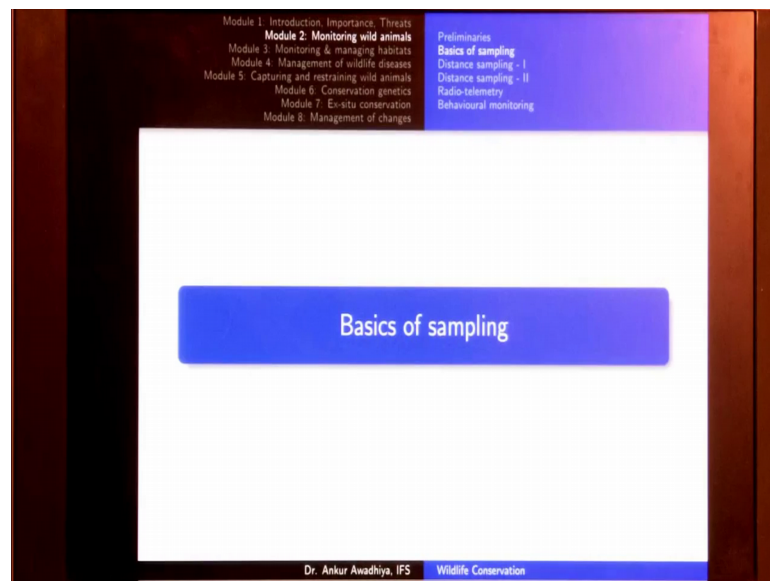


Wildlife Conservation
Dr. Ankur Awadhiya
Department of Biotechnology
Indian Institute of Technology, Kanpur

Lecture – 06
Basics of Sampling

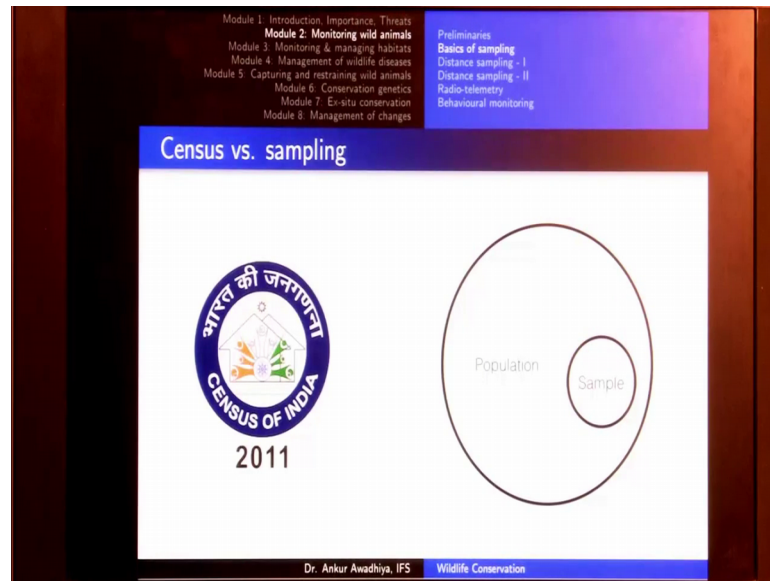
[FL] In today's class, we will have a look at the Basics of Sampling.

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Now, sampling is an important technique and the first concept is the difference between census and sampling.

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Now, census as we know is something like, in the case of India, we have a population census every 10 years. So, what happens in a census? In a census, there would be a person who would be coming to all the homes who would be asking a information about who are the residents, all the information about the family and other data, but the point to note here is that each and every person of this country would be counted which is why it is called a census.

On the other hand, when we look at sampling we have this whole population and we have a very small portion of the population that is taken out for this study which becomes a sample. So, the major difference between census and sampling is that in a census all the members of the population would be studied, whereas, in sampling only very small proportion of the people or the objects of study would be studied and that small portion would be called a sample.

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Module 1: Introduction, Importance, Threats
Module 2: Monitoring wild animals
Module 3: Monitoring & managing habitats
Module 4: Management of wildlife diseases
Module 5: Capturing and restraining wild animals
Module 6: Conservation genetics
Module 7: Ex-situ conservation
Module 8: Management of changes

Preliminaries
Basics of sampling
Distance sampling - I
Distance sampling - II
Radio-telemetry
Behavioural monitoring

Objective of sampling

"to secure a sample which will represent the population and reproduce the important characteristics of the population under study as closely as possible."²

<http://www.fao.org/docrep/003/X6831E12.htm>

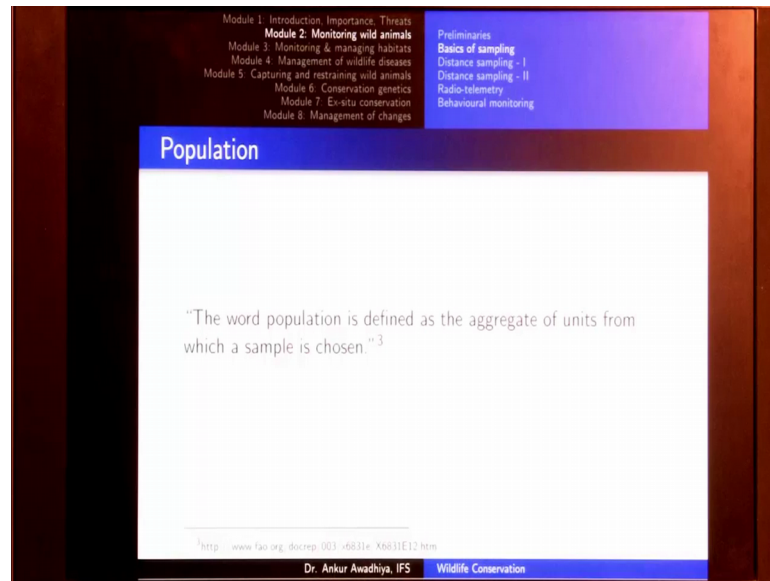
Dr. Ankur Awadhiya, IFS Wildlife Conservation

So, what is the objective of sampling? The objective of sampling is to secure a sample which will represent the population and reproduce the important characteristics of the population under study as closely as possible. What do we mean by that? Now in any case, it is always good to have a census of the complete population because that would give us a hundred percent correct information.

But when we do a sampling, when we are doing a census, it will take quite a lot of effort. It will take quite a lot of time and it will involve quite a lot of money, but if in place of studying the complete population if we can get the same amount of data with appreciable levels of precision and accuracy from a very small sample, then we would be able to reduce our effort, our cost and our time.

