Basic Course in Ornithology
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Lecture -23
Studying bird populations and communities Part 1

Welcome back to basic ornithology where today we will be looking at sampling and census techniques in studying bird populations and communities. Bird populations and communities can be sampled and censused and studied in many ways.

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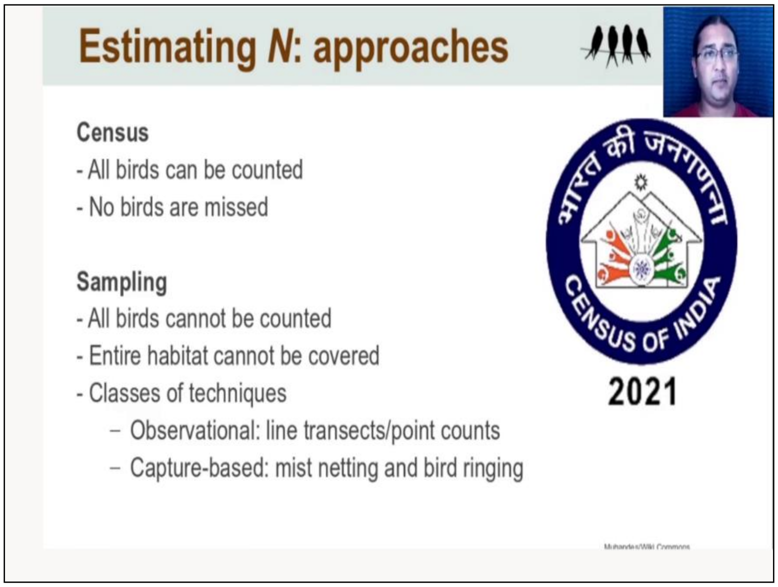

We will be looking at two broad approaches today which is the census approach and the sampling approach, both of which are geared towards estimating population size or estimating N. These census approaches assume that all birds can be counted and no birds are missed whereas the sampling technique acknowledges that very often all birds in the habitat cannot be counted the entire habitat cannot be covered.

And within the sampling techniques there are observational approaches line transects and point counts which are very very commonly used techniques to study bird populations and there are capture based approaches in sampling which of which the most common is mist-netting and bird ringing.

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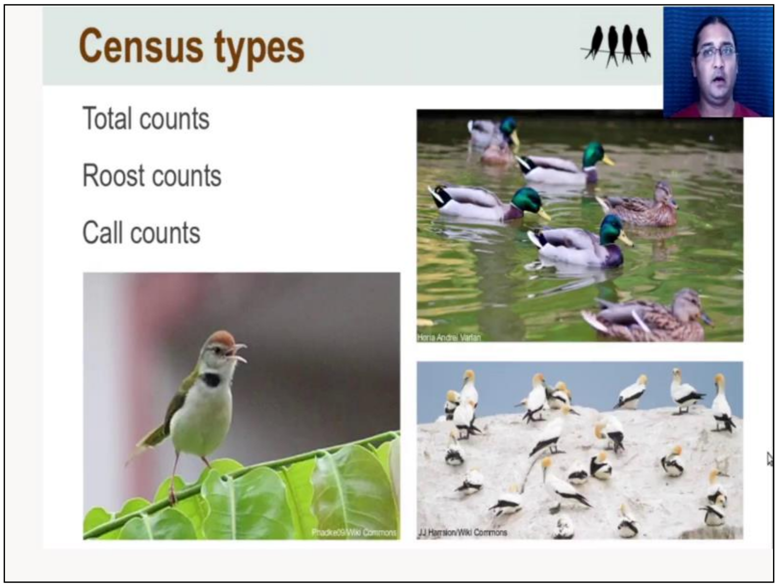

Amongst the census techniques are total counts, roost counts and call counts. So, total counts work in a situation where the habitat is open and all the birds in the habitat can be seen. Now, this often is used to census water birds like ducks and geese because lakes and ponds for instance can be the entire extent of the lakes and ponds can be seen and therefore almost all of the waterfowl on these lakes and ponds can be counted and very very few will be missed.

So, total counts are used in those situations. Roost counts are used for species that actually return to roost every evening for example a lot of species will forage at different locations or feed at different locations throughout the day. But all those individuals will come back in the evening to roost for the night in a particular location like these gannets that you see at the bottom right. So, if we know that all of these birds are coming back to the same location to spend the night then at dusk or at dawn before the leave of origin one can count these population sizes are these roosts.

A third census type is the call count where if you assume that all of the individuals especially all of the males of the population of a bird are calling or singing then you can walk through the habitat and count the number of birds that are calling in that particular part of the habitat.

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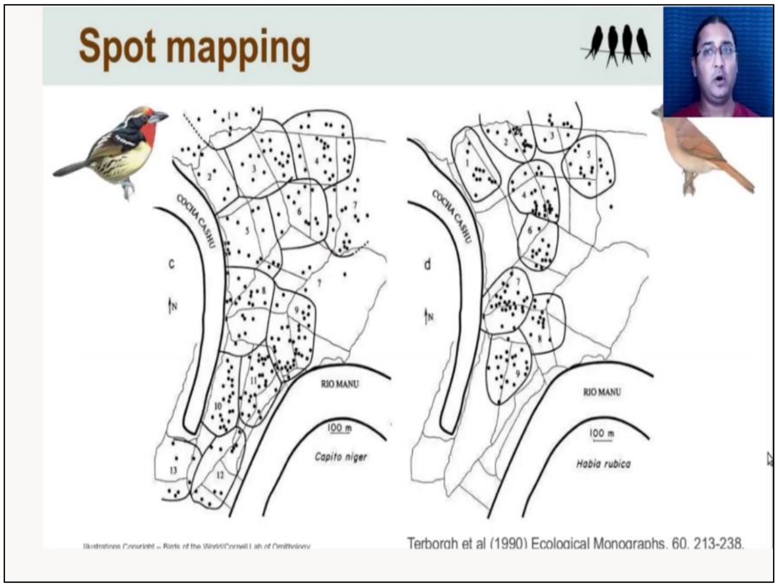

One of the ways in which call counts have been used to estimate population sizes of the estimate how many territories of a bird is present in a habitat is what is called spot mapping. So, this is showing you spot maps of the territories of two bird species in the Amazon basin. What you have is the habitat between two rivers the Cocha Cashu and the Rio Manu and you have a network of trails which are represented by those thin black lines.

And what observers do is they walk along these trails repeatedly. And as they walk along these trails they note where these birds are calling from. And over time, if you note where these birds are calling from and you also observe not only single bird calling but other birds calling in response to birds that are already calling which is a territorial display then what you can do is you can figure out where the birds are and where the limits of their territories are.

And therefore, in this area you can estimate the number of territories that are there and therefore the number of territories gives you also an idea of the population size in that area. So, these are examples of two species with territories have been delineated using spot mapping. There are 12 territories of the first species in this area and there are nine territories of the second species in this area.

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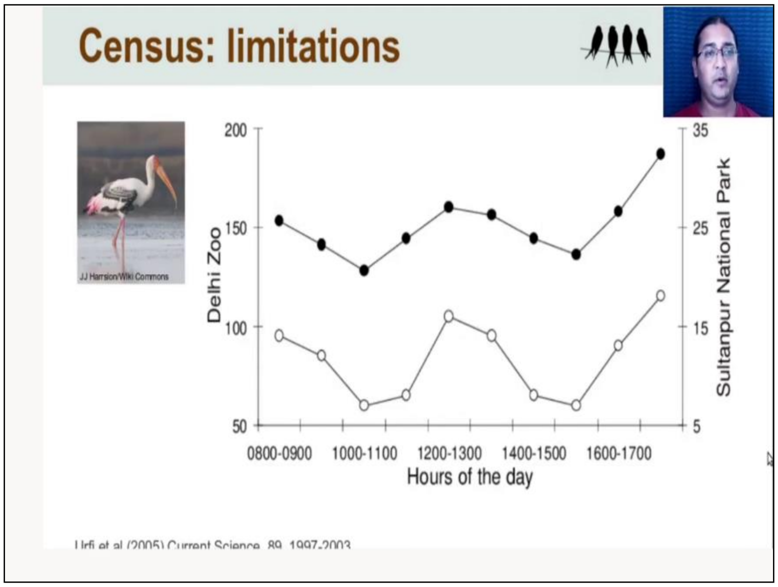

But very often the census-based techniques have limitations and that is because all the birds in the location cannot be counted necessarily. This is an example of counting Painted Stroks at two locations in Delhi zoo and in Sultanpur National Park. And you can see that depending on what time of the day the counts are being made, the counts can change quite a bit. So, in Delhi zoo, for example, if you go early in the morning at 8 o'clock you might see a hundred Painted stroks.

But you go in at 10 o'clock you might see only 50 Painted stroks. So, the total counts can vary quite a bit depending on time of day and other factors. And so, you might not get an accurate idea of how many birds are actually there in the habitat because some species some of the individuals might have left the habitat temporarily. They come back to feed or to roost and so the census has these limitations in that very very often in most habitats it is difficult to count all the birds that are using the habitat because some individuals will be missed.

