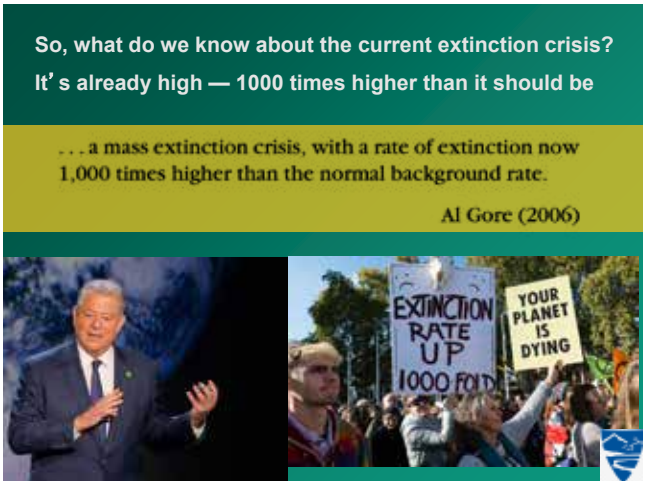
# Commemorative Lecture By Prof. Stuart L. Pimm for 2019 International Cosmos Prize November 13, 2019; The University of Tokyo

I am greatly honored to have won this year's the International Cosmos Prize. I am greatly honored to see so many students in the audience. I love teaching. I am just very happy that you are here. The idea of the International Cosmos Prize is to seek the harmonious coexistence between nature and human kind. I think that is the greatest challenge of our century, a century which young ladies and gentlemen you are going to live through most of it. Some of you may live through all of it. Because if we do not ensure the harmonious coexistence of nature and human kind we will leave to our children and grandchildren a very damaged planet. I want to address a part of that coexistence, the part of coexistence that deals with the loss of species, the loss of biological diversity. Because extinction is permanent we cannot bring species back. So, what we drive species to extinction we are changing the planet forever.




Now, if we were to ask how fast species are going to extinct you would hear from Al Gore in the movie Inconvenient Truth that they are going extinct a thousand times faster than they should be and I am very proud of the fact that this woman demonstrating in England, held up a sign showing extinction rate up a thousand fold. My work has never been featured in the demonstration before and I was very proud. The fact is that both Al Gore and this demonstration got that number from me and I want to talk about where that number comes from, how I got it, and what we can do about it. So, first, I want to talk about why we should care, why should be concerned about the loss of biodiversity.

I think there are three broad explanations. One of them is an ethical concern. That is what sort of a planet are we going to give to our children and our grandchildren. Are we going to give them an inheritance that is rich in species such as tropical forests, such as coral reefs and are we going to show them a place that is beautiful and wonderful. There is another aspect to the fact that we are destroying nature. When we hear about the loss of forests from say the Amazon, we don't always realize that people live there that the Amazon is full of people, full of people some of whom don't wear any clothes. So, I have had to adjust my slide because of young people present. We have a responsibility to nature to indigenous people and that I think is an ethical responsibility. The Catholic Pope a couple of years ago came out with a very important document and then cyclical in which he said, we have no right, we have no right to destroy the planet because of what that does to future generations.

The second is, it's a matter of esthetics, it's a matter about culture, about heritage and just two examples. The last time I was in Japan was in January and when I came people asked me where I wanted to go and I said, I wanted to go to Hokkaido in January. They asked because January is famously cold and the answer was yes because I wanted to see these birds called the Japanese crane. But there are parts of our heritage too. This is one of a famous set of wood cuts, the 36 views of Mount Fuji and I love the fact that several people are trying to estimate the side of a tree by putting their arms around it and it's too big. This tree is so large that you can't put several people's arms around it. So, what are we doing to our forests? Have we destroyed our forests, are we keeping them as

part of our heritage.