So, the aim of sampling is to do the sampling in such a way that even this small bit of information that we are taking out from the sample is able to adequately represent the complete population. So, that we have a good amount of data.

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Now what is the population? The word population is defined as the aggregate of units from which the sample is chosen.

So, in the case of humans if we know the human population in the case of our census would mean, all the residents, all the citizens of the country. In the case of wild life, the population would mean all the animals of a particular species that we are studying which are there in our protected area with the national park, a sanctuary, a tiger reserve whatever. So, for instance if you wanted to know, what is the proportion of animals say chital in our park that are diseased. So, the population would mean all the individuals of the chital species that are present in our national park. Next is sampling unit.

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Module 1: Introduction, Importance, Threats
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Preliminaries
Basics of sampling
Distance sampling - I
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Behavioural monitoring

Sampling units

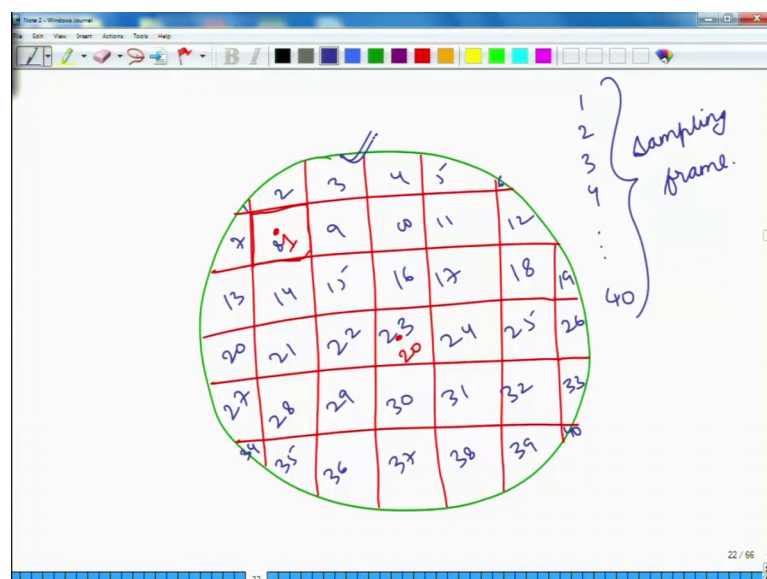
"Sampling units may be administrative units or natural units like topographical sections and subcompartments or it may be artificial units like strips of a certain width, or plots of a definite shape and size. The unit must be a well defined element or group of elements identifiable in the forest area on which observations on the characteristics under study could be made. The population is thus sub-divided into suitable units for the purpose of sampling and these are called sampling units."⁴

⁴<http://www.fao.org/docrep/011/n031e/y681e17.htm>

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Now, a sampling unit may be an administrative unit or a natural unit like topographical sections and sub compartments or it may be artificial units like strips of a certain width or plots of a definite shape and size. The unit may be must be a well defined element or groups of elements identifiable in the forest area on which observations on the characteristics under study could be made. The population is this sub divided into suitable units for the purpose of sampling and these are called sampling units.

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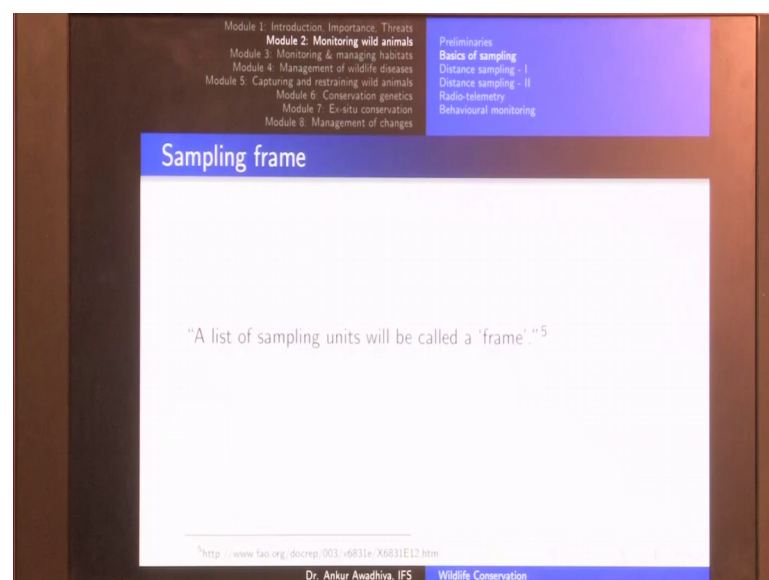
So, to show it graphically, so, to show it graphically, suppose this is our complete forest and we have divided it into some compartments. Now, those compartments could be artificial. So, for instance, we take strips of equal width. So, in this case, we have divided the whole forest into this gridded arrangement and we can very clearly de mark it this portion of the forest with this portion of the forest.

So, we can very clearly see that this portion is different and this portion is different. We can always go back if we say called this portion 1. This 1 is portion number 20. So, we have clearly de marketed it in such a way that if ever we wanted to go to this place again; if we set that we wanted to go to section number 1, we would be able to clearly identify that this is our section number one.

So, in this case sampling unit would mean all of these sections together. So, to take another numbering we have, 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40.

So, in this case, we have 40 different administrative units or natural units that are well defined and are covering our forest completely. So, these 40 units in total will be called the sampling unit the next thing is a sampling frame.

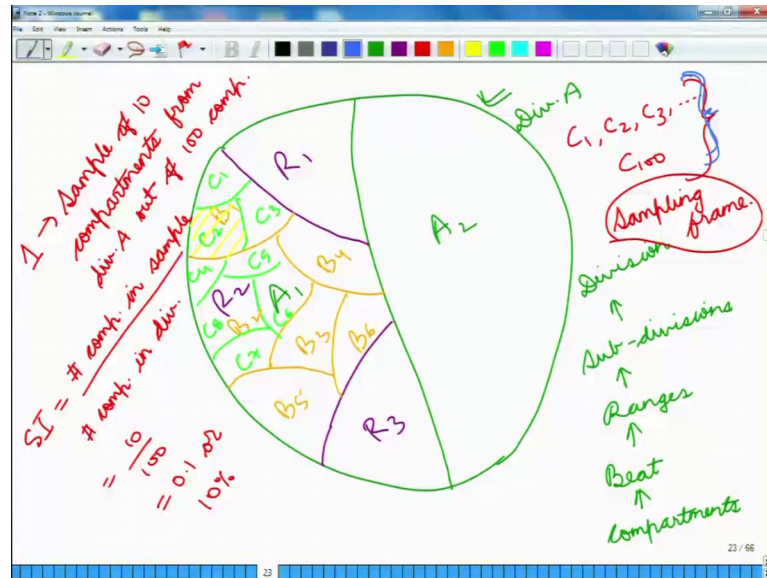
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A sampling frame is the list of sampling units which will which is called a frame. So, essentially when we are considering this whole area of the forest, when we say that our

units are 1 2 3 and so, on up till 40, then this list becomes sampling frame. Now once we have decided on a sampling frame, now it is important to note here that this was one arrangement in which we have put up a gridded system.

