Basic Course in Ornithology
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Lecture -24
Studying bird populations and communities Part 2

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Now, get to another technique of sampling bird populations which is capture mark recapture which actually involves the capture of these bird species. And you can see this is a Grey-sided Laughingthrush that has been captured in the past and has been ringed with a numbered aluminium ring and so you can identify individuals based on their ring numbers when you recapture them again.

And in this case, the bird also has two coloured rings and so if you colour band each bird with a different combination of colour rings you can actually identify individuals even without having to capture them and read the ring number. So, capture mark recapture is a very very common prevalent method of estimating various population parameters of bird populations.

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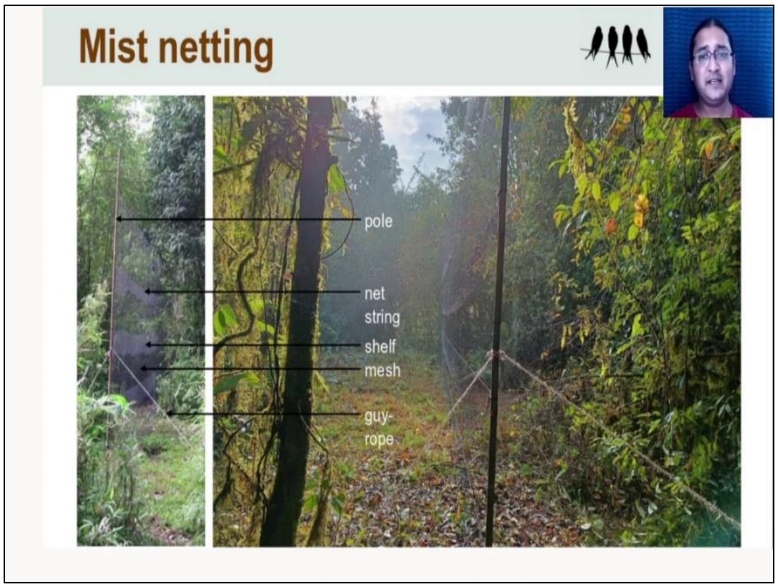

The commonest technique for catching forest birds and there are various other techniques for capturing birds like shore birds and so on but the commonest technique used for capturing forest birds and forest passerine songbirds is what is called mist netting. So, you are seeing here pictures of two mist nets these are vertical nets that are placed in the habitat these particular nets are 12 meters long and two and a half meters high and they are attached to poles at two ends of the mist nets.

And with the help of guy ropes these poles are anchored to the ground and the tension of the net and these guy ropes holds the net up vertically. Now each of these nets has a certain mesh size in this case the mesh size is 16 millimeters. So, every mesh 16 millimeters square and some parts of the net actually sag down to form shelves. And so, birds actually cannot see these mist nets very clearly if they are against a background of vegetation actually, they fly into these mist nets and they get captured within these within these nets.

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And once these birds are captured like this on the left you see a Golden fulvetta that has been captured in a mist-net they are very very carefully removed from the mist net and then processed further you know with banding and so on.

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So, the first thing often people do with captures from these mist nets is to use very specialized aluminium rings and specialized banding pliers different sized aluminium rings for different bird species of different sizes and you can see that you know this specialized banding plier has holes of different sizes. So, that you can ring a bird of different sizes with different sized rings and these numbered aluminium rings are placed on the birds they do not hurt the birds they are not harmful.

It is like a bangle like wearing a bangle or a bracelet that these birds are ringed with and each of these rings like I said has a unique number. So, that if we catch this bird again in the habitat. We know exactly which individual was where it was captured previously etc etc. Well, one of the advantages of capturing birds is that it provides you with a lot more information than observational techniques.

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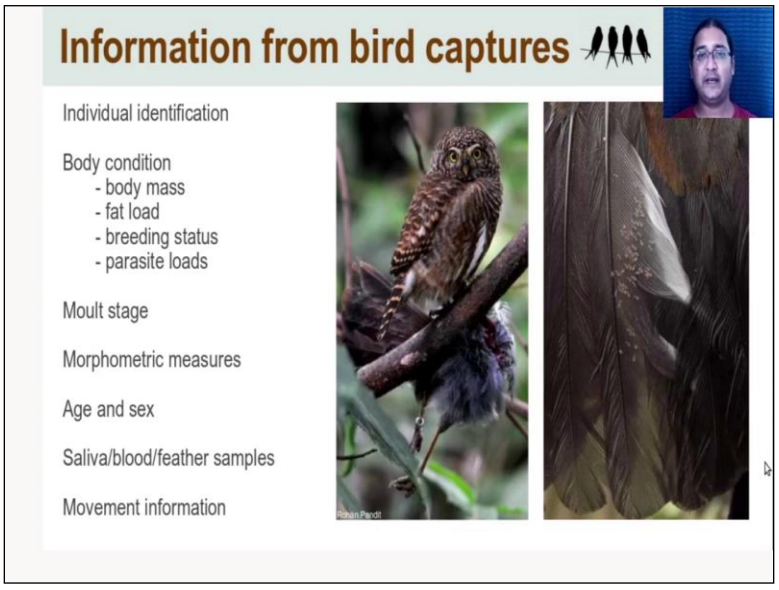

So, because you have the bird with you in the hand, one is with ringing and so on or colour banding you can get an individual identification. You can measure things like body condition through things like body mass, the fat loads that the birds have, the breeding status whether the bird is breeding or not based on something called the brood patch, you can look at things like parasite load.