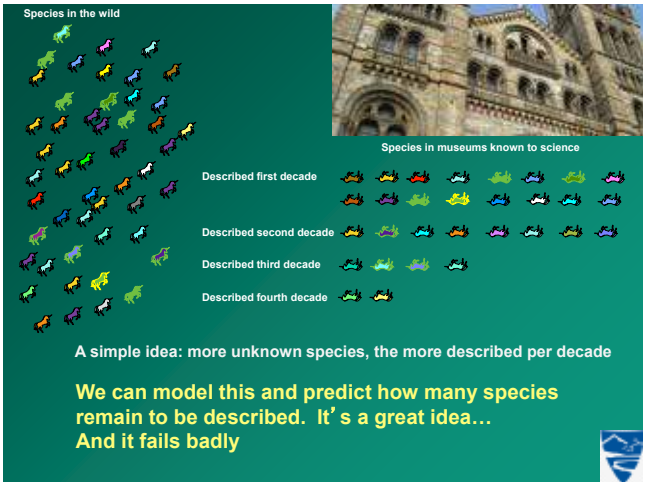
Economics is an important reason for serving biodiversity too. Many poor people around the world like these fishermen on the coast of Goa in India depend upon the diversity of the oceans for their food. We depend upon a whole variety of different animals and plants for our survival. So, we destroy the oceans, if we destroy the land, we're destroying something that is valuable to us. We also value nature and we go and see it, we go and visit it. Tourism, ecotourism is a very, very important industry. It's worth 100s of billions of dollars. And African countries get most of their money, some of them from tourists.

The species can be interesting and important in other ways too. These are cone shells. Sometimes people pick up these beautiful shells on the beach and stick them in their pockets. That can be a very dangerous thing to do because these cone shells surprisingly feed on fish. I know what you are thinking. How can a snail that moves very slowly feed on the fish that swims very quickly? The answer is the snail has a poison dart that if it shoots at the cone shell and then it reels the fish in… I think you will nightmares thinking about that tonight. Why is that important? It's important because that poison paralyses the fish. It dulls the nerves. And the poison from cone shells are used as medicine for people who are terminally ill with cancer that cannot be helped by the normal kind of painkillers and that cone shell painkiller gives people a substantial amount of relief from pain. It's an example of how we use biodiversity in our medicines.

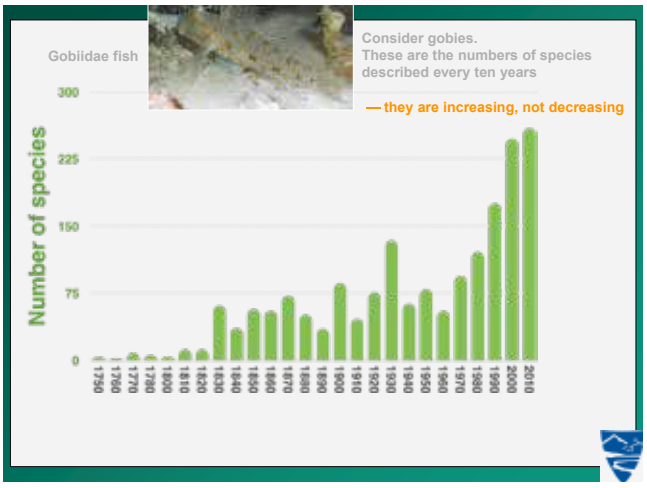
Finally, nature does a lot of things that we call ecosystem services. When we burn the Amazon, we put carbon dioxide into the atmosphere. We warm the atmosphere and we know that the tropical storms, the typhoons, the hurricanes are becoming more powerful and more damaging over time and that destroys people's lives and their homes. Protecting nature is good economic sense.