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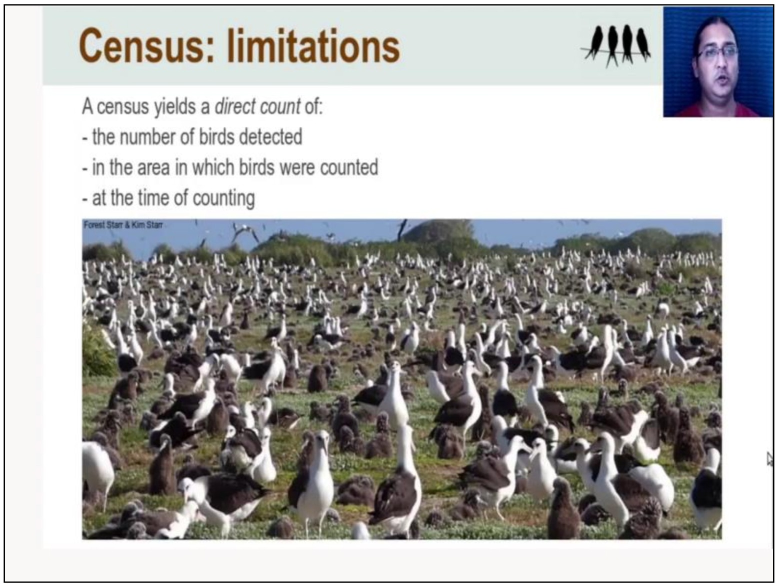

So, a census what it does is that it yields a direct count of the number of birds that were detected or the number of birds that were seen or heard by the observer in the area in which birds were counted and at the time of counting. So, if you come at a different time, you might get a completely different number of birds being detected. So, the limitations of the census are that you get just this direct count at a particular location at a particular time and those direct counts can change over time.

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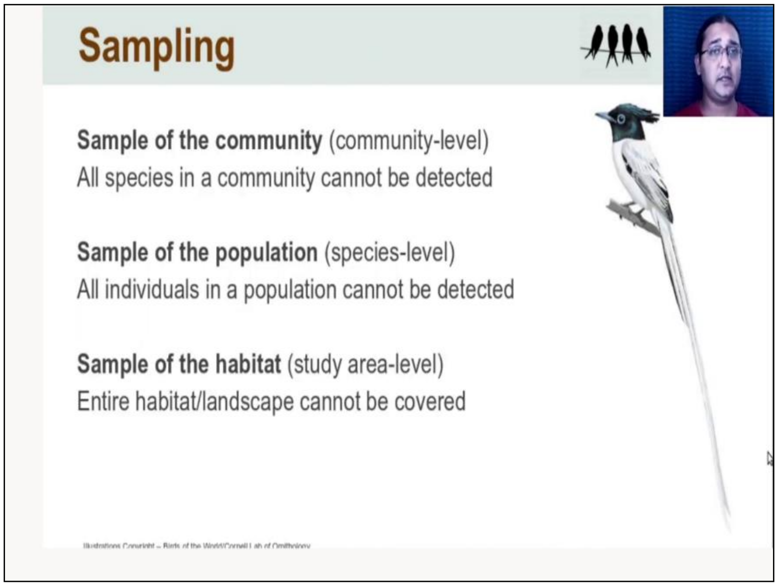

Many of the limitations of the sensors based techniques are overcome by sampling. Sampling indicates that all species in the community cannot be detected. So, when you go out into a let us say a rainforest that has many species and you spend some time sampling or observing what species you are seeing or hearing you will not observe all of the species. So, it is a sample of the community in that the rarer species are less likely to be detected.

And therefore, in the sample that you collect, . all the species are not going to be present. In addition, it is a sample of the population because all individuals in the population cannot be detected right. So, for a particular species, if you are walking through the habitat and trying to count the number of individuals, some will be hidden, some might not call. And therefore, you might not be able to hear, detect them.

And therefore, even the count within a species of the population size is a sample of the population and finally sampling acknowledges that you cannot cover the entire habitat. So, for existence if you are interested in counting the number of paradise fly catchers in a protected area, let us say you want to count the number of Paradise flycatchers in Bandipur national park then you obviously cannot cover all the area of Bandipur national park.

But you will be limited to covering the small area and therefore if you want to try and understand or try and estimate the total number of paradise flycatchers in Bandipur national park, you will have to extrapolate, you will have to say "*here is my sample of the habitat, this is the number of birds in my sample of the habitat in the area that I have covered*" and then make some guesses and say "*if the total area of Bandipur is this much and the number of birds I have detected in my sample in 10 square kilometers in this much*".

Then you can extrapolate and say that the likely number of paradise flycatchers in all the all of the national park is likely to be this number. So, it is the sample of the habitat as well, because the entire habitat or landscape that you are interested in studying cannot be covered.

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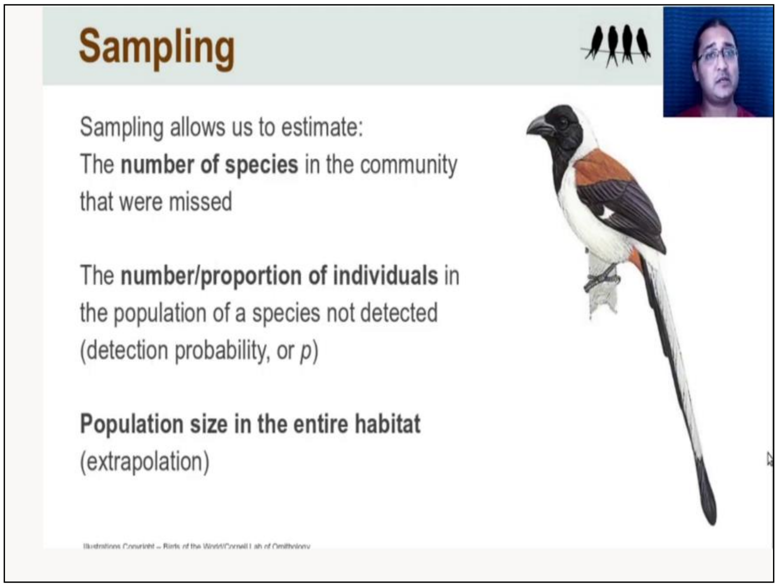

So, therefore sampling allows us to estimate the number of species in the community that were missed. We will often not know what those species are but it allows us to estimate using various methods, the number of species in the community that were missed it allows us to estimate the number or proportion of individuals in the population of a single species that were not detected which is called detection probability or P and it then allows us based on the sample of the habitat that we have covered, the population size in the entire habitat and that is called extrapolation.

So, sampling allows us to estimate the number of species that we have missed from the community as a whole for a single species, the number of the proportion of individuals that we did not count and finally allows us to extrapolate from our sample the population size in the entire habitat.

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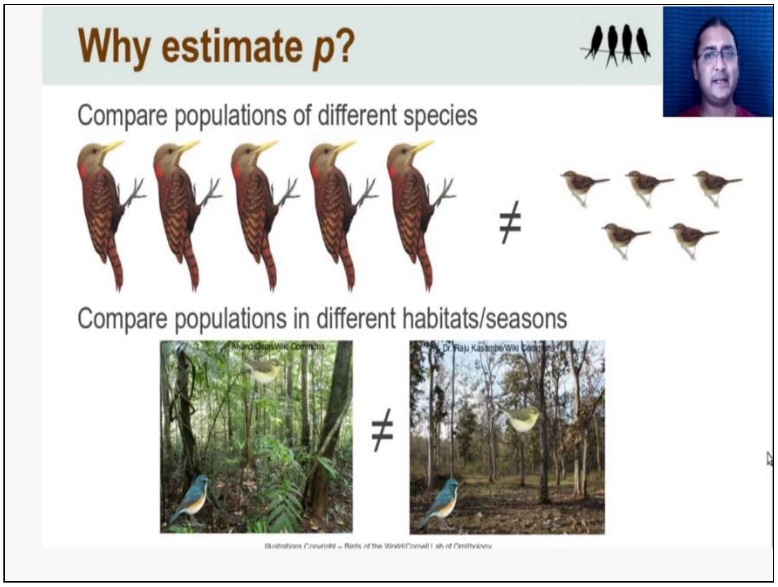

But why estimate detection probability, why is that something that we need to estimate? It is because, if you go out into a forest for example and you have a large loud conspicuous species you are more likely to miss a fewer number of those birds because they are loud, they are conspicuous, they are easy to see or they are easy to hear. And so, the detection probability of that species is high and therefore you are likely to count a higher proportion of the population of that species in the habitat compared to a species that is small silent cryptic often hiding.

And you are likely to count only a small proportion of the population of a smaller cryptic species. And therefore, if you go out into a forest and you count five large loud woodpeckers and you count five small tiny little warblers. It does not mean that the population sizes of both these species are the same. Because you have missed a lot more of the warbler species than you have missed of the woodpecker species.

So, if you want to compare the population sizes of different species you need to know what is the probability of missing individuals for different species and then correct for that to be able to get at the right estimate of the population sizes of these species. In addition, if you are comparing populations of a species in different habitats for example or the same habitat in different seasons, then some habitats that are dense, in these dense habitats you are likely to miss a lot more birds than in a habitat that is more open where these birds can be seen.

And therefore, you know 10 birds in a closed habitat dense vegetation and 10 birds in the open habitat in open vegetation does not necessarily mean that the population sizes of both these populations if these two habitats are equal because you are likely to have missed a lot more birds in the dense habitat than in the open habitat.