You can see the feather on the right that has a number of feather lice and so you know birds that have poorer body condition tend to have more ectoparasites on them. So, you can measure parasite loads, you can measure moult stage, you can measure beak length, tarsus length etc. There is morphometrics of these birds for some species, you can tell the age of the bird and in some cases, you can tell the sex and if you are interested in you know physiology of these birds or you are interested in phylogeography/biogeography etc. You can collect saliva, feather or blood samples that can then be later analyzed in the lab.

And all of these are very very standard techniques that have been evolved over a lot of time to minimize any sort of stress and harm to the birds. And finally, you can get a movement information right this is what is on the left is a Collared Owlet that has caught a Grey-sided laughingthrush and the person who took this photograph was actually able to read the ring number on the grace on the Grey-sided laughingthrush that had just been killed by this owlet.

And we looked at the data and realized that this Grey-sided laughingthrush was banded at a particular location ringed at a particular location in April 2011 and then killed by this owlet in November 2012, only 40 meters from where it was banded or ringed and so you can get all this other sort of incidental information from bird catchers.

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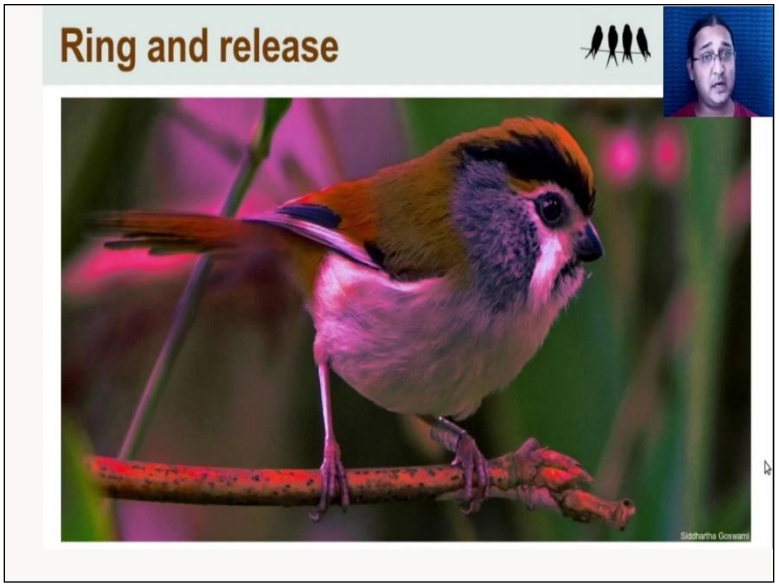

So, once the birds are ringed, they are released they go out into the habitat, they are you know doing what birds do. This is a Black throated parrotbill that has been ringed and then released. And it is in the habitat and somebody photographed this Black-throated parrotbill with the ring on it. Once, these birds have been ringed and released there are two ways in which you can get at population sizes. One is through recapture.

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So, you go back to the same habit at the same location and you put out the nets in exactly the same places and you get recaptures of birds that have been ringed before. Let's say you do this every year then this particular bird has been ringed in a previous year it has survived that that time period between the last netting session and this netting session and it is been recaptured. And based on the number of recapture and the fresh captures which have not been drink you can get all sorts of interesting information about the populations of these birds.

Another way is to actually just colour band these birds with unique colour combinations. So, in this case you have an orange and white on this Grey-sided laughingthrush and in fact, you do not need to capture them again because you can just use your binoculars and figure out what individual bird this was and not have to capture these birds again after the initial capture.

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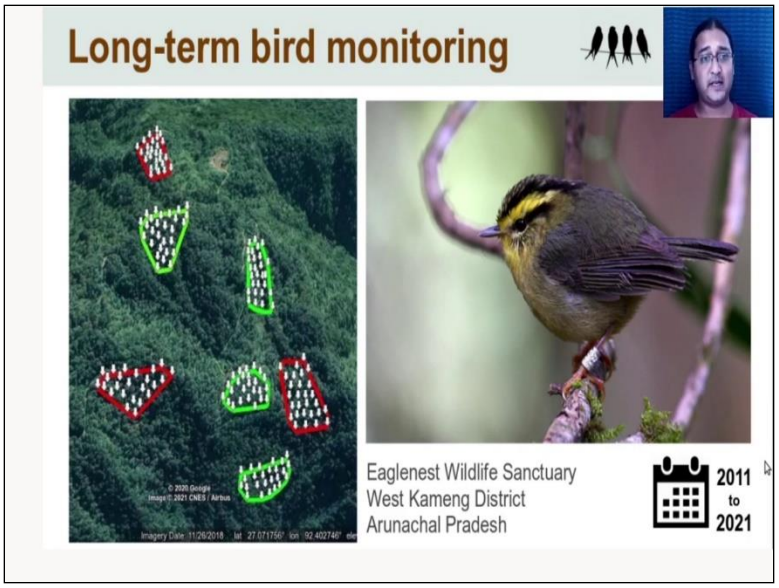

Here is an example of some of the work that we have been doing in long-term bird monitoring in Arunachal Pradesh where we have habitat patches that are primary forest that have not been disturbed before. So, this old growth of primary forests which are outlined in green and then logged forest or degraded forest which are outlined in red and within each of these plots. We placed mist-nets in these in these locations.

So, every plot you sample for three days and then move on to the next plot sample that for three days and move on to the next plot and so on and so forth. So, all the plots are not sampled at the same time, one plot is sampled at a particular time and then we move to the next plot. And we have been doing this the same locations in the same habitat since 2011. So, about 10 years of population dynamics data from these plots at 2000 meters in Arunachal Pradesh.