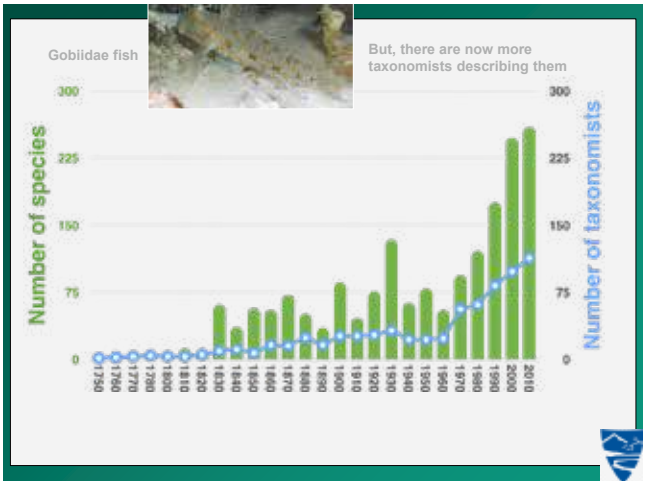
So, with that I want to go back to why Al Gore and other people talk about the extinction rate being a thousand times higher than it should be. What's wrong with simply talking about how many species are going extinct per day? Why can't we say something simple like three species of extinction per day? Well, the problem is we don't have a very good idea about how many species are on. And so I want to address four questions.

1. How many species there are and how many we don't know?
2. How fast are those species going extinct?
3. What are we doing to protect them?
4. And how can we do better?



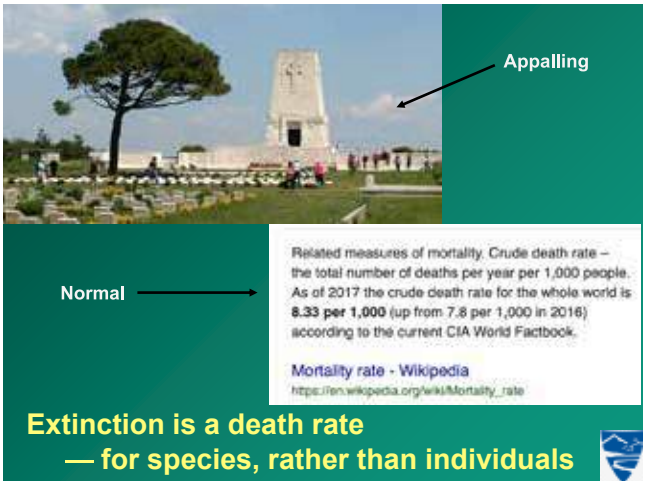

Well, we have scientific names for about 2 million species. But the idea is that there are many, many more species for which we do not have scientific names. And I want to suggest a way of estimating how many species there are. Supposing that there is a magical kingdom where there are many species of unicorns as yet unknown to science and we enter this magical kingdom and we begin to describe those species of unicorns by collecting them and putting them in a museum. So, in the first decade, we might describe quite a lot of unicorns. In the second decade, we describe fewer because there were fewer ones that we haven't already described. I think you get the idea. As time goes on there were fewer species that are unknown and so the rate of species description goes down. The more we know the fewer that are unknown and the harder it is to find new ones. It's a great idea and it fails badly.




And there is an example of this. I want to show you why. This is a group of fish called gobies. They are group of marine fishes. And if you look at the number of species of gobies that are described every year, the number of gobies is increasing not decreasing. We seemed to have more and more kinds of gobies every year. From one year to the next we know more and more not fewer and fewer new ones. There seems to be an unlimited number of gobies out there. Well, part of that is due to the fact that we have more people describing gobies now. Taxonomists, people who do goby descriptions. That number is going up, so more taxonomists, more gobies. So, perhaps the number of species divided by the number of taxonomists is going down. And the answer is it isn't. And the culprit I have to say with great respect is his Imperial Majesty the Emperor Emeritus who is one of the world's leading experts on gobies and is responsible for describing many of them. He is a legend in my community and not just because he is your Emperor Emeritus but vis-à-vis contribution to taxonomy. So, when we wish the Emperor Emeritus a very long life many of my colleagues do so hoping that he would describe more new species of gobies. The fact is the number of goby species described is not going down. So, we have no way of estimating when we are going to run out of new gobies. We have no idea how many species of gobies there are.