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On the other hand in the forest, we could also be having an administrative system. So, in our country we have the arrangement such as this. So, we have a beat or we have compartments which are the smallest areas the smallest management units are the compartments, then we have the beats, then we have ranges, then we have sub divisions, then we will have a division.

Now, suppose this whole forest forms part of a division called division A. Now this division is divided in to two sub divisions which are sub divisions A 1 and A 2. Now the sub division called A 1 is divided into say, 3 ranges. So, these three ranges are called say R 1 R 2 and R 3. Now a division is governed by a divisional forest officer. A sub division is governed by a sub divisional forest officer. A range is governed by a range forest officer.

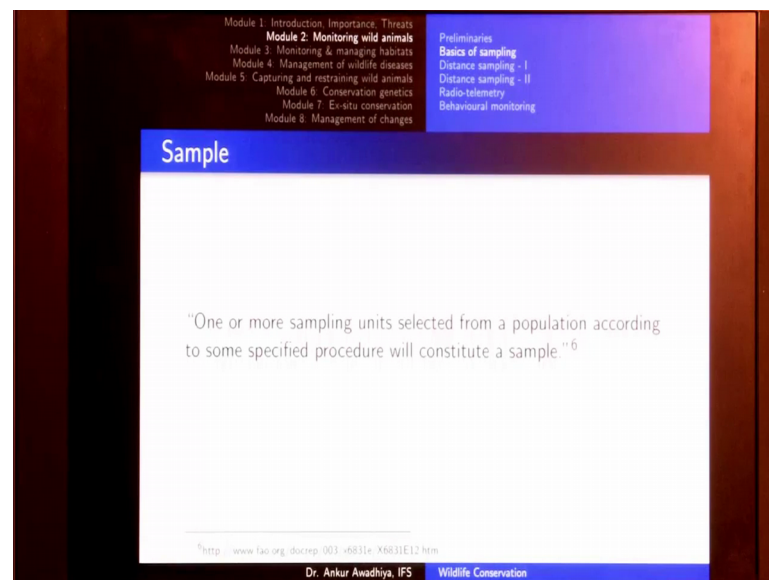
Now, within this range these ranges. So, let us consider range R 2, it will be divided into a number of beats. Now each of these beats; so, let us called these B 1 B2 B 3 B 4 B 5 and B 6. Now each of these beats in the range R 2 all of these beats B 1 B 2 B 3 B 4 B 5 and B 6 are governed by a forest guard [vocalized-noise.] And in each beat, we will be

having some compartments. So, let us call this C 1 C 2 C 3 C 4 C 5 C 6 C 7 C 8 and so on.

So, when we say compartment C 2, we can very clearly say that this compartment C 2 is a part of B to B 1 which is the part of range R 1 which is a part of sub division A 1 which is a part of the division A. So, in place of our previous arrangement of a gridded arrangement, we could also make use of these administrative divisions.

Now, once we have decided on the frame, so, in this case the frame was 1 to 40. In this case, our frame would be say, the all the compartments. So, we have C 1, C 2, C 3, so on, say up till C 100. So, all this list becomes our sampling frame.

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Now, from this sampling frame, the next concept is that of a sample. So, coming back to this slides. A sample is one or more sampling units selected from a population according to some specified procedure which will constitute a sample. So, essentially what we are saying is that coming back to the board. So, once we have decided on our sampling frame our sample would say consist of 10 compartments out of these 100 compartments.

So, now the question is which of these 10 compartments should form our sample? Do we take the first 10 compartments? Do we take the last 10 compartments? Do we take every tenth compartment in which case, we will be taking C 10, C 20, C 30, C 40 up till C 100. So, the question is what is the rule from using which will be taking out these sampling

units from the sampling frame that would constitute the sample? So, one or more sampling units that are selected from a population according to some specified procedure will constitute a sample. The next concept is that of sampling intensity.

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The slide is titled "Sampling intensity" in a blue header. It features a table of contents on the left and a definition of sampling intensity in the center. The table of contents includes:

- Module 1: Introduction, Importance, Threats
- Module 2: Monitoring wild animals**
- Module 3: Monitoring & managing habitats
- Module 4: Management of wildlife diseases
- Module 5: Capturing and restraining wild animals
- Module 6: Conservation genetics
- Module 7: Ex-situ conservation
- Module 8: Management of changes

On the right, under "Preliminaries", it lists:

- Basics of sampling**
- Distance sampling - I
- Distance sampling - II
- Radio-telemetry
- Behavioural monitoring

The central text defines sampling intensity as:

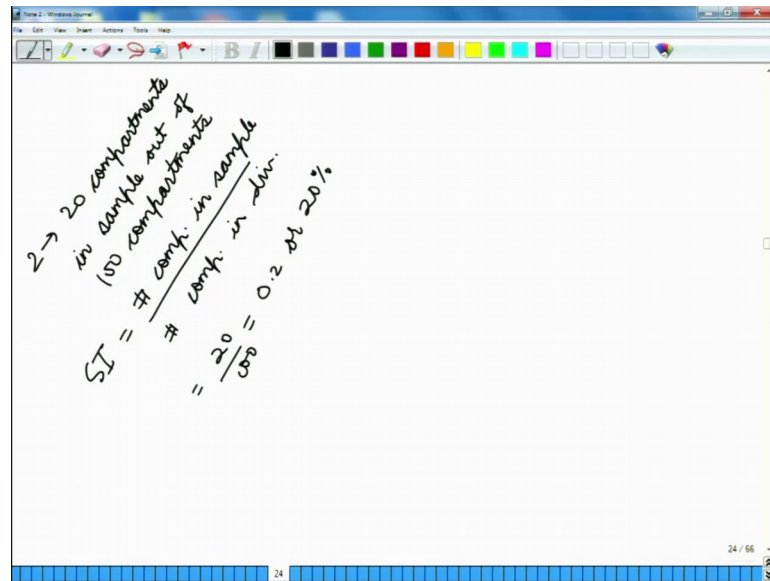
"Intensity of sampling is defined as the ratio of the number of units in the sample to the number of units in the population."⁷

At the bottom, there is a footnote: ⁷ <http://www.fao.org/docrep/003/x6631e/X6631E12.htm>

The footer includes the name "Dr. Ankur Awadhiya, IFS" and the text "Wildlife Conservation".