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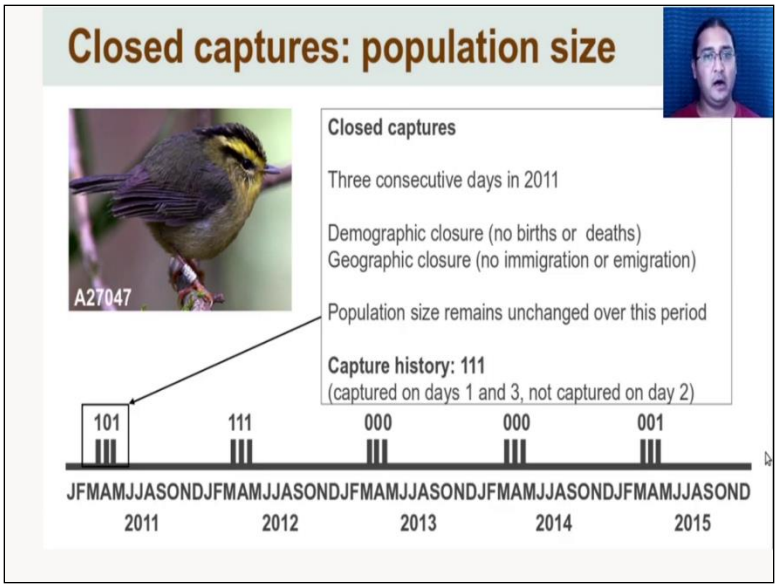

The way we do it is this way. So, let us say we go to… So, this is the way that one way in which you can use mist netting to track populations over time. So, if you go every year. So, you have a year and the months on the bottom of the line over there and you go in the breeding season that is in April and May and for three days you sample the habitat three consecutive days you come back the next year in the early breeding season again in April-May some of the habitat for three consecutive days and so on for every year.

And the way we the data that are collected is what is called a capture history. So, let's say you have a bird which is ringed with the ring number 827047 that is now an individually identified bird. In the year 2011, it was caught on the first day caught on the second day and caught on the third day. So, if it is caught it is represented by a one. In 2012 it was caught on the first day not caught on the second day and caught on the third day and so on.

So, in 2013 -14, it was not captured at all despite three days of sampling in that habitat, it was we could not capture this bird. and in 2015 in the three consecutive days, it was captured only on the last day. Now, mark capture estimates of population size and other population parameters can be divided into what are called close captures and open captures. Closed captures allow you to estimate population size at a particular time point.

So, in 2011, if I go out and I capture figure out you know have a capture probability for this particular bird and you have multiple capture histories of multiple individual birds some of which are caught on the first day caught on the second day some of which are not caught on the first day you also have multiple capture histories of multiple birds that are individually identified. At a particular point in time in a particular year with these three consecutive days, I can assume that the population is not changing it is not changing either because there are no births happening or no deaths happening.

So, the population is demographically closed or it is and it is also geographically close. So, there is no birds leaving that habitat or coming into the habitat and I can say this is a valid assumption and that you know in these three days there are not going to be massive changes in the population of the birds right it is only a three days period. So, the population is likely to be what is called closed both demographically and geographically.

And you have a capture history of 101 in this case which means it is captured in day one and day three not captured on day two.

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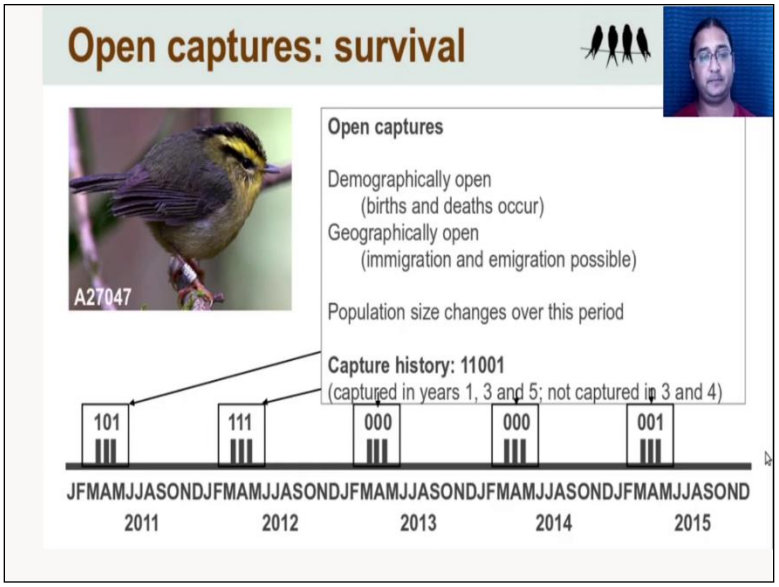

Open captures on the other hand are used to estimate not population sizes but the probability of survival from one year to the next. Here you are using the data of each of those different years and the intervals between these years and obviously when you go from 2011 to 2012 some birds would

have died birds would have been born some birds would have left the habitat others would have come into the habitat.

So, the population is open, it is open to additions and subtractions from birth death immigration and emigration. So, population size changes over this period and if you club all the information from those three days in each of those years, you get an open population capture history in this case it was captured in year one captured in year two not captured in years three and four and captured in year five. So, the capture history looks like double one double zero one.

So, that is a one or a zero for each year of the sampling depending on whether the bird was captured or not.