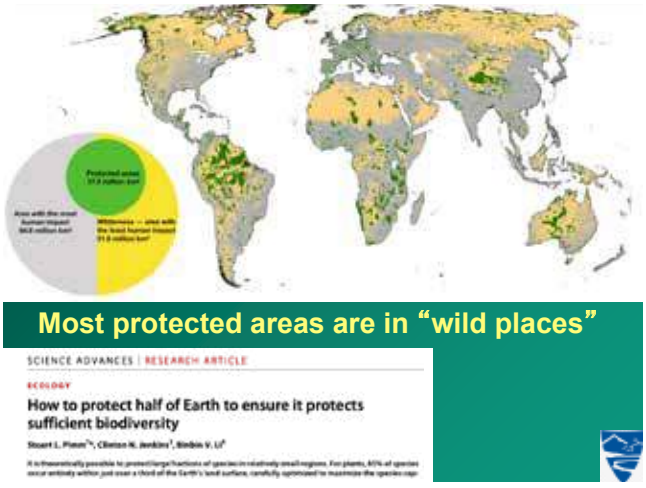
We can do this kind of calculation for other species. We have a pretty good idea of how many species of vertebrates there are, how many birds, how many mammals, how many amphibians. When we do this for plants we think there is probably about 15% more plant species out there than we know. But for many other species for insects, for fungi, for many organisms, we simply don't know how many species there are. So, it doesn't make any sense to say we think three species are going extinct today when we really don't know whether there are 2 million species or 8 million species or 30 million species.




We can, however, calculate a death rate for species in much the same way that we can calculate the death rate for people. The typi-

cal human death rate is about 8 people per 1000 per year. I want to assure you that nobody has ever died during one of my seminars. I would be very concerned if I bored you young men and women and you die during my seminar you may go to sleep but I promise you won't dies. On the other hand, there were clearly times in our history when we have had wars and the death rates have been very high. What's happening in nature is we are declaring war on species. And extinction is a death rate but it's for species rather than individuals. I am not going to explain the slide in any great detail but what it shows is that the death rates of species run at the rate of between 50 and 500 extinctions per million species per year. Take a million species, look at them for a year, you would expect between 50 and 500 dying. That's what we are doing to nature and the question is how much higher is that than we would expect?

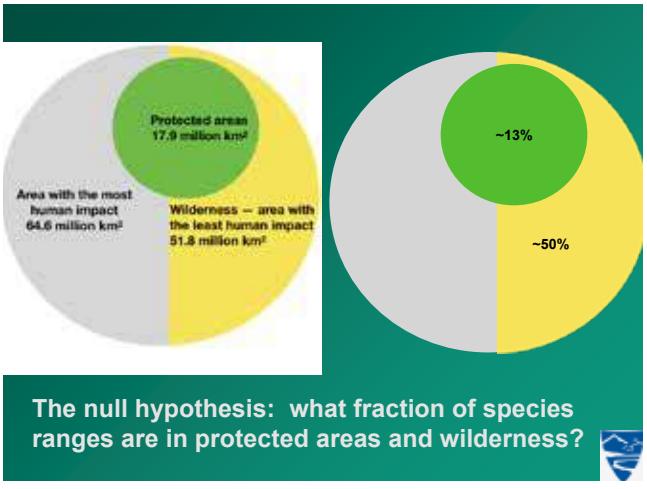
Well, one way to compare that is to look at the fossil record. It's actually quite hard to interpret the fossil record. So, what I want to talk about is how fast species are born, how fast are species created during the process of speciation, during the process of evolution? And we can get that number by looking at molecular phylogenies. You look at the DNA of species and you see how similar they are and you can work out how quickly species are formed during evolution from this molecular phylogenetic tree. We know for example that we human split from chimpanzees about 6 million years ago. For this particular group of orchids, we have a very, very detailed description of how fast these species are being formed. And the number that comes out of that in this particular case is 0.26 new species per species per million species per year. That's the birthrate. The death rate you may recall was between 50 and 500. And it's that difference between how fast species are dying and how fast they are born that leads to that conclusion that we are driving species to extinction a thousand times faster than they should go extinct. We need to know that number because it's a measure of what we are doing to the planet. We need to know that number so we can measure whether we are reducing the species extinction rate.