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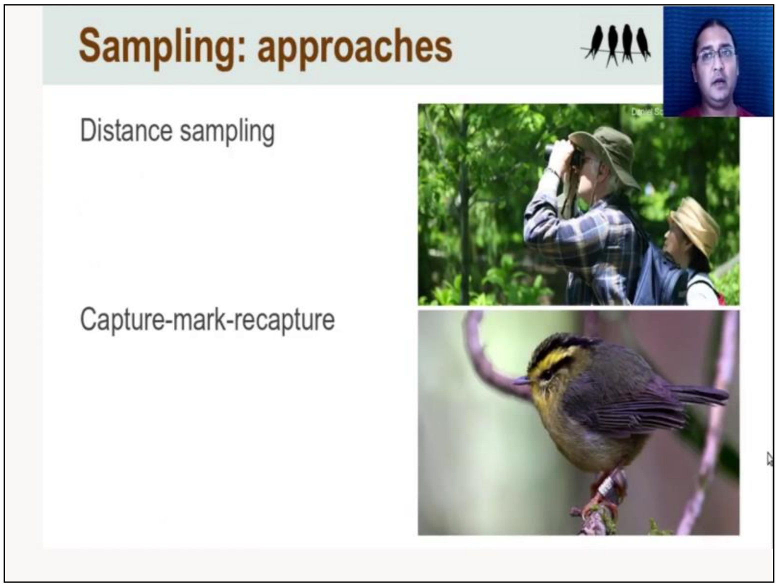

The two main approaches in sampling that we will talk about today are distance sampling and capture mark recapture. So, let us look at distance sampling to begin with.

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Distance sampling; the two main techniques are line transects and point counts and it is completely observational it is not based on the capture of any of the individuals in the population at all. So, it is basically walking through the habitat or standing stationary in the habitat at a particular point and counting the birds that you see around you. And the equipment that you need for distance sampling is a compass to estimate to measure the bearing or the angles at which species are individuals are sighted and the range finder that allows you to measure the distance to the bird from where you are standing.

So, the rangefinder is actually sending out a laser beam which then reflects off the bush or the tree on which the bird is sitting and then comes back and tells you what the distance between you as the observer and the bird is and that is why this is called distance sampling.

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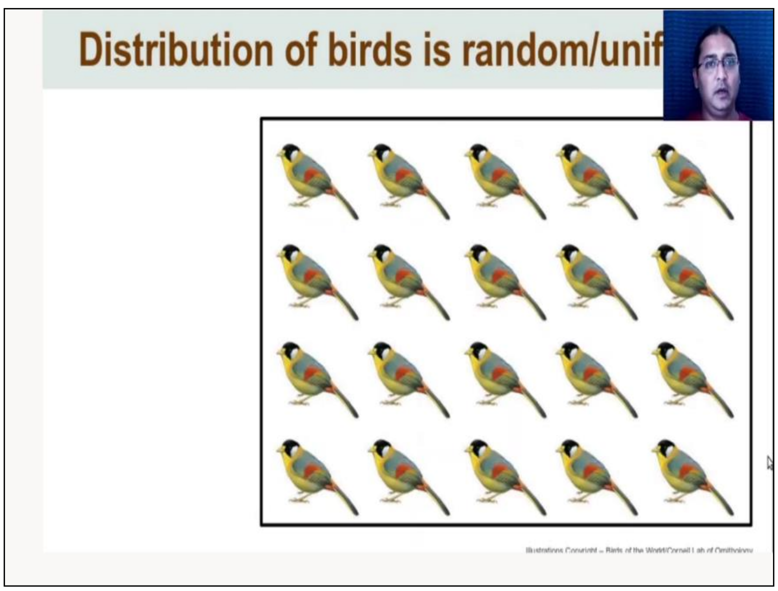

Let us assume that you go into a habitat and in this habitat the distribution of birds is random or uniform. So, if you are looking at this habitat or the study area from the top (just imagine that you are looking at an area square area of the forest or the habitat from the top), let us assume that the distribution of birds is uniform right. This is a uniform distribution of birds the density of birds or the population sizes of the birds is pretty much uniform throughout the habitat.

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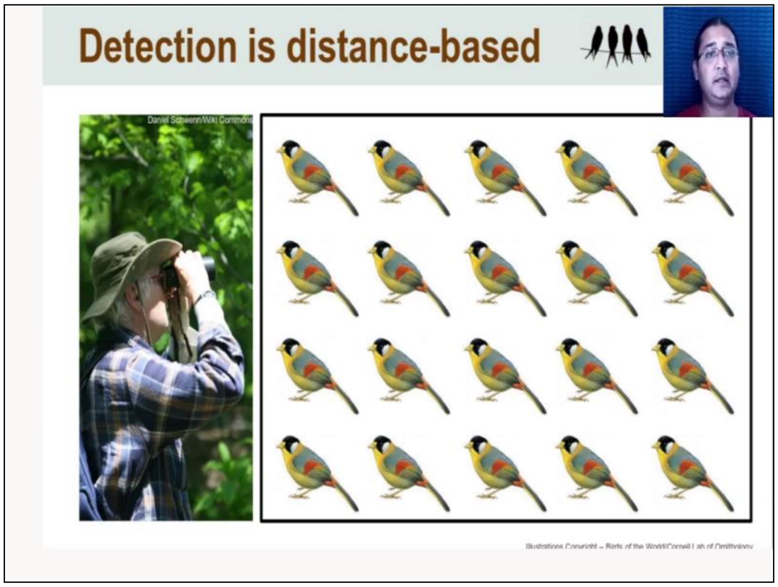

But if an observer comes to this habitat and stands at this location, the detection of these birds is going to be distant space. So, the birds that are closer to the observer are more likely to be detected more likely to be seen or heard than birds that are farther away from the observers. So, although the actual distribution of birds in the habitat is uniform what the observer sees is something more like this.

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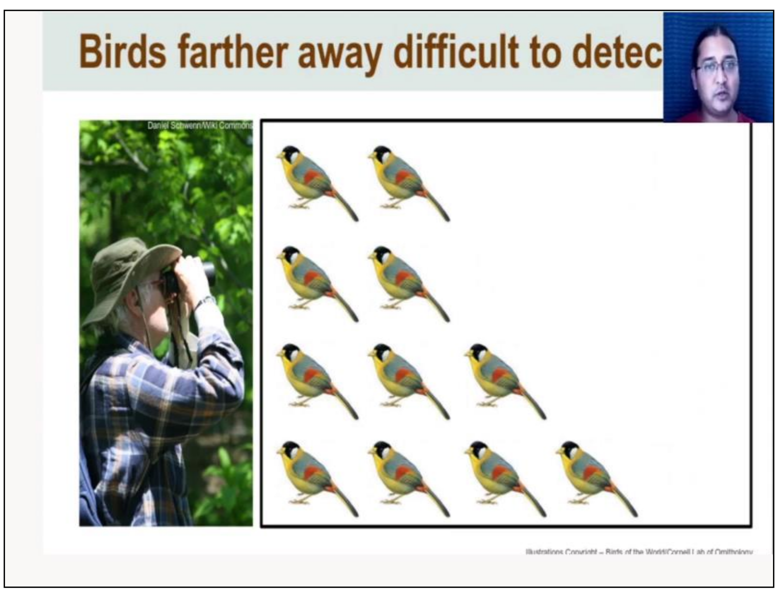

Where the birds that are closer to the observer are likely to be observed and entered into the data sheet or likely to be you know part of your data set. Whereas the birds that are farther away are more difficult to see and the farther away the bird is from the observer the less likely the observer is to see the bird. So, the observer will see more birds close by and as the distance from the observer increases the number of birds in the population that are actually seen comes down.

So, there is a relationship between the distance of the bird from the observer and the probability that the bird is detected and that is a negative relationship. So, in this context let's look at distance sampling and let's start off with line transect sampling.

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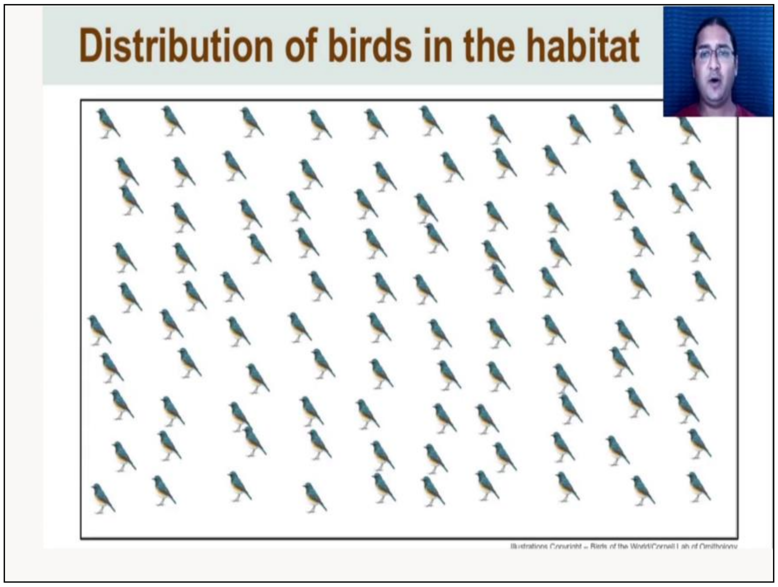

Let's say habitat in which there is a particular species that you want to know the population size of and this particular species is distributed randomly or uniformly in the habitat pretty much you know the abundance is not changing across the habitat. It is not like there is one part of the habitat where all the birds are clustered and other parts of the habitat where there are no individuals of this bird species.