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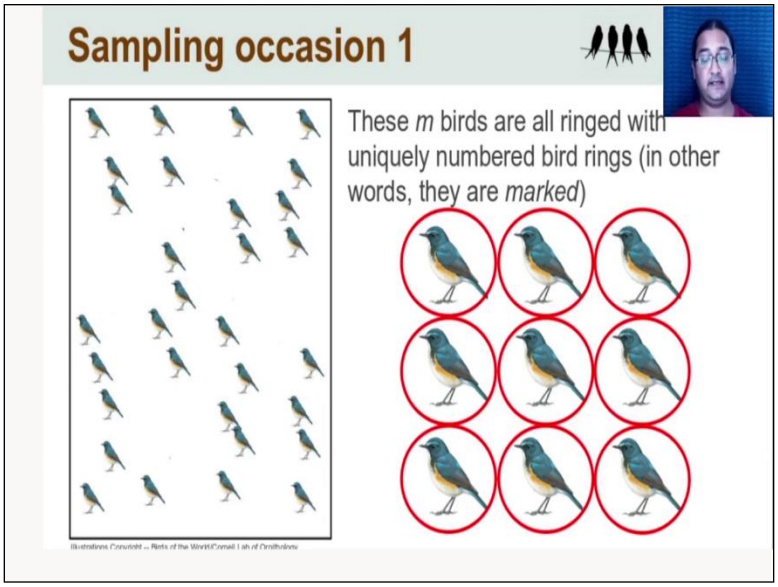

How do we use closed captures to estimate population sizes? You have a population of birds in the wild with some unknown population size this is what you are interested in estimating. You are interested in estimating the size of the population of these bunch of birds. And you have this habitat that you are sampling and population size of these birds which you do not know is some value N. What you do is on the first capture occasion on day one let's say, you are removing some number of birds from the population *m* number of birds that you know.

Here so, you sample some proportion of this population. You are capturing some of these birds out of the total population on the first netting or sampling occasion and this some value m. Here, we know what that value n is we have 9 birds from this population that have been captured. These 9 birds are then ringed with uniquely numbered rings or they are marked and after marking they are released back into the habitat, back into the population.

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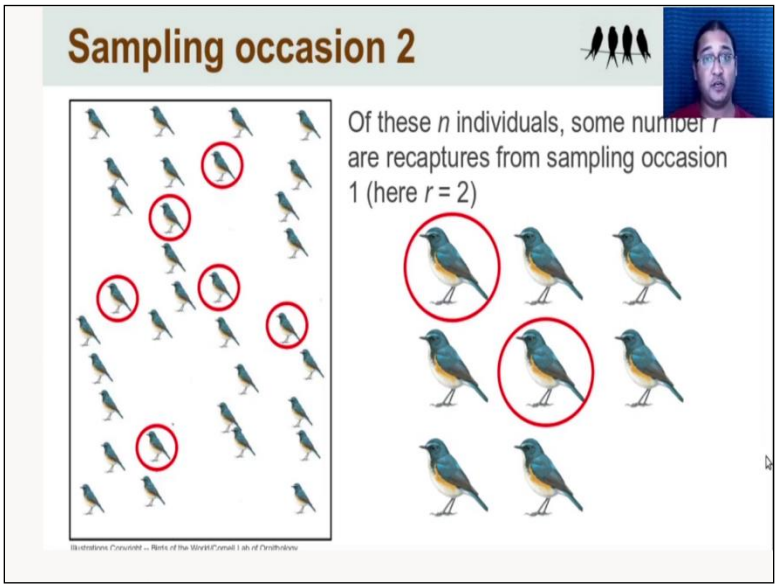

And they mix with the birds in the population. So, now you know that there are m birds out of some unknown number n that are in the population of these birds there are m marked or ringed birds in the population over here. You come back on the second sampling occasion and some known number of birds are captured again on the second sampling location right in this case small n here n is 8. On the second sampling occasion you capture 8 birds of those 8, 2 are ringed in the previous sample and six of them are new captures or fresh captures.

Now, in this case, some number r of these n individuals are recaptures from the first sampling location and so here

$$r=2$$

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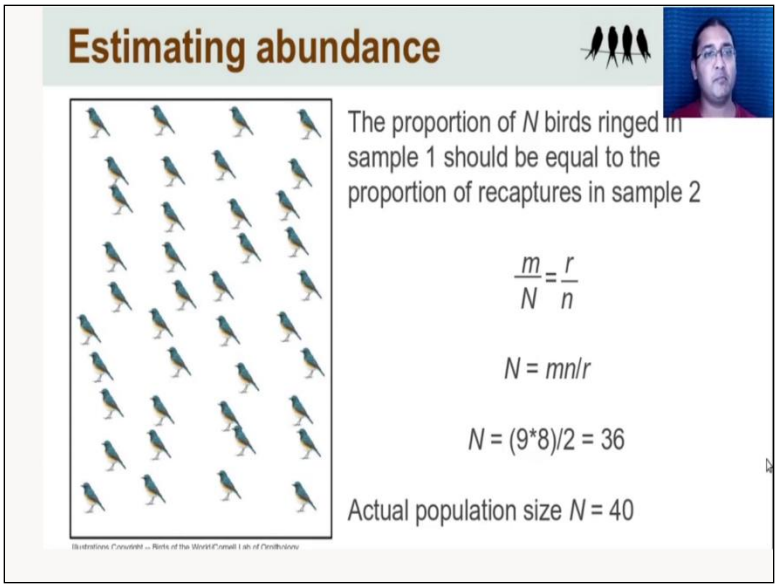

And the assumption is that and here when you released those ringed birds back into the population, resampled the population and you have a certain number of recaptures. Then the proportion of these unknown number of birds ringed in sample one should be equal to the proportion of the recaptures in sample two. So, therefore m which is the number of birds captured in the first occasion, 9 divided by the total number of birds in the habitat which is capital N which we do not know is equal to the proportion of recaptures in the second sample location.