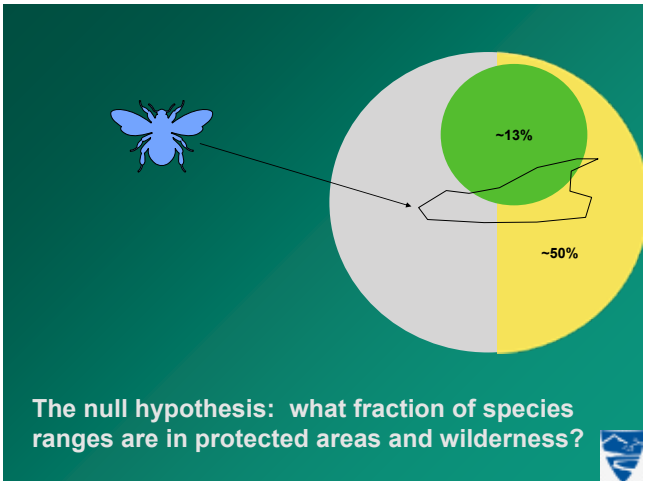



In short, that's the impact we are having on the planet, driving species to extinction a thousand times faster than they are being created. What are we going to do about it? What are we doing to protect species? Well, the answer is that over the last 30 years or so, we have – we the global community have protected a lot more of the planet by creating national parks and other protected areas. This map shows in green where the protected areas are and it shows in yellow where the wilderness is and by wilderness I mean places where few people live, few people live in the boreal forests, few people live in the Arctic, few people live in the Sahara. And as you can see most of the green areas are in wilderness, most protected areas are in the places where there were few people. One question of course is should we protect more of them. This is a politically relevant question. Next year in China the various nations of the world will come together to talk about the future and biodiversity at the convention on biological diversity. They meet regularly. This is the 15th meeting and they will plan an agenda for political action for the next decade. Do we want to protect more of the wild places or do we want something else?

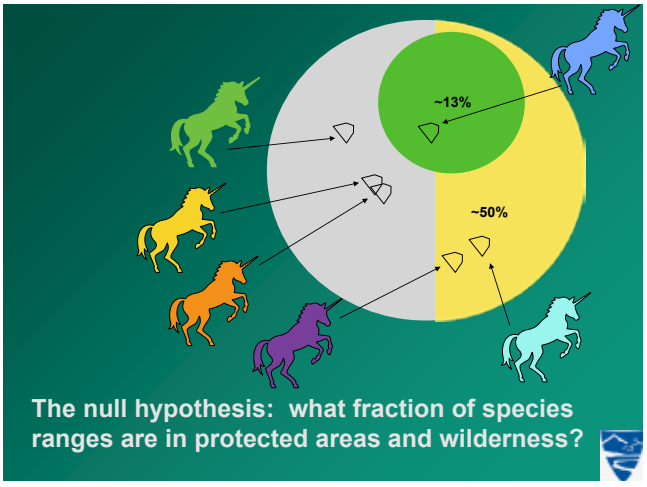
The problem with many of the wild places is that they have very few species in them. That photograph is of a huge national park. It's a million square kilometers in the north of Greenland. I took that

photograph myself. I am very pleased with myself for doing that. When you fly from the United States to China, you go straight over the top. You go to north, right over the North Pole and come down the other side. So, that was taken from an airplane. I have no intention of going to Northern Greenland. It's far too cold for me. It's a big national park but it doesn't do much for species. There were not many things if any that live in such a remote place. So, protecting more remote places is not going to enable us to protect more biological diversity.