So, we have intensity of sampling is defined as the ratio of the number of units in the sample to the number of units in the population. So, now, coming back to the board, suppose we have a scenario 1; in scenario 1, we took a sample of 10 compartments from division A out of 100 compartments. So, in this case our sampling intensity would be the number of compartments in sample divided by the number of compartments in the division which would be 10 by 100 which is 0.1 or 10 percent. So, this is our sampling intensity.

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The image shows a screenshot of a software window titled "Notes 2 - Windows Journal". Inside the window, handwritten text in black ink calculates the Sampling Intensity (SI). The text is written diagonally and includes the following:

2 → 20 compartments
in sample out of
100 compartments

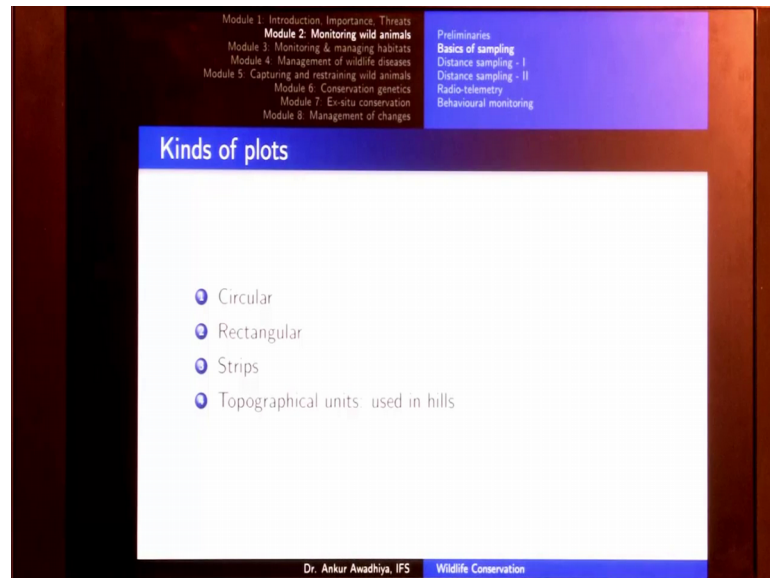
$$SI = \frac{\# \text{ comp. in sample}}{\# \text{ comp. in div.}}$$
$$= \frac{20}{100} = 0.2 \text{ or } 20\%$$

The software window has a standard toolbar at the top with various drawing tools and a status bar at the bottom showing "24 / 66".

On the other hand, in place of taking 10 samples; in another scenario 2, we took a 20 compartments in sample out of 100 compartments. Then our sampling intensity becomes number of compartments in sample divided by number of compartments in the division which is 20 by 100 is 0.2 or 20 percent.

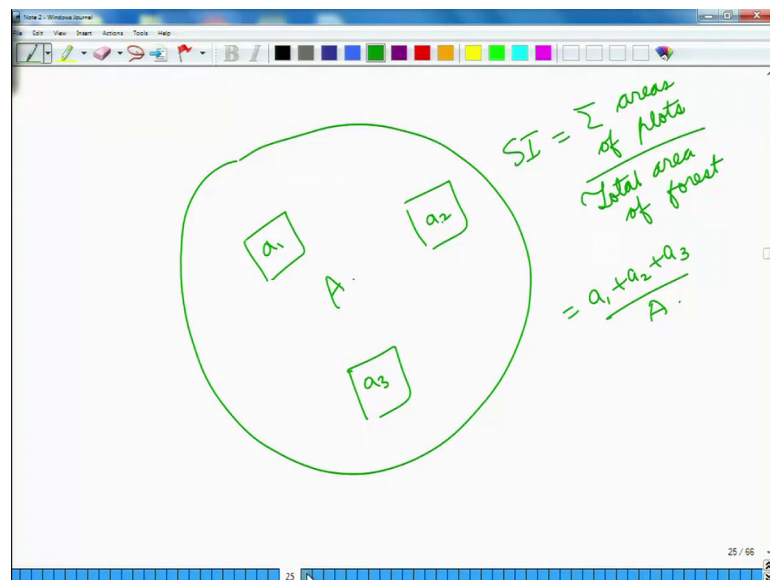
So, as we see. So, we can see here that as we increase the number of compartments in our sample, out of a total of 100 compartments our sampling intensity increases. Now, what happens when we have all the 100 compartments in our sample that were there in the division? So, in that case our sampling intensity would become 100 divided by 100 which is 1 or 100 percent in which case, it would our results will be very close to the sensors results.

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Now, next when we are selecting our areas; so, coming back to the board. So, in this case, we had selected ours our sampling units in the form of these grids, but in place of these grids we could also select some plots. So, what do we mean by a plot?

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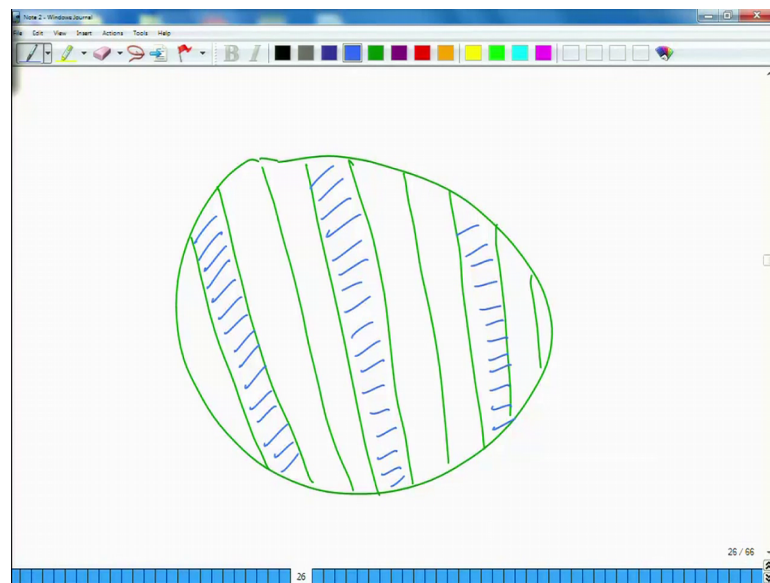


So, in this forest area, we could say that we will be having we use our computer to find out 3 coordinates. And in these 3 coordinates, we draw circular plots and we say that that these three circular plots become our sample.

