat may not be able to move around Spain so much and may not be able to move between these populations and make them become isolated. which causes other problems. And so land use change and climate change act together so if climate change is going to force species to migrate in the future and if human land use change means that the habitat is less suitable for their species to migrate, then they may not be able to move in response to climate change, and therefore they may decline and go extinct.

Slide 18

So that's one way that climate change can cause declines if they're not able to migrate due to human land use change. If they cannot migrate to find suitable habitat and they may decline other species may be in more trouble because there may be no more suitable habitat for them. So if the Earth is warming different types of habitat may migrate towards the poles. If there's a cold adapted species, they need to be in the cold. If where they are is becoming too warm they will migrate northwards to kind of keep pace with that cold habitat type. But what about species that are already at the poles there may be nowhere else for them to go, and this is also worth thinking about for species that are already at high altitudes. So generally as you go up an altitude it gets colder. So species that are already at the top of mountains may have nowhere else to go they can't migrate to a higher altitude, because there's no other habitat at a higher altitude to them, so this is something to think about in mountainous areas. So this example here is in Scotland. Scotland has the highest mountains in the UK and after the last ice age as the ice sheets retreated towards the poles and it was kind of an example of that climate change so as a species migrated poles or up in altitudes. Certain species that are adapted the cold may have migrated North through the UK and now just live relatively high altitudes in Scotland. So they're kind of stuck on these islands of habitat around which is the top of these high mountains around Scotland. So living in isolated populations in these small areas that are cold enough for them to survive. And one of the examples of this is this dwarf willow, so this already lives at the top of the highest mountains and Scotland. As climate change progresses there's no other there's no more high altitudes for it to migrate so therefore If climate change progresses the species may become extinct.

Slide 20

One of the other big threats for certain species, which wasn't on that graph of the most important threats, but it's definitely worth thinking about is hunting or harvesting. So again, as I said before, this is most often important for large vertebrates. An example often used is the North American bison. So before Europeans arrived in North America or before Europeans colonized North America, and there were millions and millions of this species across the continent and their reports have herds of up to a million of this species. And, but around the 19th century as European settlers moved Westwards and as they increased the infrastructure present on the continent and it allowed them to go and hunt these animals. Now Native Americans were quite heavily or certain native American cultures were quite heavily reliant on the bison as a source of food and as sorts of other resources, including for meat and fur. And so as Europeans colonized North America. Yes, they could hunt animals for meat or for sport and other things like that. But as they wanted to get rid of the Native Americans, because they wanted to take this land for themselves, part of their strategy of doing that was to kill as many bison as possible to take away that resource from the Native Americans. So this became especially bad when the transcontinental railroad was finished and it allowed huge hunting parties to travel around the continent to kill the buffalo that the native Americans relied on.

So it wasn't just get the train to a certain area get off the train go hunting often. As the train moved across the continent, they would just be shot from trains. So they weren't actually used for anything then. They weren't used for food, and they were just shots from a train and then train kept going and the buffaloes would just be left to rot, and so this is a quite horrible way of approaching oppressing these Native Americans and of killing lots of them because they didn't have the resources to survive.

And this led to an incredibly fast decline of the species so as you see here there's by the mid 19th century there were 30 to 60 million bison. By the end of the 19th century, so maximum 50 years

later, there were only 300 left. So this is a rapid rapid decline this species, which was partly to try and take resources away from the native Americans. So humans do have the capacity to lead to very because very fast declines of certain species due to direct hunting and harvesting.

Slide 20

The other example i'm going to talk about now is the invasive species. Sorry at the start of the lecture I said I talked about this in week one but i've actually put it in this lecture here. So invasive species are particularly damaging for certain types of habitat and certain types of animal. And so I did talk a bit about it last week with the dodo. So invasive species are species that are moved by humans to a new area where it hasn't existed before. And so that's an alien species, it becomes invasive when it causes damaging effects on that new ecosystem. So most often this affects most badly island habitats which often contain a lot of endemic island species have been evolutionarily isolated for a long time. So the dodo is an example of this on Mauritius. So that's an isolated island ecosystem. Lots of birds in these places, including the dodo evolve to lose the power of flight because they no longer need it. If there aren't mammalian predators around they need to escape from they lose the power of flight and they become flightless. But when you do then bring mammalian predators, such as rats, on to those islands those species are very vulnerable because they don't have adaptations to escape those predators. An example of this is the brown tree snake on guam which is an island in the Pacific. This was introduced to this island and it quite quickly caused the extinction of the native forest bird species. And I don't think these are all flightless and none of them may have been flightless but this tree snake could get into the nest eat the eggs. It kind of reduced the rate of breeding to almost none. It can also kill the adults and it caused the extinction of these animals, very quickly, because they had no defences against this new predator.