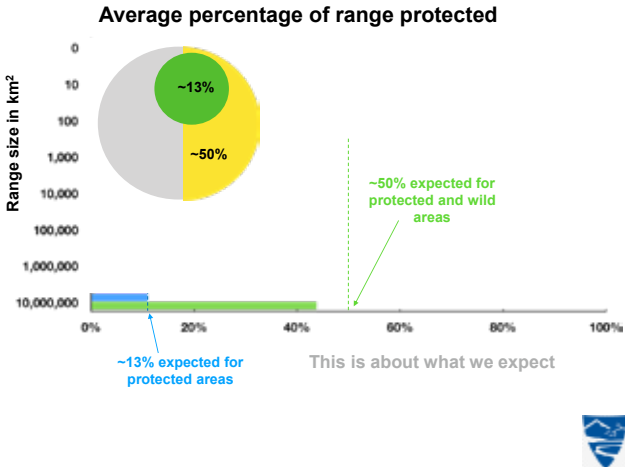


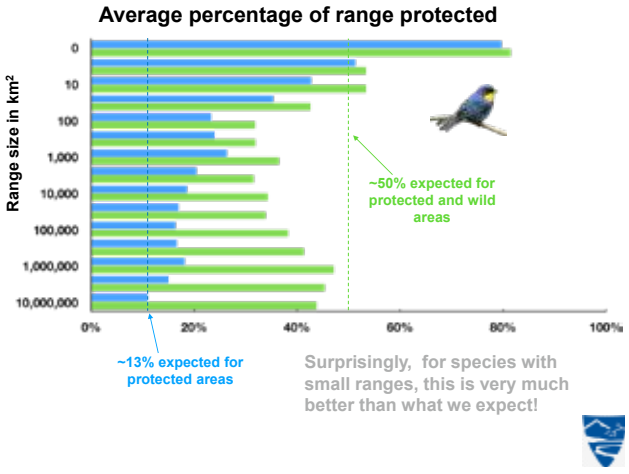




So, let's look at how well protected areas are doing to preserve species. Thirteen percent of the land, this is the ice-free part of the land, 13% is protected. What species occur in that 13%? Let's take this hypothetical insect, this bug. Supposing it has a large geographical range what would we expected? By chance we would expect that 13% of its geographical range shown in that black outline the 13% might be on the protected area and perhaps 50% of it could be in wilderness.




Now, let's go back to my mythical kingdom of unicorns. I have shown six species of unicorn. Perhaps one of those unicorns would be in the protected area, two in wilderness, three in other places, but again on average 13% of the ranges of unicorns would be protected, 50% would be in wilderness. That's what we expect by chance, technically under what we call the null hypothesis.




So, let's look at what we have achieved globally. For species with large geographical ranges more than the million square kilometers or more, we have actually protected species just as well as we would expect. About 13% of these species are protected and close to half of their ranges are in wilderness. So, that's good. That's not better than we expect. It's about what we expect. The very surprising thing is what happens when we look at species with small geographical ranges. These are important because species with small geographical ranges are much more likely to be threatened with extinction than species with large geographical ranges. It's easier for us to destroy a species with a tiny range than to destroy a species with a large range. And we have done really rather well of protecting species with small ranges.


Let's look at some examples. The animal at the top left is called a Skywalker gibbon named after Luke Skywalker from Star Wars. If you see in the latest episode of Star Wars, we have Luke with his hood up. So, this is named after him, the Luke Skywalker gibbon. The bottom left is a very special humming bird. The frog at the bottom right is called a poison dart frog. Indigenous people take the darts they are going to use to hunt and they rub them on the skin of the frog. The frog skin is poisonous, so when they have their blow guns and shoot a dart at a bird it poisons the bird, it falls to the ground and they get a meal. The fact is that all four of these species have small geographical ranges but we have done a good job in protecting them. In short, we have done reasonably well. We need to do better but we are doing better than many people expect.

The question is what should we do next, can we do better? Well, we currently have internationally agreed targets that suggest we need to protect 17%. But my good friend E. O. Wilson who is also the International Cosmos Prize winner suggested that we want to protect half of earth. What worries me about that is that if we ask the politicians to protect half of earth they will give us more places like Northern Greenland, the middle of the Gobi desert of China, the middle of the Arctic, places that will not protect a lot of biodiversity. When E. O. Wilson on the right and I on the left discuss

these issues, we realize that we need to be careful for what we ask. We need more protected areas but we need them to be in sensible places, places that will protect biodiversity not just remote places that are politically convenient.