So, in that case our sampling intensity would be the some of the areas of plots divided by the total area of forest. So, essentially if this was areas a_1 a_2 and a_3 and in the total area of the forest was A . So, our sampling intensity would be $a_1 + a_2 + a_3$ divided by capital A .

Now, in place of taking circular plots, we could also take rectangular plots. So, things like this. So, in place of grids, we could also go for rectangular plots we could also go for strips.

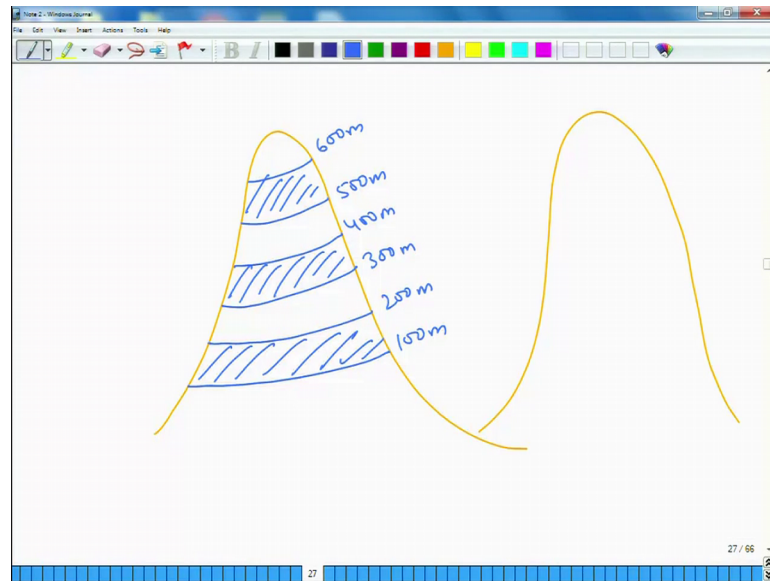
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So, in the case of a strip, we take this whole area and we divided it into strips and let us say that we include every third strip starting from strip number 2. So, this is strip number 2, this is a part of the sample, then we leave two others, then we take the third one, then we can take we leave two others and then we take the third one and so on.

So, we can even use strips to de mark it R our samples. The forth thing is topographical units which is generally used in the hills.

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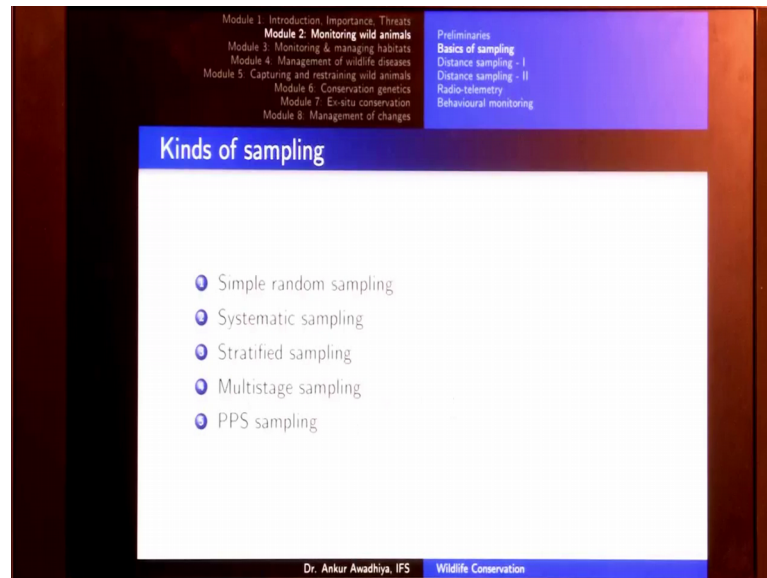
So, essentially if you have hills you could say that we will use the contour lines. So, contour lines will tell us the height.

So, let us say that this is a contour line. These are contour lines that represent say a height of 100 meters 200 meters 300 meters 400 meters 500 meters and 600 meters. So, we could even say that our sample is all the area which falls between two contour lines and will take every other strip as our sample. So, this is a part of our sample, this is a part of our sample, this is a part of our sample. So, we here we have taken a sampling intensity of close to 50 percent and we have taken topographical units.

So, the plots that are used to demarked are sampling units could be any of these we could have. So, coming back to the slides, we could have circular plots, we could have rectangular plots, we could have strip plots. Now, strip plots are generally used in plane areas or we could have topographical units which are generally used in the hilly areas.

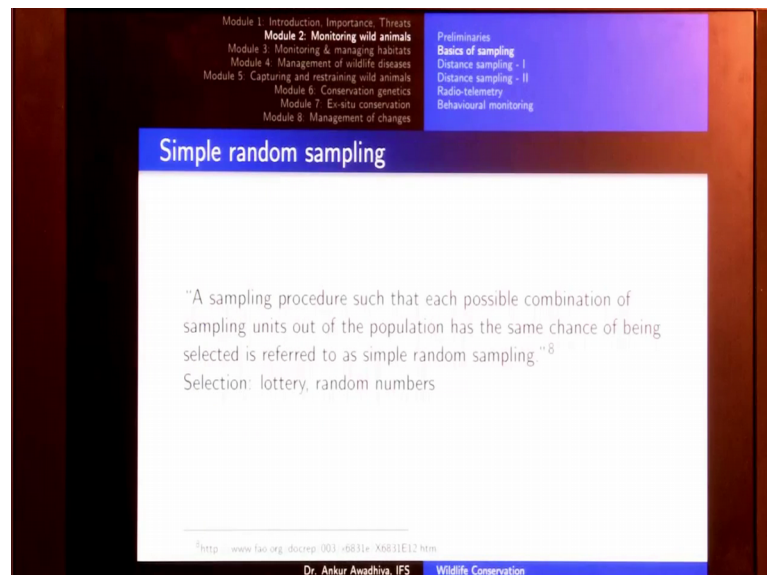
So, once we have decided on the sampling units how do what is the formula that we use to take out are sample from the sampling units.