it's not just island species that invasive species effects it can have on continents as well and but it's just that these endemic species are particularly vulnerable. Other examples of this are the cane toad in Australia which is poisonous to animals that eat it. So that caused the declines because native Australian species would try to eat it without kind of being adapted to know that it was poisonous. And then it's not just the direct impacts of in animals, they can sometimes bring foreign diseases with them as well, which the native species are not adapted to deal with. So an example of that is the Grey squirrel in the UK, which came from North America and it brought a thing called a squirrel pox with it, which affected the red squirrels very badly and lead to very quickly to declines of those red squirrels.

Slide 21

And one of the other threats that ecosystems face is pollution. So it can affect any ecosystem, but as I said, for the nitrogen deposition bar of those of the threats of that graph of threats earlier on. And it particularly effects fresh water ecosystems and often because they are, and I put this in inverted comma here they are downstream of terrestrial ecosystems. So say you put a fertilizer on a farmer's field and then it rains that fertilizer gets washed into the nearest stream into the nearest river.

And so, so those streams and rivers become kind of meeting points for lots of the pollutants that were on the land, so they kind of concentrate into those freshwater ecosystems it's not just agriculture. Certain industries can actually put those pollutants directly into rivers and streams because it's an easy way of getting rid of them. There are other problems, such as other industries such as mining, which is particularly prevalent in tropical rainforests at the moment, and so they can

use mercury and other heavy metals, to try and help industrial activities and they're very damaging for certain species.

And amphibians are particularly vulnerable to pollutants, because of their permeable skins. So if they come into contact with a pollutant in the water, it can get into their bodies quite quickly, whereas with other species that have less permeable skins, such as mammals or fish and they may not be affected as badly.

Another thing to think about with pollution is called biomagnification. So this is where you have a food chain, or food web. So say you have something that eats plants and then so in a fresh water ecosystem that may be a type of fish and so that's eating plants from the bed in the bottom of the river and then you have another type of fish that eat that that smaller herbivorous fish. And then say you have a bird of prey that's like an osprey that eats that predatory fish. So you have a chain or a food web where things that are eating other things. I'm sure you're familiar with this concept, but if you have pollutants at the bottom of this food chain, so say that those plants are taking up a certain pollutant the small fish, that herbivorous fish, is eating a lot of those plants. So the little bits of pollutant in each those plants or get concentrated in that small fish. The bigger predatory fish is then eating a lot of those small fish so again they get concentrated into that big fish, and then the bird is eating off those predatory fish. So each step up that food chain you're getting higher and higher amounts of these pollutants, so this is called bio magnification. And what this leads to is that the animals at the top of that food chain apex predators are consuming huge amounts of these pollutants. So famous example of this in Europe was a pesticide called DDT, so this is a chemical that farmers were using to try and kill the insects that were damaging their crops. This was being washed into these freshwater ecosystems, it was bio magnifying up these food chains and then it was causing big declines of predatory birds, these raptors I was talking about.

Slide 22

And one of the big problems that this was causing was eggshell thinning. So birds that had a lot of this pesticide in this body probably wouldn't die straightaway, but the eggs they produce have very thin very weak shells, which could easily be destroyed just by rolling around in the nest. So as soon as the shell breaks the fetus inside the egg may die. So this is just an example here of how normally if you press the pencil against an egg it wouldn't break the shell if you did it quite gently. These eggs have really thin shells and so a lot of them wouldn't have hatched because the features inside would die before they hatch. So this is an example of a of an unintended consequence, so the farmers weren't trying to kill these birds, it was sort of a byproduct of their use of this particular pesticide which they were putting on the fields, not to try and kill two birds to try and kill other species, but an unintended consequence of that was it would was into fresh water, it would biomagnify up the food chain.