The second subject occasion, we have had 8 birds which is n (and the small n) and the number of recaptures is 2 and so

$$\frac{m}{N} = r/n$$

So,

$$N = mn/r$$

So,

$$N = (9 * 8)/2 = 36$$

But the actual population of birds $N = 40$

And so, this is sort of a brief introduction to how estimating abundance is possible using marked individuals and capture mark recapture.

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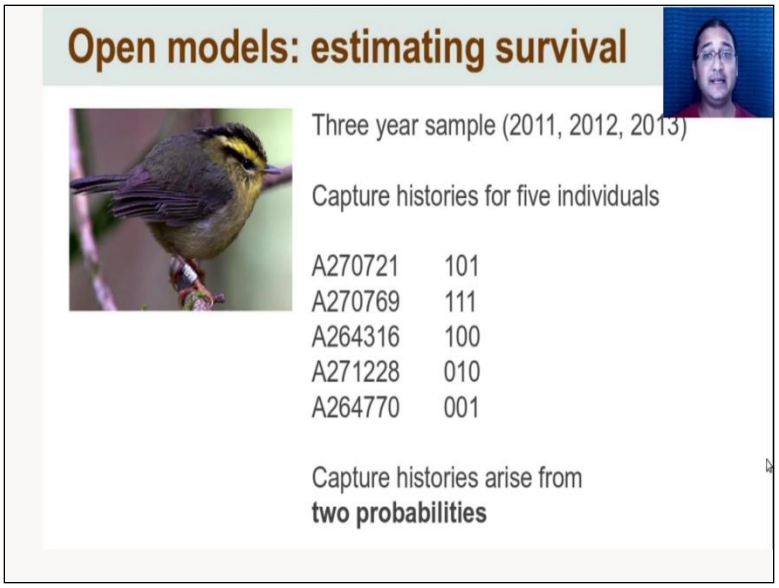

In open models on the other hand, you are estimating survival rates or estimating what is the probability of a bird surviving from one year to the next. So, let's say you have a three year sample 2011, 12 and 13 and you have captured histories for five individuals you know these are three the five different birds marked with five different ring numbers and capture history. So, for example A270721 was caught in 2011 not in 2012 and then caught again in 2013, A264770 the last bird over here was caught in only in 2013 and not in 2011 and 2012.

So, you have a separate capture histories for a number of birds in the population. You cannot tell using this technique whether each individual bird has survived or died but as a population as a whole you can estimate the probability that a bird survives. And these capture histories arise from two probabilities the whether you get a 101 or a 111 or a 101 etc arises from two capture properties.

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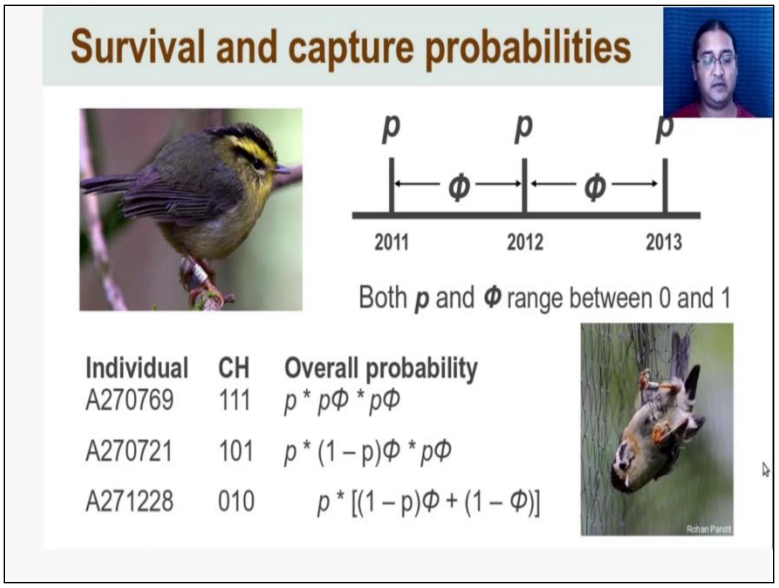

These are survival and capture probabilities. In 2011, 12 and 13, there is a certain capture probability P that you actually capture the birds. So, for example if there are 10 birds in the habitat and you go out in 2011 and you place your nets in 2011 in the habitat and you capture four of these nets then capture probabilities 0.4 or 40%. And so, every time period is associated with the particular capture probability when you place your nets there is a certain probability with which you capture a bird.

Between the time periods there is the probability that the bird actually survives and is available for capture. If it dies then there is no capture probability at all, because it is dead it is not available for capture. But if it survives with some probability let us say survival probability is 0.7 or 70% it means that if there are 100 birds in the habitat, 70% or 70 birds will be alive in the next sampling location the next year.

So, there are 100 birds in 2011 and capture survival probability represented by Φ is 0.7 then in 2012 there will be 70 individuals that have survived from the last year to this year and both P and Φ range between 0 and 1 they are both probabilities. And each of these capture histories is associated with a certain probability. For example, if you have a 111 then it is the bird has been captured if you have a capture history of 111.

The bird has been captured in the first occasion, has been captured in the second occasion, has been captured in the third occasion and it has lived between occasion one and occasion two and location two and location three and therefore this gives you an overall capture overall probability

$$p * p\Phi * p\Phi$$

and so on and so forth. So, for every capture probability you can create this formula of what could give rise to a capture probability like this.

And we will not get into the details here but every unique capture probability has this certain formula of P and Φ - capture probability and survival probability that describes that capture history.