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Now that formula would give us different kinds of sampling which are these are the most common types of sampling; simple random sampling, systematic sampling, stratified sampling, multi stage sampling and PPS sampling which stands for probability proportional to size sampling.

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So, let us now look at these in greater detail. The first is a simple random sampling, now a sampling procedure such that each possible combination of sampling units out of the

population has the same chance of being selected is referred to as a simple random sampling. For example, lottery or random numbers.

So, coming back to our example of the grids or, let us take the compartments. So, here we have 100 compartments C 1 to C 100. Now, if we say that we are going to select 10 compartments and the method of selecting those 10 compartments is lottery. So, what we do is we take out chits of paper, we write all these names 1 to 100, then we fold them, we put them into a box, we mix it up and then we take out 10 slips.

So, the numbers that are there will form a part of our sample. So, such a procedure will be known as a simple random sampling because all of these 100 compartments have an equal probability of forming a part of this sample. Another way of doing the same thing is by using random number generators. So, we can write a computer program to generate random numbers for us and then those random numbers would be from 1 to 100 and then we take the first 10 random numbers.

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The slide features a table of contents at the top and a definition of systematic sampling in the center.

Module 1: Introduction, Importance, Threats	Preliminaries
Module 2: Monitoring wild animals	Basics of sampling
Module 3: Monitoring & managing habitats	Distance sampling - I
Module 4: Management of wildlife diseases	Distance sampling - II
Module 5: Capturing and restraining wild animals	Radio-telemetry
Module 6: Conservation genetics	Behavioural monitoring
Module 7: In-situ conservation	
Module 8: Management of changes	

Systematic sampling

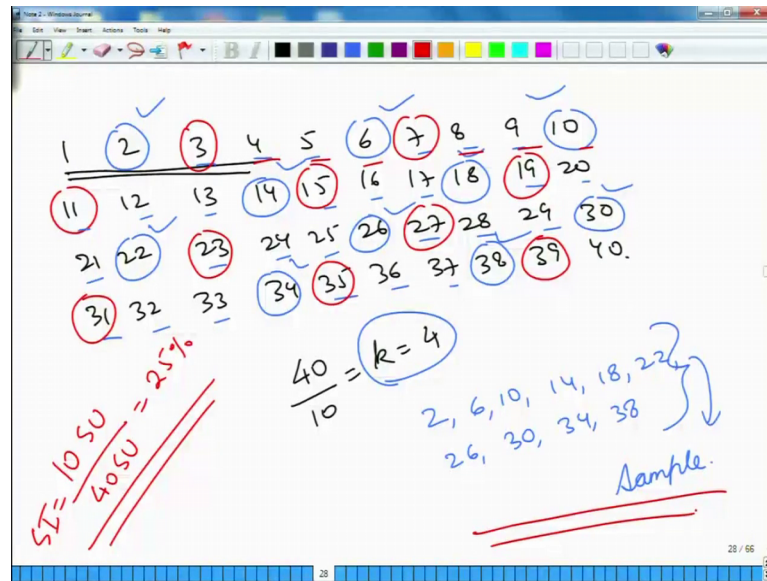
"Systematic sampling employs a simple rule of selecting every k th unit starting with a number chosen at random from 1 to k as the random start."⁹

⁹<http://www.fao.org/docstore/2003/x6831e/x6831e12.htm>

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So, formula such as these form a part of the simple random sampling. The second sampling is known by the name of systematic sampling. Now a systematic sampling employs a simple rule of selecting every k th unit starting with a number chosen at random from 1 to k as the random start. So, essentially this means that when we took out these numbers; so, let us take the example of our 40 grids.

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So, we have, 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40.

So, we have these 40 grids and we are doing a systematic sampling. So, in the case of systematic sampling, we will first decide that how many numbers do we want to out of these 40? Let us say that we want 10 numbers out of these 40 numbers. So, we have 40 numbers and we have ten units that will form our sample. So, we will have the value k is equal to 4. So, if we take every fourth value, then we will have a total number of 10 samples here.

Now, those fourth values can start from any of these first 4 and that number would be taken at random. So, let us take the second value. So, this is this becomes our first value for the sample. Now, the next unit would be two plus the fourth one.

So, we will leave 1 2 3 and we take the forth one because our k is equal to 4 here and we leave 1 2 3, take the fourth one; 1 2 3, take the fourth one; 1 2 3 take the fourth one, 1 2 3 take the fourth one, 1 2 3 take the fourth one 1 2 3 take the fourth, 1, 2, 3 take the forth one, 1, 2, 3 take the fourth one. How many have we taken till now? 1 2 3 4 5 6 7 8 9 10.

So, these 10 values that is 2 6 10 14 18 22 26 30 34 and 38, this become part of our sample. When we have done this whole exercise, we have constituted our sample from the population by making use of a systematic sampling.

Now, if we take the starting position as something else, suppose we started at number 3, so, here also we will perform the same procedure. So, we leave 1 2 3 take the fourth one, 1, 2, 3, take the fourth one. So, essentially these values would form part of our sample. The main thing to note in the case of a systematic sampling that here we are making use of some formula. The formula is to take every k th unit and how do we get the value of k ? We get the value of k from our sampling intensity.

So, in this case we had said that we wanted 10 sampling units. In the sample out of 40 sampling units in the population, so, we get a sampling intensity of 10 by 40 which is 25 percent. So, once we have decided on the sampling intensity, we can get the value of k and from that value of k and selecting the first value at random, we can form a sample. So, this is all about a systematic sampling.

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Module 1: Introduction - Importance - Threats
Module 2: Monitoring wild animals
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Preliminaries
Basics of sampling
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Stratified sampling