And then these birds of prey began to decline, because of that. So this is an example of how ecology and conservation can be quite complicated and it can be quite hard to figure out. The chain of causation between an action and a state of an unfavorable state of a conservation target like we we talked about at the start. So in this example the decline of the birds of prey is the unfavorable state of the conservation target. So go right back to the start, and you can kind of think about this. The threatening mechanism is the use is the chemical that is bio magnifying up the food chain, the source of the threatening mechanism is the farmers applying to the fields and the underlying driver is the economic demand for food and the desire of the farmers to increase their profitability. So we all need food, we all need to be fed which causes farmers to try and maximize that food production,

maximize their profit. So they use this chemical which leads to these declines of birds of prey but figuring out that cause of that chain of causation can be quite complicated and very difficult.

Slide 23

Finally, I'm going to talk about disease. So this can be an important driver of local biodiversity decline and can interact with other causes. This is particularly relevant now in the middle of the COVID-19 pandemic that we're in now. There have been some studies that have been published that show that greater amounts of habitat destruction lead to greater incidences of diseases jumping from one species to another. So the more we destroy habitats, the more likely we are to come into contact with diseases that can affect us and lead to pandemics, such as COVID-19. So disease isn't just relevant for conservation, but also relevant for humans. A particularly sort of damaging example of how disease is leading to biodiversity declines at the moment is this chytrid fungus, which causes chytridiomycosis. So, again amphibians are particularly vulnerable to fungal diseases and other diseases, because of their permeable skins and this chytrid fungus has caused the decline of many amphibian species around the world.

Slide 25

So, we've gone through sort of some of the main causes of biodiversity decline around the world and how they go from underlying drivers to proximate causes to biodiversity decline. But it isn't just these direct effects that lead to biodiversity decline. Some of the impacts of these anthropogenic activities lead to secondary problems and which can amplify the consequences of these things. I talked a little bit about how ecology is complex and how it can be difficult to figure out the chain of causation between an action and a decline of the species. But it isn't just that certain lead to declines on one species at a time. Species exist in communities and ecosystems. And so, an impact on one may lead to impact on others. So say that we are hunting a particular species. It may lead to the decline of other species if it relies on that one for food. Then we may cause a decline of an associated species, you know we aren't directly impacting other species. So say that we kill a lot of wildebeest in East Africa because we want to use them for food. Not that that really happens. But just an example. Then the lions that rely on the wildebeest for food may start to decline as well, so having a cascading impact through the ecosystem, which is what it's often called. So you get these trophic cascades where impacts on certain species lead to impacts on other associated species in the food web or the food chain, I talked about before.

So an example of this is Yellowstone National Park in America. So wolves have gone extinct from this ecosystem for a long time and then we've reintroduced them in the 1990s and this provided researchers with an opportunity to study the impact on the whole ecosystem of reintroducing that apex predator back into the ecosystem. And this picture here just gives an idea of what happens. So on the left here, which is before wolf extinction and the system is different to what you have after all extinction. So by killing all the wolves you get rid of their predatory function within the ecosystem. What this does is this leads to an increase in large herbivores. So the wolves are no longer killing elk and moose as much or at all if they've gone extinct, and no longer hunting these animals, so those populations go up. The populations of smaller predators, such as coyotes which would have competed with the wolves their populations also go up. And so you're having impacts on species that are eaten by the wolves and compete with wolves. When the populations of elk and other herbivorous species go up the browsing pressure, the amount of tree that elk eating also goes up. Therefore more trees are likely to die, the number of trees in the park is likely to decline, that simplifies the plant community. And because some tree species might disappear completely some might be reduced massively. And that leaves lower songbird diversity, because there is less shelter

for those songbirds and plants for them to eat and it changes the ecosystem massively. This also has knock on impacts on not just songbirds, beavers and bears as well, which I will actually talk about a little bit in the next lecture. So by hunting and killing the wolves and making the wolves extinct in this area by extirpating the wolves in this area, we are not just getting rid of that one species we're not just affecting that one species we're also affecting all the other species in this ecosystem.

So causes of declines don't just impact one species at a time they impact lots of species in one go.