What line transect sampling does and remember you are looking at this from the top you are looking at this rectangular shape habitat from the top and this is the actual distribution of birds in the habitat and what one does with line transect sampling is that through the habitat you establish a line. So, there is a line of a certain length, a straight line path through the habitat at a certain bearing and the bearing is measured using the compass.

So, the direction of the line transect is measured using the compass. So, if the line transect was completely straight and pointing upwards the bearing would be due north or zero degrees. If the line transect was pointing due south and downwards then the line transect would have a bearing of 180 degrees. In this case, the line transect is pointing roughly north east. So, the line transect bearing is somewhere close to 50 degrees and this straight line path is now set through the forest.

So, the line transect is marked in the forest as a straight line path at a particular bearing. And now as the observer walks through the habitat along this line transect from the start of the line transect to the end of the line transect.

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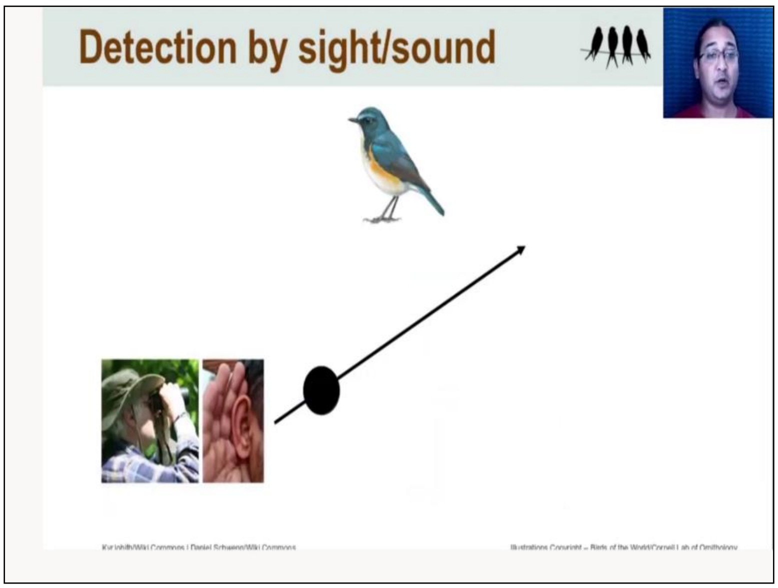

The observer at a particular point will detect a bird either by sight or by sound. So, for instance if I was walking along this line and about one fifth of the way through the line at that particular location represented by the dark circle, I see or I hear a bird in the habitat.

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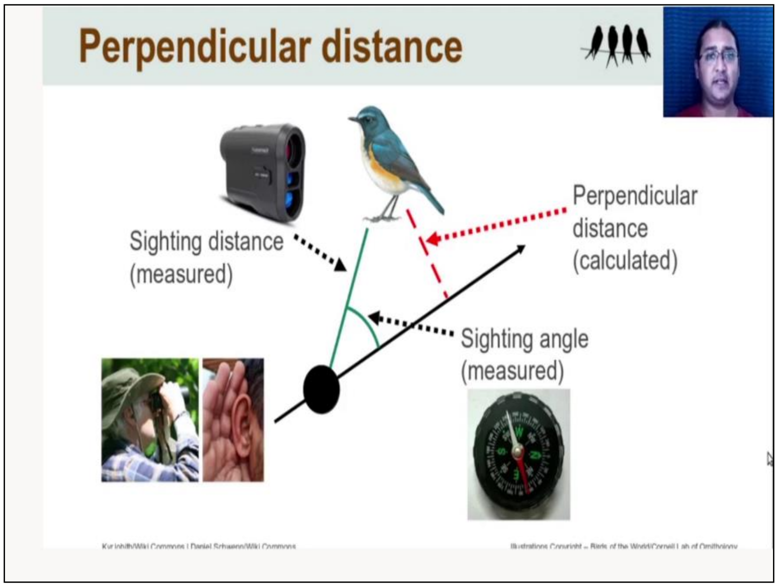

What line transect sampling involves and distance sampling involves is that first thing I do is I measure the distance to the bird or the sighting distance, the sighting distance measured by a laser rangefinder and then I measure the bearing of the bird to the transect. So, the transect has a certain bearing in this case let's say 50 degrees and the bird also has a certain bearing from my location which in this case may be about 10 degrees and the difference between the transect bearing and the sighting bearing then gives you the angle at which the bird was sighted.

Why do we do this? We do this because what we are interested in ultimately calculating based on the sighting distance and the sighting angle is the perpendicular distance of the bird from the line. So, using a bit of trigonometry and with these two measures, the sighting distance in the sighting angle we can calculate how far the bird was from the line itself or the perpendicular distance of the bird from the line. Now, once you calculate these perpendicular distances of each of the birds that you see.

So, for every bird you measure the sighting distance and the sighting angle and for every bird detected or group of birds detected, you get a perpendicular distance which is the distance of the bird from the line. Now based on that what do.

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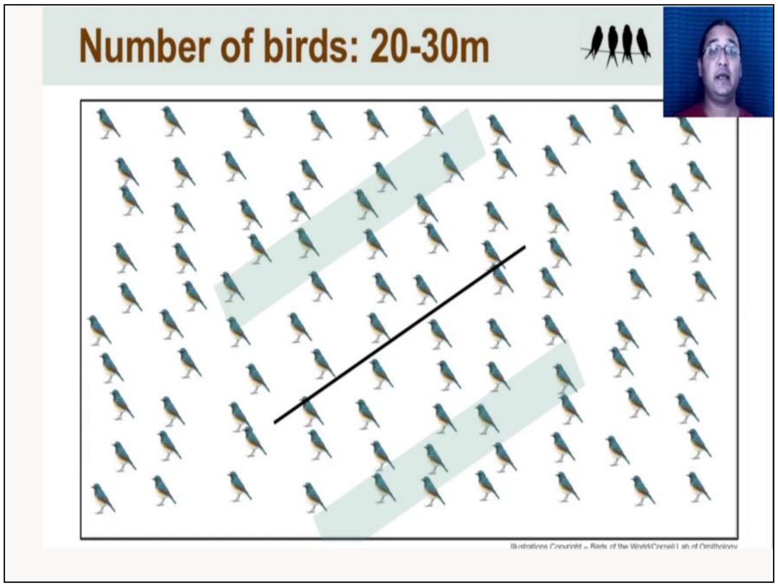

We do the distribution of birds in the habitat is uniform or random and so the number of birds between 0 and 10 meters on either side of the line. So, you have this belt or this strip which goes from the line and 10 meters on either side of the line, you have a certain number of birds in this belt which is between 0 and 10 meters from the line you have a certain number of birds between 10 and 20 meters from the line, you have a certain number of birds between 20 and 30 meters from the line.

Now because these birds are uniformly or distributed in the habitat or randomly distributed habitat the number of birds in the 0 to 10 meter band should be equal to the number of birds in the 10 to 20 meter band which should be equal to the number of birds in the 20 to 30 meter band because the areas of these rectangles are all the same and because the areas of these rectangles are all the same, the number of birds in these rectangular areas should also be the same.

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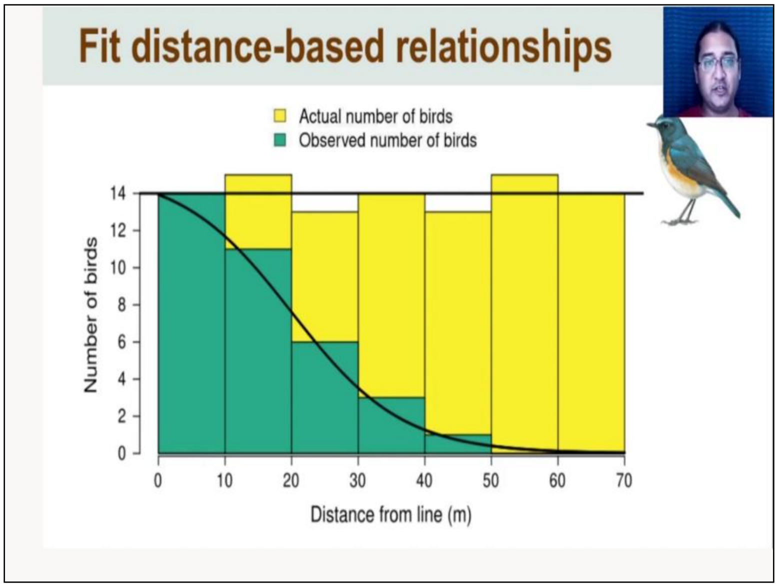

So, if you made a graph of distance from the line and the actual number of birds in the habitat, it should look something like this. So, let us say there are 14 birds between 0 and 10 meters, there are about 15 birds between 10 and 20 meters, there are 13 birds between 20 and 30 meters from the line, there are again 14 birds between 30 and 40 meters from the line, but it is a relatively uniform distribution which is that the number of birds at any distance from the line is actually roughly equal.