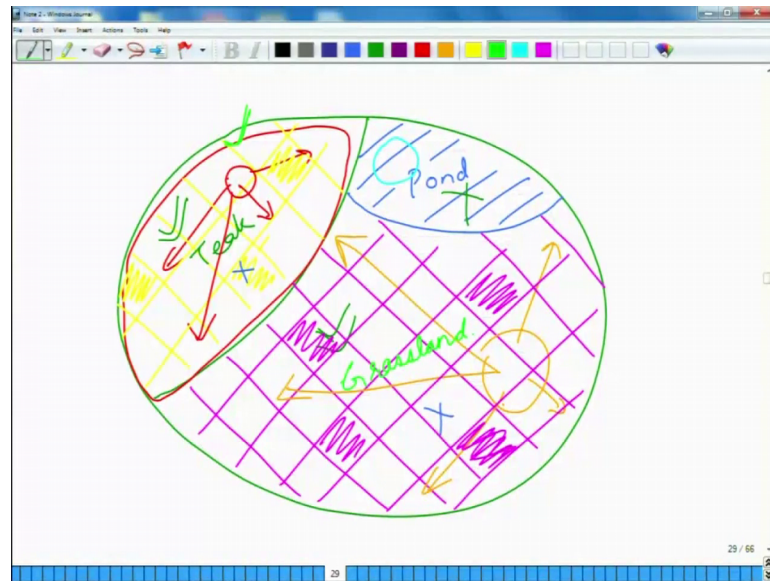
"The basic idea in stratified random sampling is to divide a heterogeneous population into sub-populations, usually known as strata, each of which is internally homogeneous in which case a precise estimate of any stratum mean can be obtained based on a small sample from that stratum and by combining such estimates, a precise estimate for the whole population can be obtained."¹⁰

¹⁰<http://www.fao.org/docrep/003/x6831e/X6831E12.htm>

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Now next thing is a stratified sampling. The basic idea of an stratified random sampling is to divide a heterogeneous population in to sub populations, usually known as strata. Each of which is internally homogeneous in which case a precise estimate of any stratum mean can be obtained based on a small sample from that stratum by combining such estimates, a precise estimate for the whole population can be obtained.

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So, what we are referring to in this case is that suppose in our area we have in our big patch of forest, we have some areas that are Teak forest then we have some areas that have water. So, we have a pond and then we have some areas that have a grassland and we wanted to take a sample of our complete forest.

So, we could divide our sample into these three areas which are already natural units. So, why do we divide it into these natural units? Because considering any animals say let us consider a water bird. Now a water bird will be found in the pond area, but will not be found in the grassland area, will not be found in the Teak area.

On the other hand, if we consider an animal such as chital. So, chital will be found here chital will be found here, but chital will not be found here because chital is a deer. And this deer uses grassland for feeding and might even be using the teak forest as a shelter or a resting place.

So, in such a scenario when we are considering the chital population, we can say that our unit is divided in our whole forest is divided into three strata. So, the first strata is the teak forest and if we take any sample from the teak forest, we would be able to extrapolate the results to the whole of the teak forest areas. But we will not be able to extrapolate those results into the pond areas and similarly we will not be able to extrapolate those results into the grassland areas. But if we take another sample from the grassland area, we would be able to extrapolate the result into the whole of the grassland

area but not into the teak area and not into the pond area and similarly for a sample in the pond area.

So, in this case we have divided our whole forest in to three strata : the teak forest, the grasslands and the pond; then we will take samples out of all these three strata. Now those samples could be taken out by means of a simple random sampling or by means of a systematic sampling. When we are we are using simple random sampling. So, in that case; so, in the case of the teak forests, we divided it in to grids, then we took a random number generator and we took out these portions as part our sample.

So, we have these three portions. So, we are doing a random simple random sampling in the teak area. Similarly in the grassland area also, we are dividing this whole area in to grids then we are using a lottery system to generate the sampling units that will form part of our sample. So, suppose we got these units. So, these were also selected randomly and similarly for the pond area.

So, from these three samples, we are extrapolating the results of the teak area into the whole of the teak area. We are extrapolating the results of the grassland samples into the whole of the grassland by multiplying these by the areas of these three stratas. So, in this case, we get a stratified sample. So, this is a stratified random sampling in case in place of using a random sampling. In all this stratas, we went for systematic sampling it could be a stratified systematic sampling of all the 3 stratas.

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The slide is titled "Multistage sampling" and features a table of contents on the left and a definition of sub-sampling in the center. The table of contents lists modules from 1 to 8, with Module 2 highlighted. The definition states: "The procedure of first selecting large sized units and then choosing a specified number of sub-units from the selected large units is known as sub-sampling."¹¹

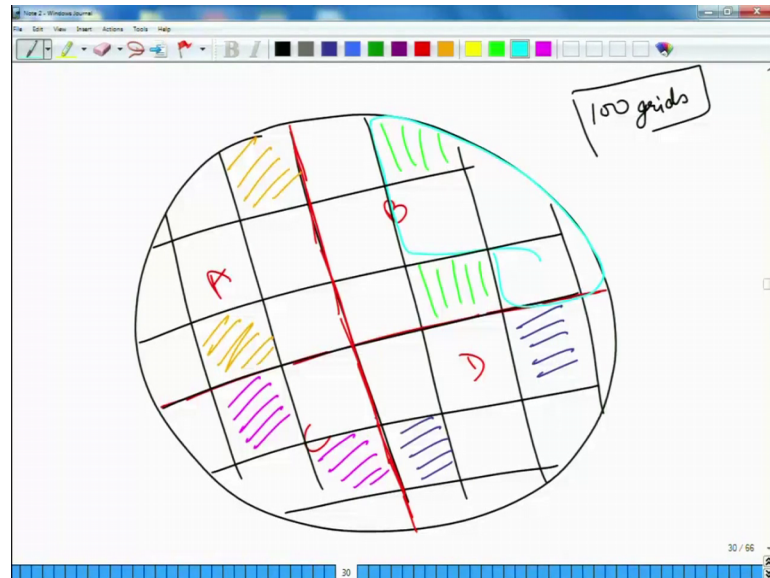
Module 1: Introduction, Importance, Threats	Preliminaries
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¹¹<http://www.fao.org/docrep/003/r6831e/X6831E12.htm>

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The next thing is a multistage sampling. Now a multi stage sampling is a procedure of first selecting large size units and then choosing a specified number of sub units from the selected large units to get a sub sample.

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So, what we mean in that case is that if we have this whole forest that we have divided into grids and suppose we have 100 grids when we are doing a simple random sampling, we will take all these 100 grids together and put it into our lottery system. In the case of a multi stage sampling, we would say that we are dividing this whole area into say 4 large units. So, we take this line and we take this line and then we will say that for section A B C and D for every section, we will be doing a simple random sampling.

So, for instance in the case of section A, we did A sample random sampling and we got these two units; in the case of section B, we got these two units; in the case of section C, we got these two units and in the case of section D, we got these two units. So, what we have done in this case is in place of putting 100 grids together, we are doing we have divided this whole area in to 4 sections and for each section consisting of 25 grids. We are doing a simple random sampling.