So, how can we do better? How can we maximize the efficiency of the protected areas that we have established? For that, I want to introduce you to the work I do for a non profit organization I direct called Saving Nature. We can map out the distribution of many species now in considerable detail. These are birds and they show that the warm, wet tropics are where most of the species are; mammals show broadly similar pattern. These are places with the greatest concentration of species and it's likely to be true for most species. Amphibians, for example, show a similar pattern while we have less detailed data for plants it's almost certainly true for them too. But just looking at species it's not sufficient. We need to dig deeper.

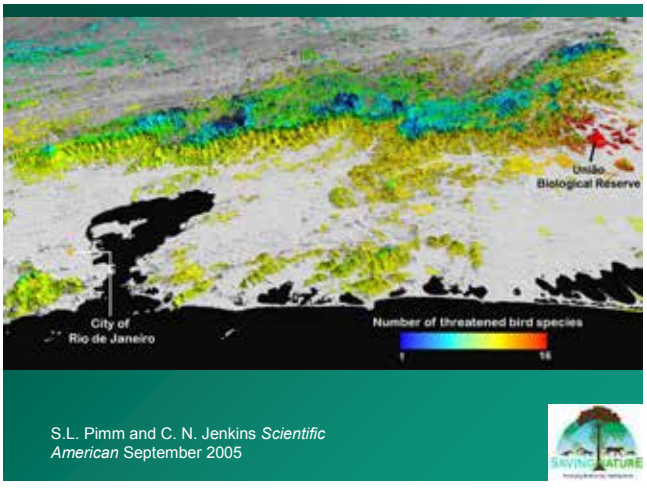
Let's look again at the distribution of bird species. In the Amazon, there are the greatest numbers of species. But if we look at where species have smaller than the median range size, those distributions are profoundly different. They concentrate in Central America and then the Northern Andes and in places like the coastal forests of Brazil. That's important because species with small ranges are much more vulnerable to extinction than species with large ranges. So, let's take world tour where threatened species are. Our first office in Northern Andes and Saving Nature is involved in several projects in Columbia and Ecuador where the habitat destruction combined with the high numbers of small range species means that there are a lot of species of list of extinction. Our second area of concern is in Coastal Brazil. Again lots of habitat concentrations of small range species means that there are worrying numbers of threatened birds and mammals and amphibians and likely many other species in these forests. The final area where Saving Nature works is in tropical Asia. We have three areas of interests, the Western Ghats of India, Assam up in the Northeast on the borders with China, and Leuser Ecosystem of northern Sumatra. These maps are what we call strategic maps. They tell us where in the world we need to act but they don't tell us exactly how to act. For that we need tactical maps. This one and I will explain those on the project pages for each of the various places where Saving Nature works.

What I suggested here is that there are key areas around the world where species are at considerable risk of extinction. It's true for the oceans too. The areas south of Japan, Okinawa and further south are a marine area that has high concentrations of species at risk. In other words, we don't have to save all of the planet to save all the species but we do have to focus on efforts on critical places. And those places we can identify using the maps we showed you but then we need to move to maps like this one which I will explain in a moment which give us a tactical approach to deciding exactly what we need to do next.

If we look at Brazil and I am going to use Brazil as my example. The species at risk in South America are concentrated in two areas on the Northern Andes of Columbia and in the southeast of Brazil. Brazil has two rain forests; the well-known one of the Amazon and the much less well known one of the coastal forests. It's where there are large numbers of threatened species both of birds, mammals and amphibians. We can see why when we look at satellite images. That's a series of satellite images that's about 500 kilometers from east to west and you can see that lot of the forest has been cleared. There are not a lot of forests remaining. That big bluish area in the middle is a city of Rio de Janeiro.