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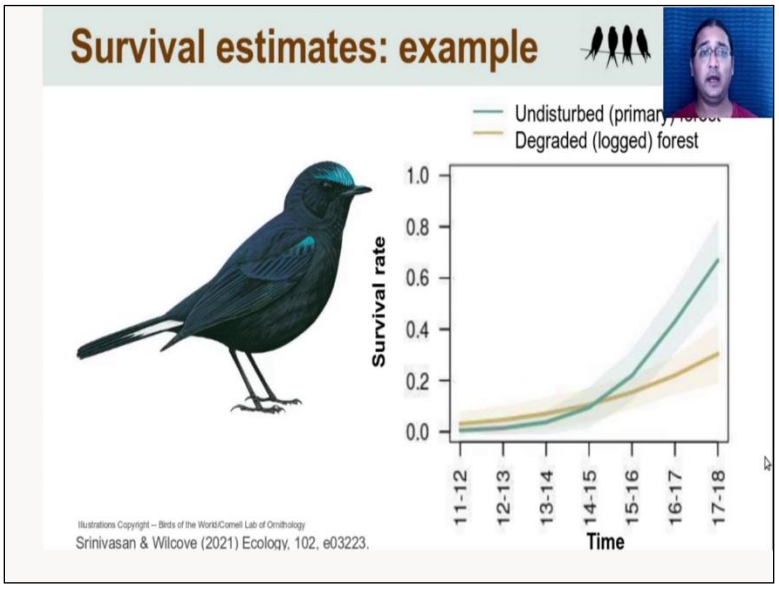

And based on that you can estimate Φ or the survival rates of these species, so, based on the capture histories this is our work from Arunachal Pradesh. We are estimating that the survival rates of the White-tailed Robin has increased from almost 0 to about 80% in primary forest which is the green line there and the survival rates of White-tailed Robin over the years has increased in logged or degraded forest also but at a much slower pace than it has increased in primary forest.

So, we get a lot of very very valuable information about how the populations of these species are doing in the habitat based on capture mark recapture.

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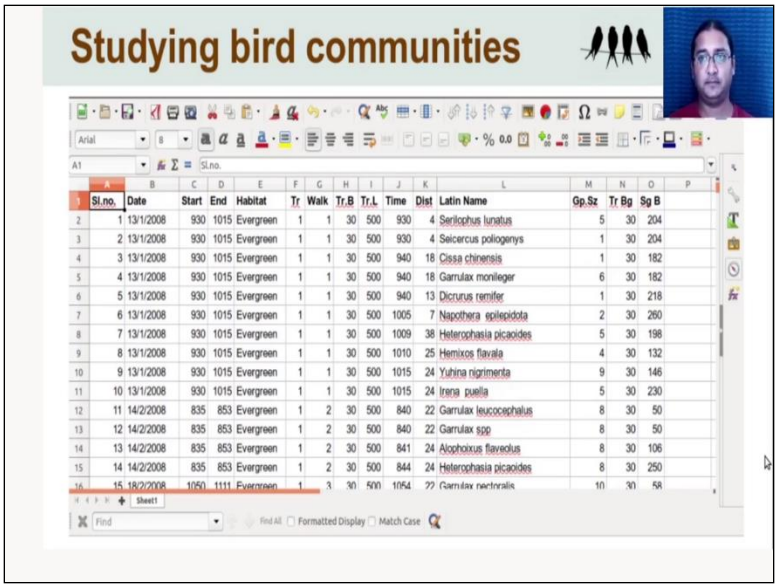

Now, that was about sampling bird populations and using these two techniques distance sampling or line transaction, point counts and capture mark recapture techniques and you know once you have actually sampled the entire bird community you can now start talking about the properties of the bird community itself. So, here is an example of a line transect data from Arunachal again different species what are the group sizes what is the bearing of the sighting angle what was the distance in meters and so on.

And based on this and then analyzing these data, we can then get at what are the population sizes of the population densities of each of these uh different bird species.

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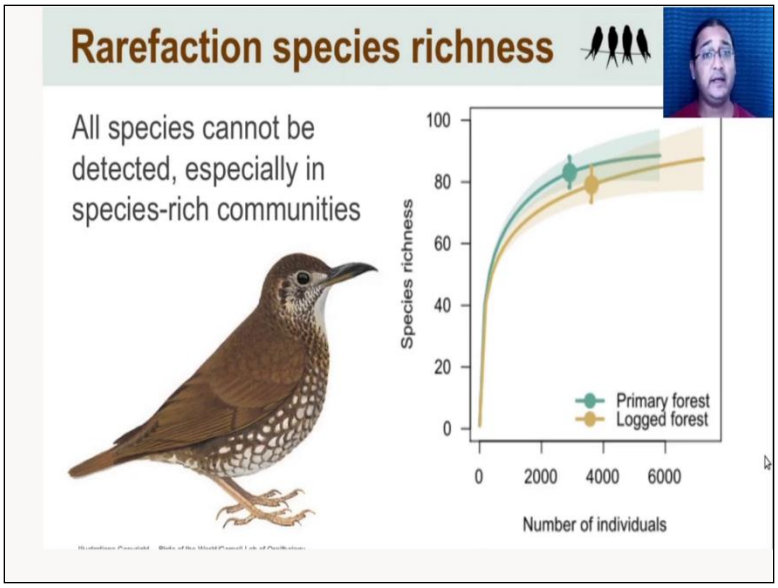

Now, in these very very diverse habitats that have a lot of bird species all species cannot be detected. So, when you have a very very high species rich community all these birds cannot be detected. But what you can do is use rarefaction to estimate how many bird species have been missed. The way to do that is to look at the relationship between the number of individuals that you have cited or captured on the x-axis and the cumulative number of species that you are adding on the y-axis.