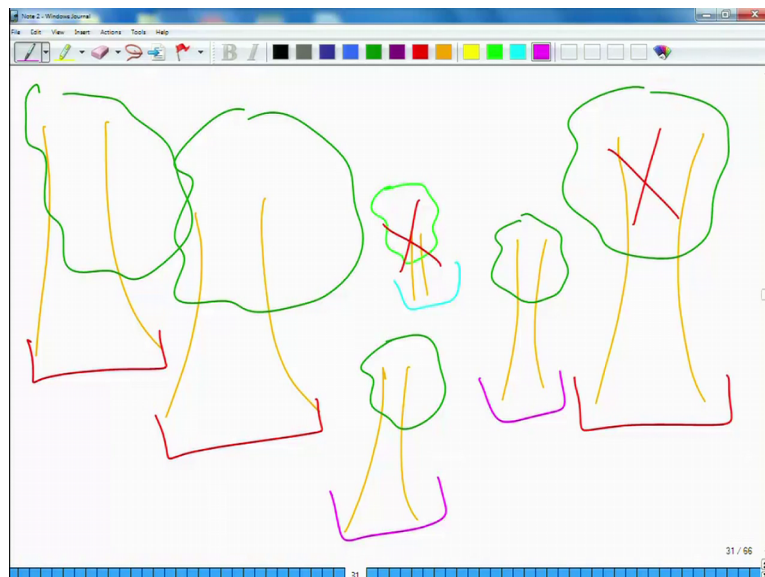
So, because we have done our procedure in to in two stages, one of selecting the large sized grids and two of doing a simple random sampling for each grid this becomes a part of a multi stage sampling procedure.

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The slide is titled "PPS sampling" in a blue header. It contains a quote: "When units vary in their size and the variable under study is directly related with the size of the unit, the probabilities may be assigned proportional to the size of the unit. This type of sampling where the probability of selection is proportion to the size of the unit is known as 'PPS Sampling'". Below the quote is a URL: <http://www.fao.org/docrep/003/x6831e/x6831e12.htm>. The slide is part of a presentation with a table of contents on the left and a list of topics on the right. The table of contents includes: Module 1: Introduction, Importance, Threats; Module 2: Monitoring wild animals; Module 3: Monitoring & managing habitats; Module 4: Management of wildlife diseases; Module 5: Capturing and restraining wild animals; Module 6: Conservation genetics; Module 7: Ex-situ conservation; Module 8: Management of changes. The list of topics includes: Preliminaries; Basics of sampling; Distance sampling - I; Distance sampling - II; Radio-telemetry; Behavioural monitoring. The footer of the slide reads: Dr. Ankur Awadhiya, IFS Wildlife Conservation.

The fourth procedure is probability proportional to size. When units vary in their size and the variable under study is directly related with the size of the unit, the probabilities may be assigned proportional to the size of the unit this type of sampling where the probability of selection is proportional to the size of the unit is known as PPS sampling.

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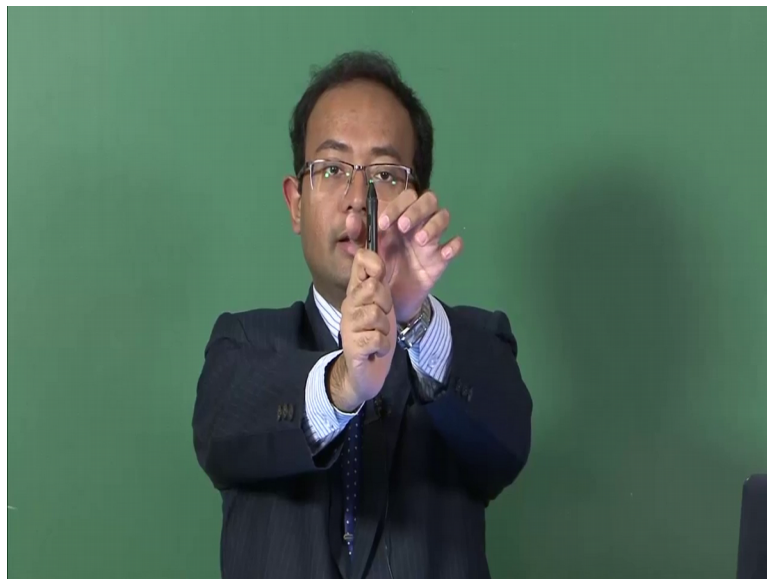


A good example here is the trees in a forest. So, let us consider a forest in which we have some large sized trees, some small sized trees and some medium sized trees. And let us consider some very small sized trees. Now, if we wanted to figure out, what is the total

amount of bio mass in our forest, then if we say left out this small tree. It would not make much of a difference to our calculation, but if we left out this tree which is a large sized tree and is having quite a substantial amount of biomass, then our results will be very different from the actual two results. So, we will not be getting accurate results in this case.

So, a probability proportional to size sampling says that for the large sized samples the probability of getting into the sample should be greater than for the smaller sized samples like this. And for the medium sized samples the probability should be in between. So, we make use of this sort of a sampling when we are using a point sampling data in the case of forest.

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So, in that case we make use of say a pen and we put it at our arms length. And we would say that any tree when we are looking from here an any tree that has a bole or its truck that has a greater diameter than this, then we would include it in to our sample.

So, this type of a sampling would become a probability proportional to size sampling because we will be incorporating the larger sized trees into your sample by may be disregarding the smaller sized trees. So, this is the probability proportional to size sampling.

So, we looked at 5 different kinds of samplings which are the most important types. The simple random sampling in which all the sampling units are put into a lottery system and every sampling unit has an equal probability of getting into the final sample. The second was the systematic sampling, in which case we made use of a formula. Then third was multi stage sampling stratified sampling, in which we had divided our whole of the area in to strata which was internally homogenous. So, internally homogenous as in forest is homogenous grassland is homogeneous pond is homogenous.

So, that is the stratified sampling. The fourth one was a multi stage sampling, in which our sub units may or may not be homogenous. This is just a way of simplifying our lottery system. So, in place of getting samples out of 100, which is also important because in this example if we had taken samples out of the complete grid say 100 samples, it is also possible that we got all our samples that were concentrated in this region.

So, in that case we would say that our results may not be completely representative of the complete forest. So, when we have divided it into these grids even though these units may or may not be homogenous we are having a much greater confidence that the results from our sample would be closer to the results of the whole of the population. So, this was the multi stage sampling and their final one was the probability proportional to size sampling in which the larger samples, the larger sampling units have a more preference of getting into our sample. So, that is all for today.

Thank you for your attention. [FL]