Let's take a closer look. When you zoom in on that area, you see that there is a forest but lot of that forest is in very small pieces, in fragments. And taking those small fragments away you see that there is a substantial amount of forests in small fragments. Now we know scientifically a lot about what happens to species in fragments.

That's what it looks like from a helicopter. When you look over this landscape, you see that there are some forests remaining but it's mostly in small fragments.





When we go to this map, what we have done here is to create a map of where the forest cover is. Everything that is covered is forest but we have covered it by the number of threatened species that occur there. We call this a tactical map because it immediately shows us two things that the greatest numbers of species of risk are in this area to the east near the União Biological Reserve and that that area like much of the rest of area is in forest fragments.

There is a long-term study done by my colleague Tom Lovejoy that looks at what happens to species in fragments. Using an area that was going to be deforested, Professor Lovejoy set up a series of experimental forest fragments. One hectare, 10 hectares or 100 hectares and followed how long it look for the species to disappear from them. The simple conclusion from this is that small fragments lose more species and they lose them more quickly that you need to create forest areas of at least 10,000 hectares to have a good chance of keeping all of your species. That's practically very useful information. It means that you need to reconnect fragments to create an area of sufficient size if you are going to prevent species going extinct.

We will identify the places where the greatest number of species is at risk of extinction and when we do that we often find they are in very fragmented landscapes. They are not in large areas of continuous forest like the Amazon but they are in the biodiversity forest spots and those places have already lost a lot of their habitats. A good example of this is in the forest to the east of the city of Rio de Janeiro in coastal Brazil. This map shows the fragment and the number of threatened species that they contain. We have not just merely destroyed so much of the world's tropical forests what we have left behind is in tatters, in fragments. And those fragments are often too small for species to maintain viable populations. There are just aren't enough males to go around for the females and females to go around for the males. And of all the places, of all the fragments one that I thought was particularly tragic was the one immediately behind me. This is the União Biological Reserve in coastal Brazil, about 100 miles east of the city of Rio de Janeiro because in this isolated patch of forests are a whole load of species on the brink of extinction, the most charismatic of which is a beautiful little monkey called the golden lion tamarin. And the golden lion tamarins in that fragment could not go forth and multiply into the forest over there because there was the cattle pasture behind me. When I saw that cattle pasture for the first time about 8 years ago, a cattle pasture just like the one I am standing in I thought it has to go. So, we have made it go away.

This is a restored forest. They help raised money for my friends at the Associação Mico-Leão-Dourado, the Golden Lion Tamarin Association. They have planted this forest and it now connects that once isolated fragment to forest in the União Biological Reserve to a much larger area of forest over in this direction. It's what we call a biological corridor and it means that the golden lion tamarins that were once imprisoned in this forest island, this forest fragment behind me can now cross through these small but growing trees and go and find new habitats, new homes, new places for their tamarin families.

So, this is what that area looked like 10 years ago that's what it looked like 4 years ago. When I visited this spot this year, I couldn't take that photograph because the area is now completely forested. We used children to plant the trees. Great thing about children is they are closer to the ground and they work for free. The important thing is that we use local people because it's their decision. We can't come in and tell them what to do. What we can do is work with our local partners to find solutions that work for them. The trees are grown by women in the local community who collect the seeds and they will the plants. They are planted by the local community and we have created jobs to the local community, a pride in the fact

that they have this very interesting species which is beginning to attract tourists.


The story that I have told you ends with planting a tree. It began by looking at a global phenomenon. I hope I made the connection. We are driving species to extinction a thousand times faster than we should. We don't even have the names of most species but we are losing something that is of extraordinary value to us. To ensure the harmonious connection of nature and human kind, we need to slow that extinction rate down. We know that there were critical places in the Americas, in Africa, and Asia were species extinctions are concentrated. We need to protect more of the planet and we need to do that in a smart way to protect the places of matter and we need to reconnect nature. We need to heal nature. With good science and commitment to local communities, we can do this. We can ensure a harmonious connection between nature and human kind. Thank you so much for the honor of inviting me here today. Thank you.