So, when you let's say you are talking about mist netting and capture, when you capture the first bird that is the first species that you have captured. When you capture the second bird it could be of the of a different species or it could be of the same species and so on and so forth. So, when you add capture more and more individuals you slowly add more and more species until at a point you have captured all the species in the habitat and so that line will flatten.

So, you are seeing that in primary and in logged forest as the number of individuals captured increases the number of species that we record also increases. But beyond the point the all the species have been captured and so the addition of new individuals in your habitat is not adding any more new species. Based on that relationship, you can determine whether you have adequately sampled the community using the methods that you are using or whether there is the possibility that some of these species have been missed.

So, if this line plateaus and reaches an asymptote and flattens out. It is likely that all of the species that have been that are in the community have been sampled. Whereas the line is still climbing the line is still moving upwards then it is likely that there are still species in the community that are yet to be suffered. With the density estimates that you get from either mark capture recapture or from distance sampling one can start now comparing communities.

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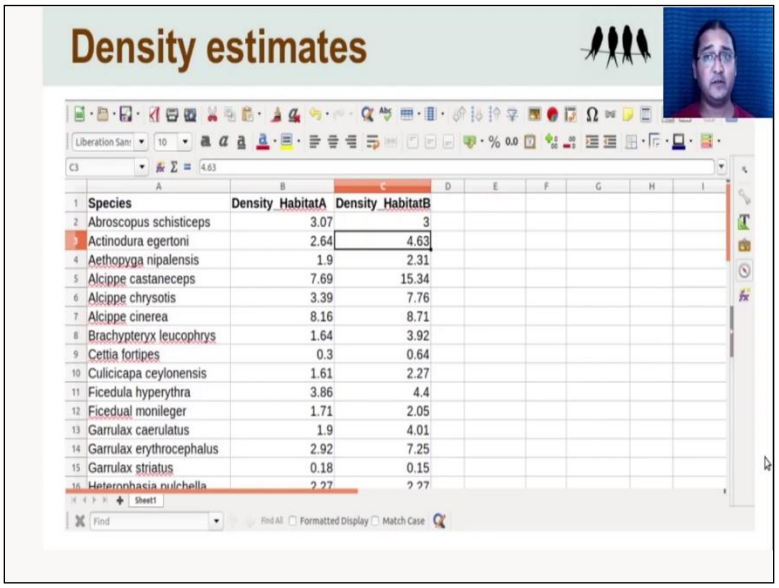

Species	Density_HabitatA	Density_HabitatB
Abroscopus schisticeps	3.07	3
Actinodura egertoni	2.64	4.63
Aethopyga nipalensis	1.9	2.31
Alcippe castaneceps	7.69	15.34
Alcippe chrysotis	3.39	7.76
Alcippe cinerea	8.16	8.71
Brachypteryx leucophrys	1.64	3.92
Cettia fortipes	0.3	0.64
Culicicapa ceylonensis	1.61	2.27
Ficedula hyperythra	3.86	4.4
Ficedual monileger	1.71	2.05
Garrulax caerulatus	1.9	4.01
Garrulax erythrocephalus	2.92	7.25
Garrulax striatus	0.18	0.15
Heterophasia pulchella	2.27	2.27

So, let's say you have two habitats habitat A and habitat B let us say that is primary forest and degraded forest (logged forest) and you have these different species that have different densities per hectare let us say in these habitats. So, for example the second species that *Actinodura egertoni* has a much higher density in habitant B then it has a density habitat A and so on. So, now not only can you compare the densities of individual species you can start asking what do these communities look like you can start comparing communities.

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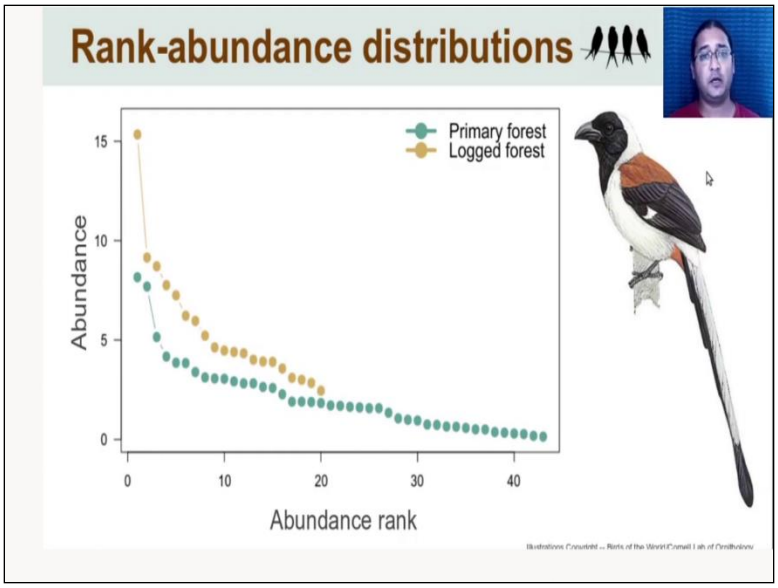

One of the ways to do that is by using a rank abundance curve or rank abundance distributions. Let's say, you have got the abundances of these species. So, what you do is you create this rank abundance distribution where on the x-axis are the ranks of the species. So, the species are arranged in order of their abundance. So, the most abundant species is towards the left and as you go towards the right the species abundance comes down species becomes rarer and rarer.

And what you can see in these two communities in primary and logged forest this is not actual data this is just illustrated is that you see that there are certain species there is one species the most common species is extremely common in logged forest. It has an abundance of maybe 16 individuals per hectare but the most common species in primary forest has an abundance of only about 8 individuals per hectare.