Slide 26

And then the other thing that I wanted to talk about just before we finish is positive feedback cycles and tipping points. So here it's not just one ecosystem, it's not just a Yellowstone National Park, but human impacts on a planetary scale and we reach points where they cause big shifts in the system. And so the best example of this is climate change and the feedback cycles and tipping points that you get in climate change. So this is just a diagram of how solar radiation gets stuck in the atmosphere, or it gets trapped in the atmosphere with greenhouse more greenhouse gases. So the more greenhouse gases, there are, the more radiation gets trapped in the atmosphere. However, that's not the only the amount of greenhouse gas isn't the only factor that impacts, how much the planet warms. As the warming continues, that has impacts on the planet that can cause cooling or heating that aren't directly caused by the amount of greenhouse gases. So the most simple example of this is the amount of ice in the sea and on land. So ice is a very reflective surface. So what that means is when a lot of ice on the planet lots of the radiation that hits the surface isn't absorbed, it's reflected off and it goes back out the atmosphere. And so when we have a lot of ice on planet and we reflect or the earth reflects a lot of radiation back into the atmosphere which cools the planet. You know we're not we're not trapping that radiation we're getting rid of it. So on the whole planet cools. And as climate change has progressed as the planet has warmed, we are melting that ice so as we have less ice on the planet we have less of that radiation being reflected out of the atmosphere.

The surface of the land and the surface of the sea absorb much more radiation than the ice. So, as the ice melts and we're absorbing more radiation. And the planet warms, so we have a positive feedback cycle here where greenhouse gases, lead to a warming the warming leads to melting ice the melting ice leads to more radiation. And the more radiation the planet absorbs more the planet warms so that cycle means that warming happens faster and faster and faster because, as the ice melts the quicker the earth warms. So we have this feedback cycle here which magnifies human impacts, which means that they have a larger impact on the planet than just that direct impact so greenhouse gases are not the only thing that's causing climate change. Melting ice and other things are speeding up the process.

And then, a tipping point is when we reach a point in a system where there's a big change in how that system operates. So one example of this may be that we reach a point where the Earth is so warm that an ice shelf on a particular continent of say on Greenland, which is in the Atlantic, so say we reach a point where that ice shelf starts to break apart very quickly. It currently covers a big area of land, and so, if that breaks apart, then and disappears, then you uncover a large area of land and sea there's then absorbing much more radiation and the ice did before. So that could be a tipping point where the change starts to happen, much more quickly and we move to a much warmer world.

This isn't just relevant for climate change another tipping point that may be coming in the future is the vegetation that is present, and what is currently the Amazon rainforest. So by cutting down the

trees in the Amazon rainforest by changing all that land from forest to pastureland we are changing the climate in that area of the world. So there is much less transpiration, which is the water that plants give off into the air. If we continue to cut down the rain forest that area of the world might become much drier, there might be much less rainfall so one of the effects of having a rain forest in that area is that because of transpiration because of that water released into the atmosphere by trees and it leads to a much wetter climate so much more rainfall. By cutting down those trees, we may eventually reach a point where it's too dry to support rain forest in that area, so very quickly, it could be that the vegetation, the rain forest that is left could be converted very quickly from forest to grassland so it's too dry to maintain the trees, we have, and they will die and we get savannah.

And then, because it's such a huge area that may have very large knock on impacts for the climate in the rest of the world as well. So it's not just the direct human impacts that are important here it's their effects on not just the local ecosystem in the case of the walls, but also the whole planetary system. So these feedback cycles these tipping points these trophic cascades mean that we have much bigger impacts and often than they could be expected from just looking at the direct impacts that humans have on the natural world.

END

So that's the end of this lecture and alongside this I'm going to upload as a short exercise and discussion a few discussion questions in a document, alongside this recording. That is going to be looking at the costs of conservation, so what I want you to do is look at the example and there's a few questions asking you to calculate what the cost of setting up particular protected areas in the scenario that I get will be. And as an example there, so you should be able to see how to do it, and what I want you to think about is how putting protected areas in different places can impact the cost of those not just in terms of buying the land and managing the protected area but importantly in their opportunity cost.

And what I'd like to have you think about at the end, there are a few discussion questions but I'd like to think about how that might lead to particular areas being protected over others, so why we end up protecting areas that are not as economically valuable for humans. So say areas that are very, very dry or very, very cold that we can't use for farming why those differences in costs lead to protected areas being placed in particular places. And alongside these lectures and after this lecture sorry I'm going to be uploading the rest of the course fairly quickly, and so this material should be up there for you to download and work through as and when you can so thanks, very much for listening and I hope to be able to talk to you directly soon.