So, the actual number of birds in the habitat with a distance from the line per particular distance from the line is roughly equal regardless of how far from the line that you go. However, the detection declines with distance. So, birds that are very close to the line are always detected. So, the detection probability of these birds is being shown by the black line there the black curve and as you move farther and farther away from the line the detection probability of birds comes down.

So, very close to the line, if the bird is on the line, you are much more likely to see it or hear it. And as you move further away from the line, the number of birds that you see even though the number of actual number of birds is the same the number of birds that you actually see will come down with distance from the line. And therefore, the actual number of birds is the observed number of birds shown by the green here is for follows a pattern like this.

Whereas where close to the line you see almost all of the birds or all of the birds and with different distances from the line increasing distance from the line the observed number of birds comes down but the actual number of birds remains the same. What one then does with this data is fit using software's a distance based relationship of the observed number of birds the actual number of birds. The distance-based relationship of the actual number of birds is a flat line.

Because the actual number of birds does not actually change with distance but the observed number of birds actually follows this relationship and you fit this curve to the data that you get from distance sampling.

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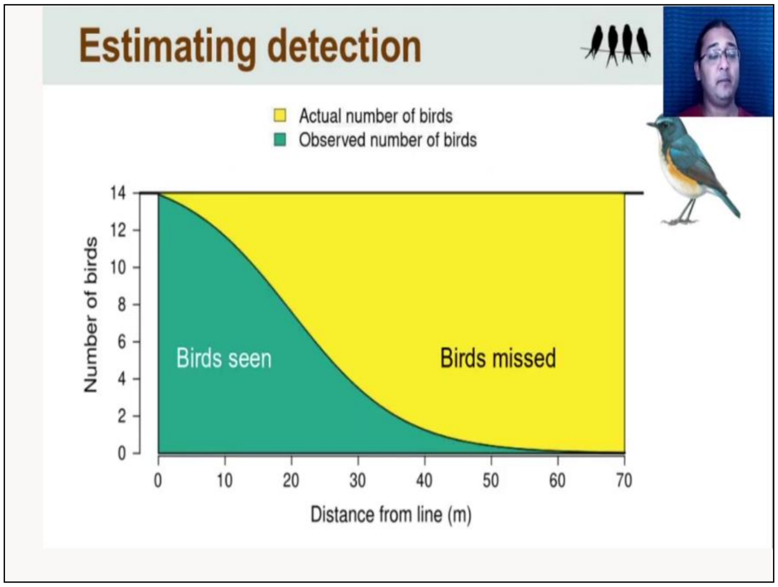

Once that curve is fit, basically all of this green area the area of the green part of this graph is the number of birds that have been seen the or heard, the number of birds detected and the yellow area of the graph is the number of birds that have been missed.

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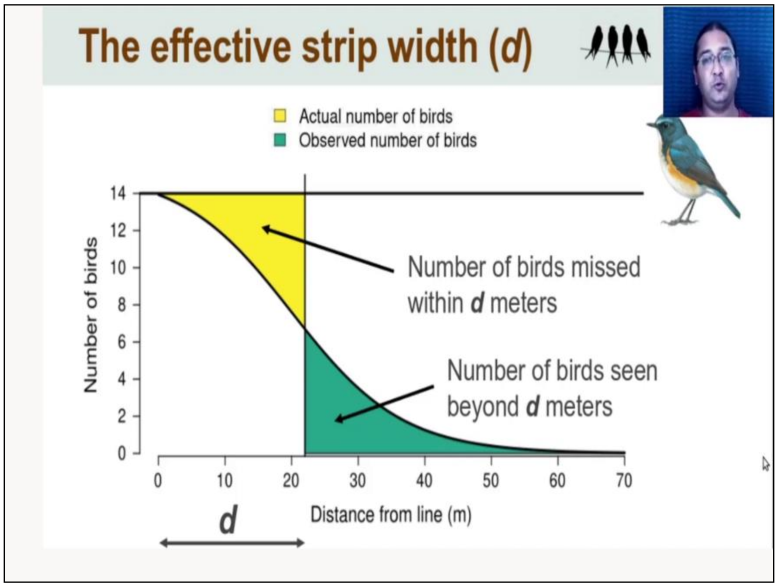

At some distance from the line which is called the effective strip width and denoted by d some distance from the line the number of birds that you have missed within the effective strip width will be…will be equal to the number of birds that you have seen beyond that striped. Now, that distance is not constant it is going to be different for different habitats it is going to be different for different species but based on the data that we collect.

And based on these distance-based relationships that we have between the number of birds seen and the distance from the line at some particular distance in this case 22 meters, the number of birds that have been missed within 22 meters is equal to the number of birds that are seen beyond 22 meters. In other words, the area of the yellow polygon is the same as the area of the green polygon.

So, if you took the green and you fold it up onto the yellow, if you just took that green and you picked it up and you replaced the yellow part with the green part because the areas are the same then basically all the birds in effect not really but in effect within 22 meters all of the birds have been detected.

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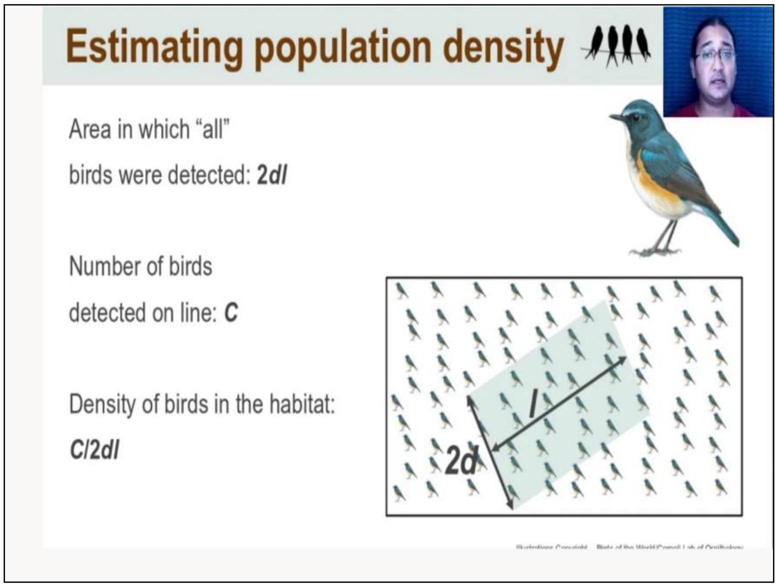

So, in this case the effective strip width is 22 meters from the line. Basically, based on our relationships between distance from the line and the number of birds that we have seen and assuming that all of these birds are randomly distributed in the habitat, the effective strip width We have estimated in this case to be 22 meters and so how do we calculate the density or the population density of these birds here.

So, the area in which all of these birds are detected and put all in inverted commas because actually all of the birds are not detected statistically we have found that within d meters from the line, the number of birds missed outside these equal to the number of birds the number of birds missed within d is equal to the number of birds missed outside of d and therefore in effect the area in which all the birds were detected is 2dl which is the area of this rectangle where l is the length of the line transect and d is the effective strip width.

So, the area of this rectangle here based on the length of the line transect and the effective strip width is 2dl, the number of birds totally detected on the line is the raw count of birds that we have actually observed which is C. Therefore, the density of the birds in the habitat per unit area is

$$C/2dl$$

All of these sampling methods are tools and their tools are suitable for certain tasks.

So, you have to pick the tool that you are using to sample these bird populations very very carefully because these tools assume certain things.

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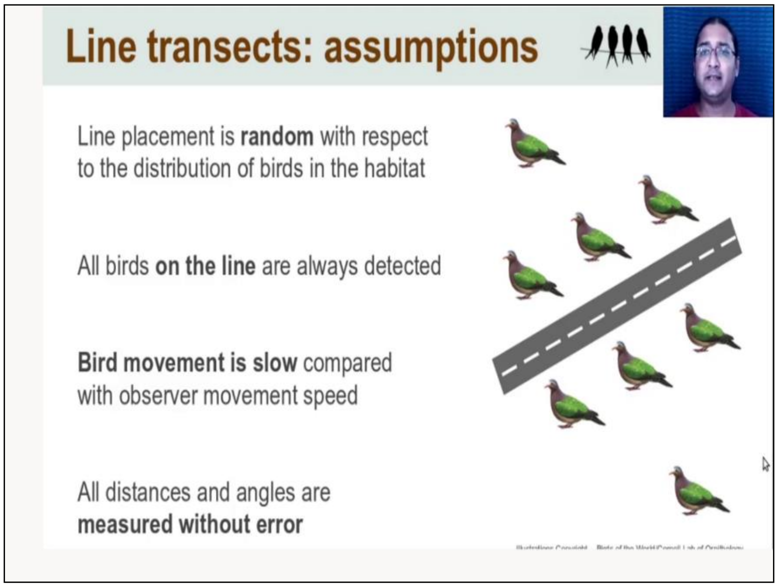

For example, in line transects the assumption is that the line transect placement is random with respect to birds in the habitat which might not necessarily be true. So, for example, certain species like Emerald Doves are attracted to roads. So, if you lose the roads as lines transect you are going to count a lot of doves close to the road. But farther away from the road there are actually lower numbers of doves and therefore the distribution of the birds in the habitat is not random with respect to the road.