So, the distribution of the abundances in primary forest and logged forests are very different. You can also see that the number of species in primary forests and logged forests are very different. Primary forest has about 40, 43 species whereas logged forest has only 20 species. So, just using this curve we are able to see that primary forest in general the densities of these birds the population sizes of these birds are more even.

They are more similar to each other than they are in logged forest and this is one way in which you can compare communities and the structure and composition of bird communities using the abundances of these species or the densities of the species.

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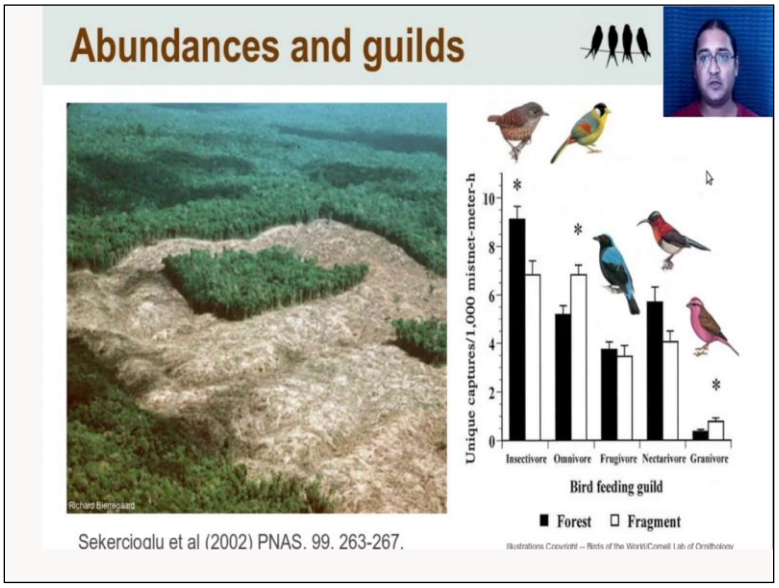

You can then also compare communities of species in guilds (functional guilds). For example, we can ask does the density or the abundance of insectivorous birds differ in a small fragmented patch compared to a large forest. And you can see here for example that based on the densities that we have of these insectivorous bird species and we have divided these birds into their feeding guilds forests (in the black bars) have higher densities of insectivores forest fragments which are small isolated patches of forest and so on and so forth.

So, you can use the density and the abundance estimates in many ways to start comparing bird communities, bird guilds, bird assemblages across different types of habitats across time etc.

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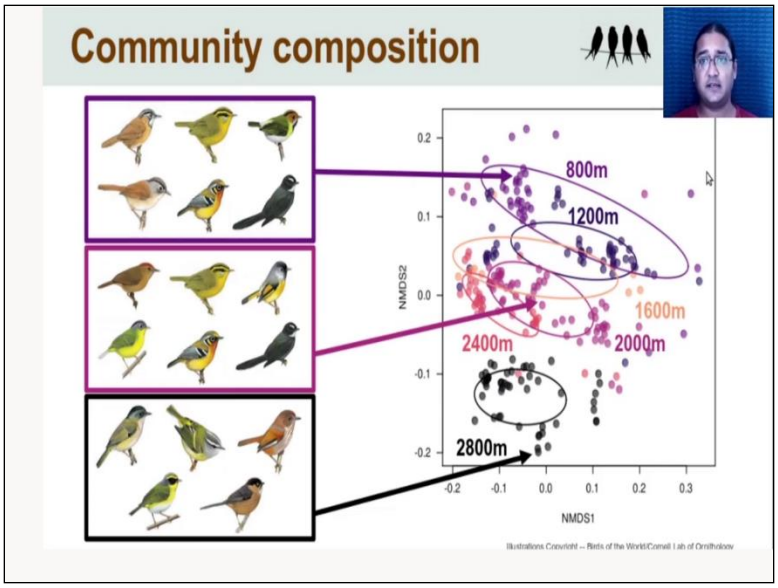

Final thing is representing community composition and one of the ways to do this is something called an NMDS a Non-Metric Multi-Dimensional Scale I will not get into the details of this. But this is a plot that is showing you the composition of mixed species bird flocks at different elevations in the Himalayas. So, every dot is a mixed species bird flock and the location of the dot in this space in this square, the location of the dot depends on which species and the number of individuals of each species that were present in the mixed species flock.

So, two dots that are very close to each other have more similar composition of these mixed species flocks than two dots that are very very far away. So, two dots that are very far apart from each other are less similar in the composition of their flocks than two dots that are very very close to each other. And you can see that for example there is a large amount of overlap between the flocks at 800 meters and 1200 meters.

So, that each of these ellipses sort of tells you what is the space occupied by the composition of these different mixed flocks at different elevations. So, there is some overlap between flocks at 800 meters and 1200 meters because some of the species are shared at those two elevations. But because the species are completely different at 800 meters and 2800 meters there is absolutely no overlap between the flock compositions at these two elevations.

So, getting at using these flocks as you know mini communities you can quantify actual community composition. I have just used flocks as a as an example of a small community of birds but you can actually quantify the composition of these communities at different sites and see how similar or how far apart how different they are based on approaches like this. So, again to recap there are several different ways in which one can measure the population sizes and survival rates and so on of birds.

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But the choice of these approaches, whether you want to use line transect or point counts whether you want to use marker capture or distance sampling is very dependent on the bird species that you are looking at the habitat that you are looking at and so on. So, I will end here this is about studying bird populations and bird communities.

Thank you very much.