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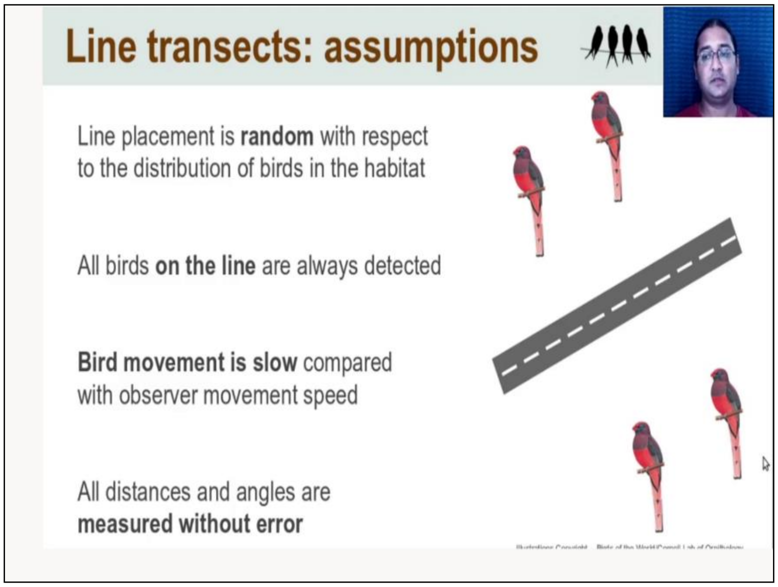

There might be other species that actually avoid roads. So, you might not find any birds close to the road but actually there are a lot of these birds farther away from the roads. So, very often we do not use roads for as line transects because the placement of the road based on bird species being attracted or repelled by the road is not random anymore. So, the placement of the line or the road itself is not random with respect to the population distribution with the way in which the birds are distributed in the habitat.

The second assumption is that all birds on the line are always detected. And we need that assumption to understand what is the actual distribution of birds in the habitat. We won't get into details here but the assumption of all birds in the line always being detected is to estimate what is the actual distribution of birds in the habitat not the observed distribution but the actual distribution of birds in the habitat.

We also assume in line transect sampling that the bird movement itself is slow compared with observer movement. So, the birds are moving far slower than the observer which basically means that the assumption is that the birds are detected more or less in the initial location at which they were. So, it is not after birds have moved that the detection happens, it is pretty much close to where the bird initially was that the observer detects this bird.

And finally, there is an assumption that all distances and angles are measured perfectly without any error there is no there are no mistakes in measuring the distances to the birds and the angles from the birds.

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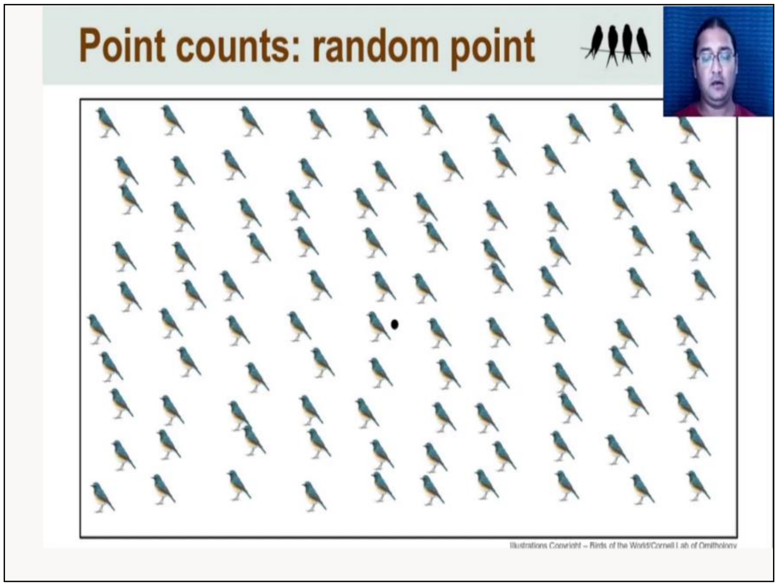

So, that was line transect sampling. Let's move on to point counts again like a line which was placed randomly with respect to the distribution of these birds in the habitat, a point is also placed at a random point in the habitat.

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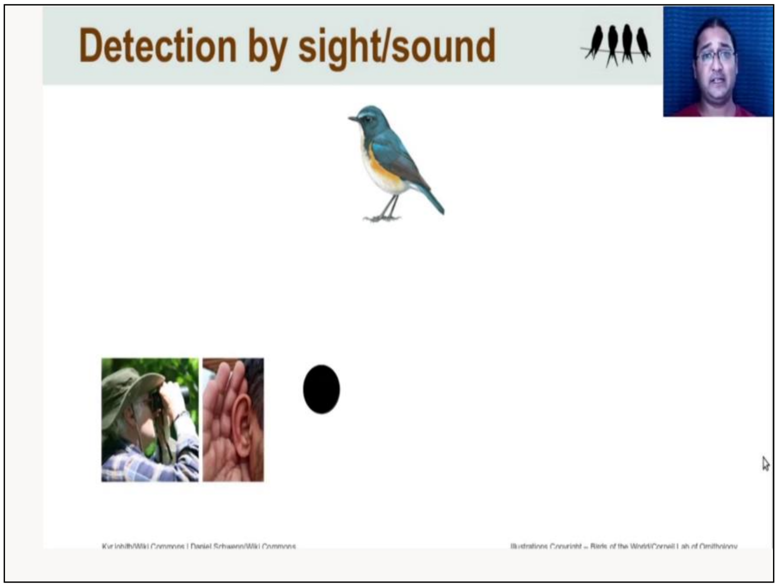

And then you know again at a point a bird is detected by either sight or sound. So, I am standing at that location there I am not walking at all. This is not a line transect, this is a point count, I get to a particular point (a location) in that habitat and standing at that location, I search for birds, I listen for birds and I watch out for birds. And in this case, I observe this one bird at a particular distance from me.

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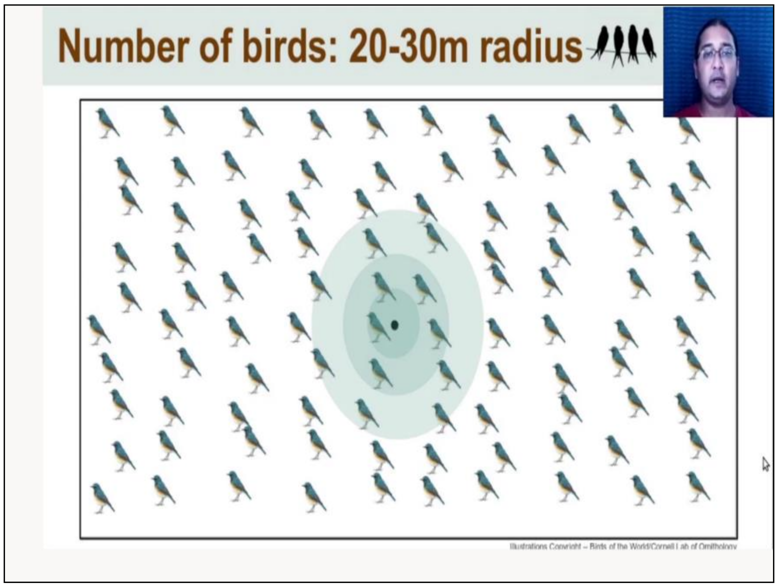

In the case of point counts, you only measure the radial distance from the point. So, there is no angle measured here unlike line transects there is no line and so there is no bearing and the only thing that is measured is the radial distance of the bird from the point using the laser range finder. So, unlike line transects, where you get rectangles of equal area at particular distances from the line.

So, the rectangle between 0 to 10 meters has the same area as the rectangle from 20 to 30 meters has the same area as the rectangle from 30 to 40 meters and so on. In point counts actually, the number of birds in the 0 to 10 meter radius is lower than the number of birds in the 10 to 20 meter radius which is then lower in the number of birds in the 20 to 30 meter radius and that is because in every radial band from 0 to 10 meters the area is lower than the circle between 10 to 20 meters and the area between 20 to 30 meters is higher than the area between 10 to 20 meters.

So, as you move away from the point, the area of the habitat is also increasing and therefore the number of birds if these birds are randomly located with respect to the point the actual number of birds should also increase with distance from the point.

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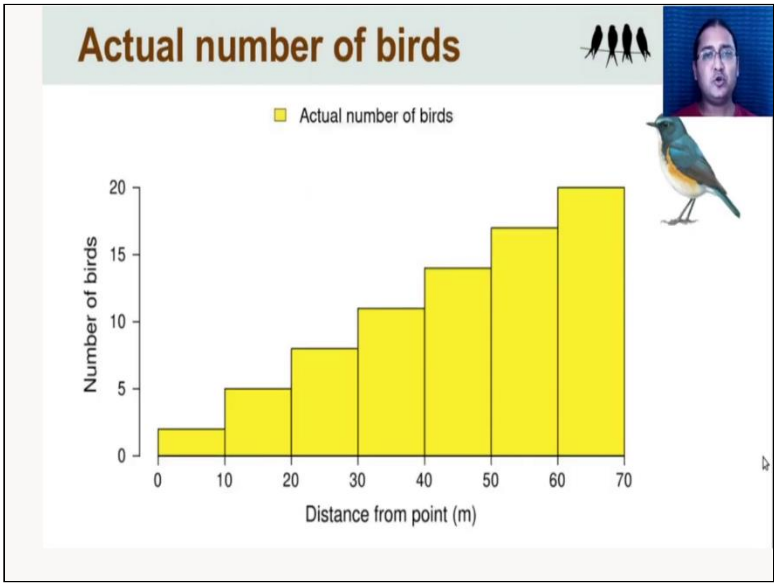

And so, the actual number of birds at various distances from the point is increasing and it increases linearly. So, there are very few birds in that small area close to the point but as the area farther and farther away from the point increases, the number of birds at farther away distance from the point will also be higher than the number of birds that are close to a point.

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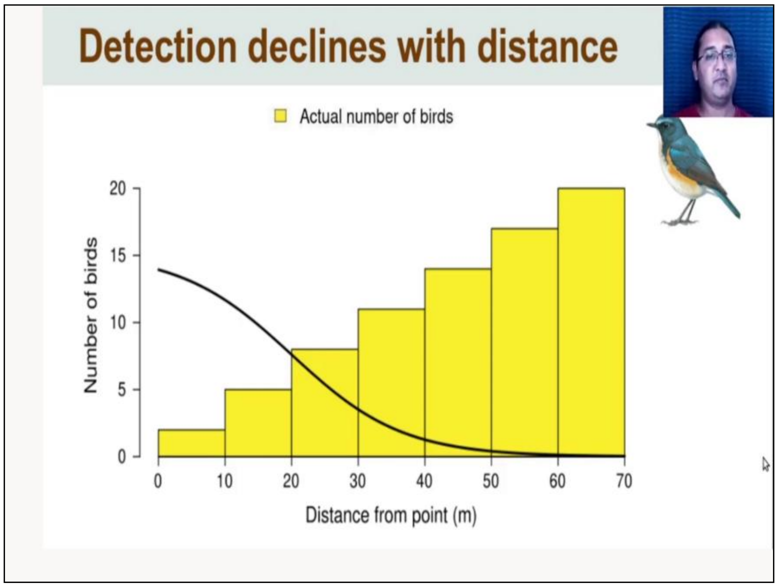

Now again with as with the line transect sampling, detection probability actually comes down right. So, birds that are close to the point are more likely to be detected but that are farther away from the point are less likely to be detected. And remember, this is birds in different radial distances away from the point. So, you have high detection probability but a low number of birds close to the point, you have intermediate detection probability and intermediate detection number of birds at a certain distance from the point.

Whereas very very far away from the point, you have very low detection probability but a high number of birds. So, the number of birds that you actually see is a product of the actual number of birds in the habitat and the detection probability of birds in the habitats. The actual number of birds you see looks something like this.

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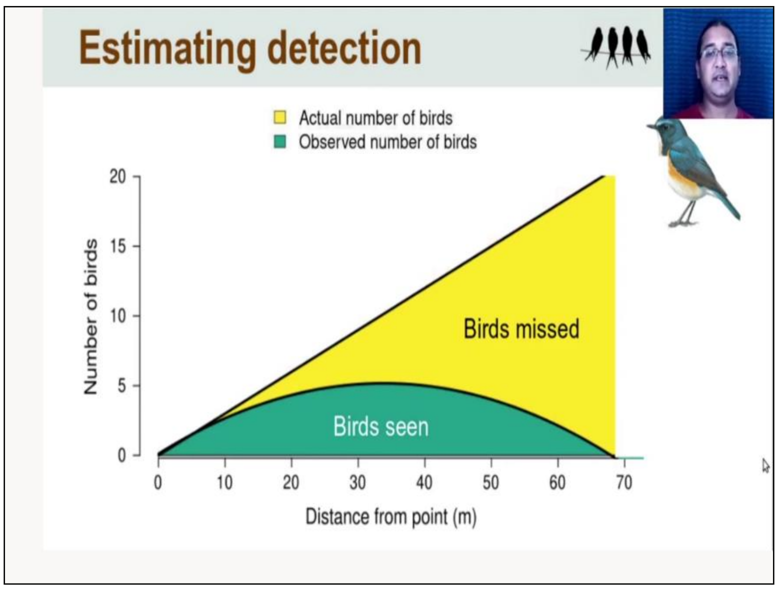

So, there are very few birds close to the point but detection probability is high. So, you see all the birds close to the point, you… as detection probability goes down further away from the point and the number of birds increases you see this hump shaped pattern where there is some distance from from the point where the number of birds that you see is maximum and even though there are more birds farther away from the point because you are much much less likely to detect them the number of actually observed birds declines as you go further and further away from the point.

So, again like with the line transect sampling you fit these distance based relationships where there is a linear line going upwards to the right which represents the distribution of the actual number of birds at different radial distances from the point. And the observed number of birds is represented by that curved line and like with the line transects as well you know the green area the area of the green polygon tells you the number of birds that are seen and the area of the yellow polygon tells you the number of birds that are missed.

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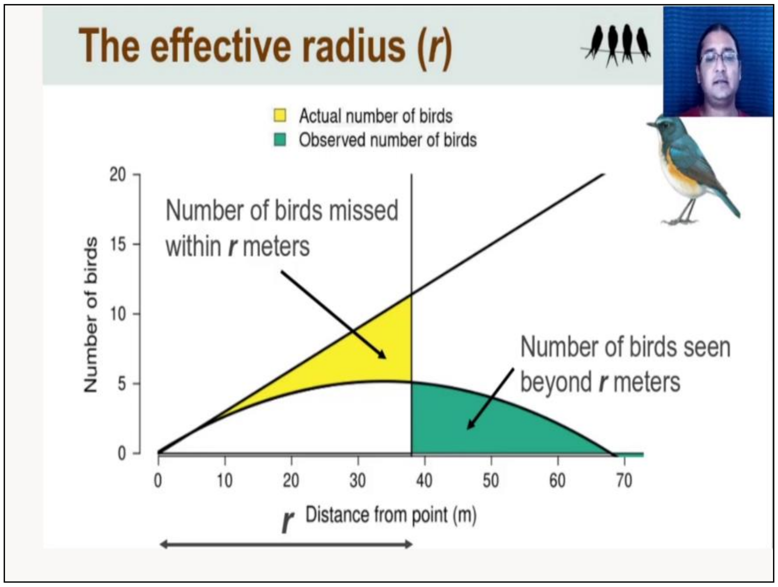

And then like line transects, there is a certain radial distance from the point which is the effective radius where the number of birds missed within r meters is equal to the number of birds seen beyond r meters. So, therefore the area of the yellow polygon and the area of the green polygon are identical. So, if you picked up that green polygon and you fold it up and replace the yellow polygon with the green polygon effectively.

Because the number of birds missed within r meters is the same as the number of birds missed beyond r meters within r meters effectively you have seen all the birds. So, the effective radius in this case again this will vary from location to location, it will vary from species to species. So, this is actually estimated from the data there is no single r value, it is this relationship between the way in which detection probability declines with distance from the point and the distribution of the birds in the habitat that gives you this r value of the effective radius value.

And so, the effective radius value for very very conspicuous species will be higher because you are detecting them farther away from the point and so on and so forth. So, this r is not a single value, in this case r is 38 meters, within 38 meters all of the birds effectively have been counted.

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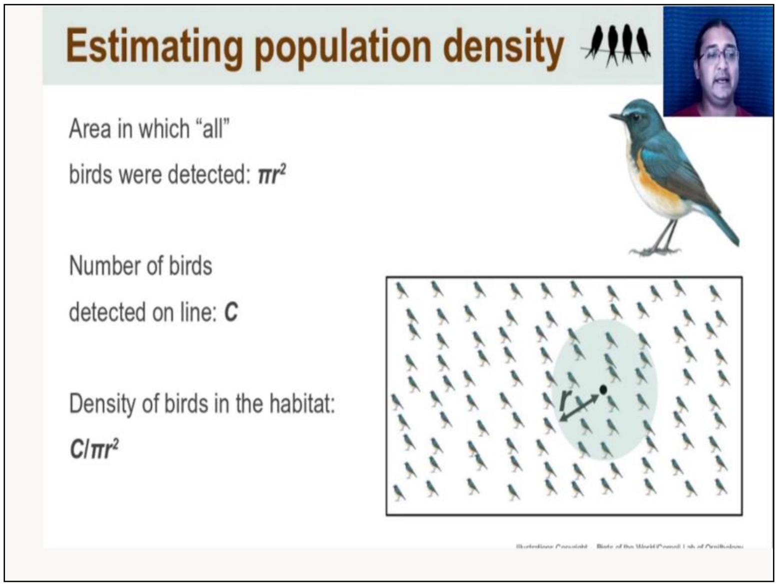

And just like line transect sampling, you can estimate population density and the area in which all the birds were detected is πr^2 that is the area of the circle where r is the effective radius. The number of birds detected on the point is C and therefore the density of the birds in the habitat is

$$C/ \pi r^2$$

and so that gives you per unit area how many birds are there in the habitat.

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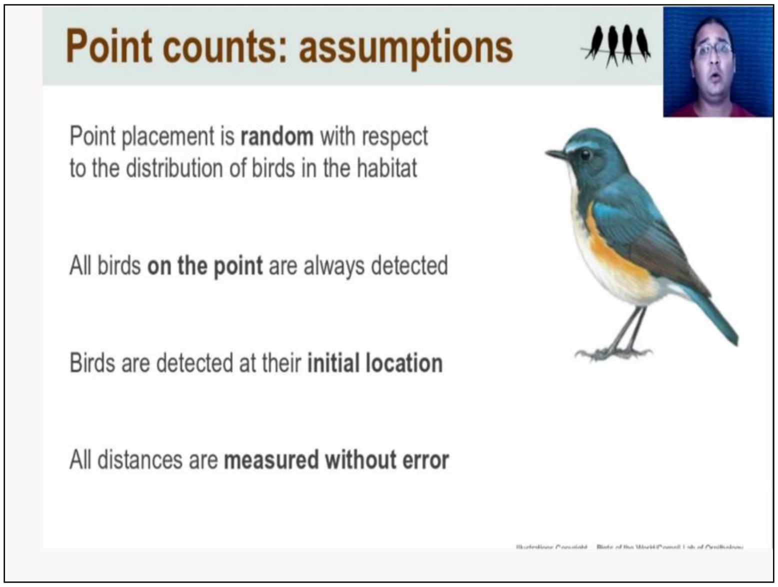

Again, like line transects, point counts have certain assumptions that the point placement is random with respect to distribution of birds in the habitat. All birds on the point you know if there is a bird right above you on the point, the assumption is that all birds on the point are always detected that birds are detected at their initial locations not after they have moved and that all distances in this case are measured without any error.

So, line transects and point counts what they are doing is that they are estimating the relationship between distance from the line or distance from the point and detection probability and then allowing you to estimate the number of birds that have been missed and therefore correcting for the fact that all of the birds are not going to be observed by an observer. And that is why this is called distance sampling because of measuring distances and based on the way in which the bird populations or the bird detections are declining with distance.

You can actually estimate the number of birds that have been missed and correct for non-perfect detection of these birds in the habitat.

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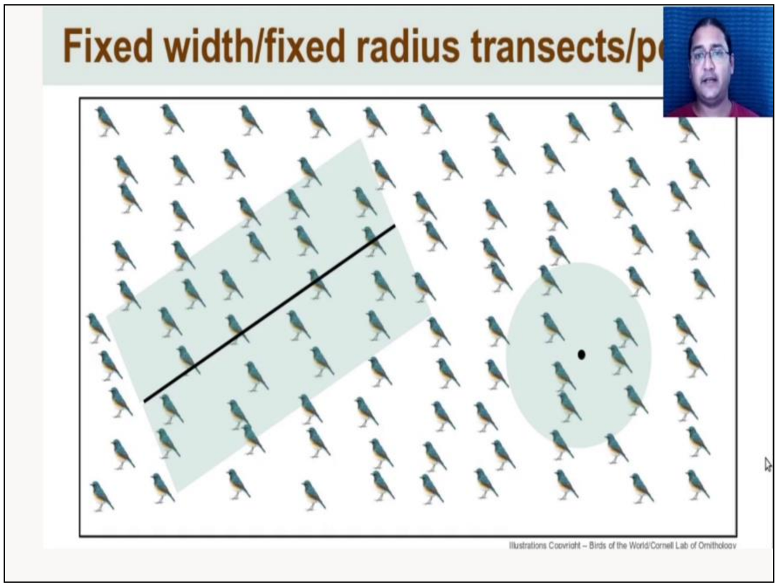

But very often though one of the ways in which people sample birds is by using fixed width of fixed radius transects or point count. So, the fixed width transect or the fixed radius point count of some certain width in the case of the line transect to some certain radius in the case of the point count where it is assumed that this belt is so small that all the birds within the belt have a detection probability of one.

Or that the distance the fixed distance from the point of the line is so small that it is not likely that any of the birds within these within this belt transect or within this fixed radius point count are missed and in this case, observers do not take distances but they simply count. Let’s say within 30 meters on either side of the line, I am going to count how many birds there are assume that I have counted all the birds within that short distance close to the line.

And therefore, get my density estimates from there and in the case of the fixed radius point count as well within a certain small radius I can assume that I am not going to miss any birds and so within that radius the actual number of birds that have counted does give me a an idea of the population density of birds in the habitats.

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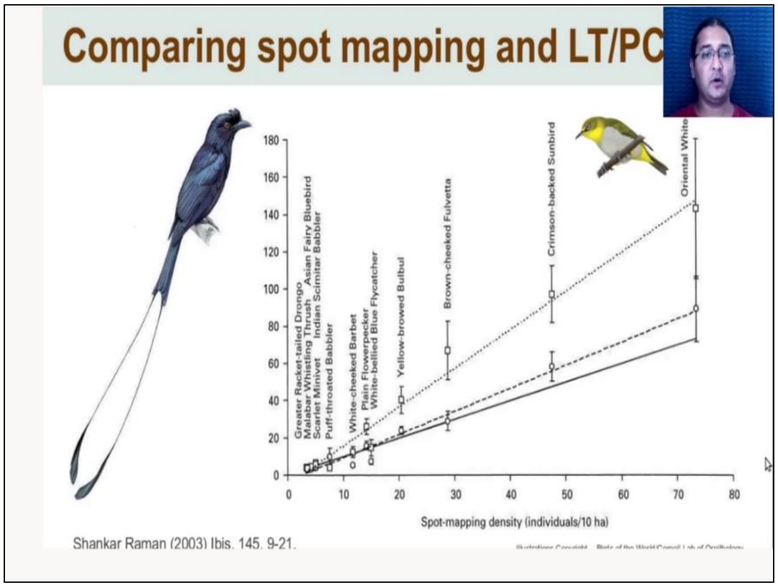

Now of these methods which perform the best. So, if you compare spot mapping density individuals, we're getting the number of individuals per 10 hectares the density of individuals in the habitat. You are comparing spot mapping with line transect sampling and with point count sampling the estimates would be very closely correlated if they were identical. So, you have spot mapping density of individuals on the x axis and the densities from point counts and line transects on the y-axis.

If these densities were identical from the point counts and the line transects and the spot mapping what you would see is that all of these points would lie on that dark black line. Each of these points represents the density estimate of a certain species. What you find often is that the density estimates from line transects which is the dashed line is often higher than the density estimates from territory mapping or spot mapping especially for birds that are very very abundant like the Oriental White-eye which is the last point there and the point counts in fact the abundance estimates are far higher than spot mapping or line transect sampling.

So, for example from spot mapping the density estimates of Oriental White-eye here are about 75 individuals per 10 hectares but the point counts are giving you almost double about 140 birdsper 10 hectares. So, very often point counts overestimate the number of birds in the habitat and one must be careful in using these different methods not violating any of the assumptions of point counts or line transect sampling.

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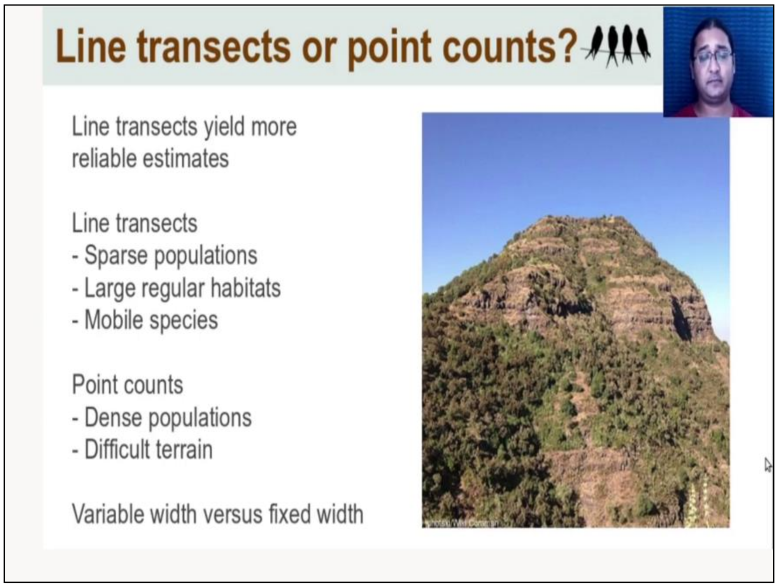

So, why use point counts at all? The line transects generally yield more reliable estimates of bird density in the habitats but often it is not possible in many habitats to lay a line to actually lay a long 500 meter or one kilometer line especially in habitats like mountains right mountain terrain is difficult and it is not possible to have a 500 meter or one kilometer straight line in this habitat. And so, point counts are used in places where the terrain is difficult and especially where the populations of the birds itself are dense. You know high population sizes of these birds are the high densities of these birds.

And line transects are more used for where the bird populations are sparse the density of the birds is sparse and in large regular habitats with mobile species. So, this is this is where the choice of what you use to estimate bird populations becomes important if the population sizes are generally low or densities are low and you have a large habitat that is regular and the terrain is not a problem. Then line transects are definitely preferable to point counts.

But in some cases, the terrain is difficult one might have to be forced to resolve the point counts rather than line transects. That was about line transection point counts and distance sampling and fixed width and fixed rate is a transection point count sampling.