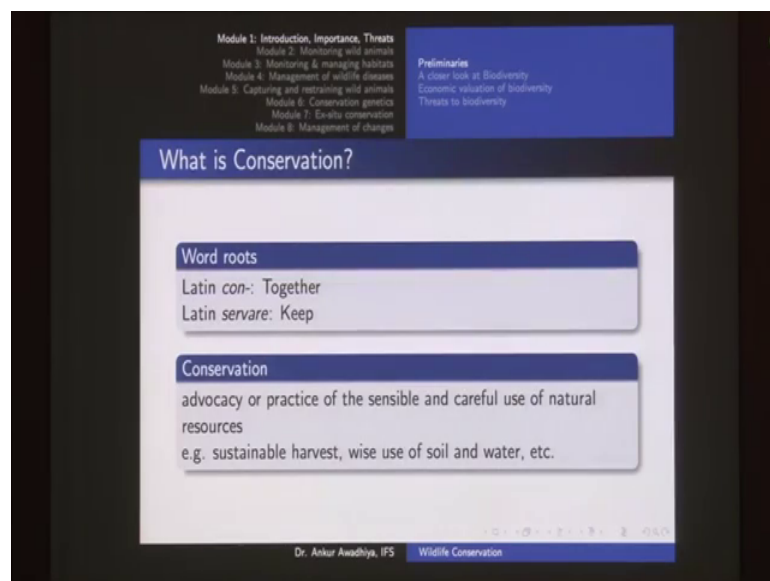


**Wildlife Conservation**  
**Dr. Ankur Awadhiya**  
**Department of Biotechnology**  
**Indian Institute of Technology, Kanpur**

**Lecture – 38**  
**Revision – I**

[FL] Now that we have reached to the end our course, we are going to have 3 revision classes and which we will go through, what we learned in the whole of the course.

(Refer Slide Time: 00:28)



So, let us begin with our first class. So, we began with this module of introduction importance and threats. In which the most important thing is when we talk about wild life conservation, what is conversation? What is wild life?.

So, conversation is advocacy or practice of sensible and careful use of natural resources and it means any of the sustainable use of resources. So, whether you are talking about sustainable harvest or you are talking about sustainable use of soil, sustainable use of water and so on.

(Refer Slide Time: 00:49)

The slide is titled "Differences" and compares three concepts: Preservation, Environmentalism, and Ecology. It includes a table of contents in the top left and a "Preliminaries" section in the top right.

Concept	Definition
Preservation	"allowing some places and some creatures to exist without significant human interference"
Environmentalism	"concerned about the impact of people on environmental quality"
Ecology	"Science of relationships between organisms and their environments"

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And this is different from preservation, in which you do not touch anything, environmentalism which is concerned with environmental quality and ecology, which is the science of relationship between organisms and their environment..

(Refer Slide Time: 01:01)

The slide is titled "What is wildlife?" and defines wildlife according to the Wildlife Protection Act (WPA) 1972 and a dictionary definition. It includes a table of contents in the top left and a "Preliminaries" section in the top right.

Definition	Text
Definition as per WPA 1972	wild life includes any animal, aquatic or land vegetation which forms part of any habitat
Dictionary definition	wild animals collectively; the native fauna (and sometimes flora) of a region

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Now, when we talk about wild life conservation, what is wild life? So, this is the most important definition because, this is coming from one of our laws, the Wildlife Protection Act. So, wildlife includes any animal aquatic or land vegetation, which forms part of any habitat. Now the important thing is it includes animals, it includes plants and which form

part of any habitat. So, this habitat may be a wild habitat or this habitat may be any other habitat as well..

(Refer Slide Time: 01:29)

The slide is titled "The IUCN Red list categories". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section on the top right. The main content area is divided into two sections: "Extinct (EX)" and "Extinct in the Wild (EW)".

**Extinct (EX)**  
A taxon is Extinct when there is no reasonable doubt that the last individual has died.  
e.g. Dodo

**Extinct in the Wild (EW)**  
A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity, or as a naturalised population well outside the past range.  
e.g. Northern white rhinoceros

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Next we talked about the IUCN red list categories. So, we have these categories of a animals, there are animals that are completely extinct, there are animals that are only there in captivity..

(Refer Slide Time: 01:39)

The slide is titled "The IUCN Red list categories". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section on the top right. The main content area is divided into two sections: "Critically Endangered (CR)" and "Endangered (EN)".

**Critically Endangered (CR)**  
A taxon is Critically Endangered when available scientific evidence indicates that it is considered to be facing an extremely high risk of extinction in the wild.  
e.g. Javan rhinoceros

**Endangered (EN)**  
A taxon is Endangered when available scientific evidence indicates that it is considered to be facing a very high risk of extinction in the wild.  
e.g. tiger

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Then there are animals that are critically endangered. Now a good example is the Javan rhinoceros; now critically endangered and then next is endangered. So, tiger is endangered, Javan rhinoceros is critically endangered.

(Refer Slide Time: 01:55)

The slide is titled "The IUCN Red list categories". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section on the top right. The main content area is divided into two sections: "Vulnerable (VU)" and "Near Threatened (NT)".

**Vulnerable (VU)**  
A taxon is Vulnerable when available scientific evidence indicates that it is considered to be facing a high risk of extinction in the wild.  
e.g. snow leopard

**Near Threatened (NT)**  
A taxon is Near Threatened when it has been assessed against the criteria and does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for, or is likely to qualify for, a threatened category in the near future.  
e.g. polar bear

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Extincting species include dodo, then we have vulnerable near threatened. So, we are coming down in the threat category..

(Refer Slide Time: 01:59)

The slide is titled "The IUCN Red list categories". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section on the top right. The main content area is divided into one section: "Least Concern (LC)".

**Least Concern (LC)**  
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened.  
e.g. cow

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Then there are domesticated animals like cows, dogs, cats, that are the least concerned animals..



(Refer Slide Time: 02:05)

The slide is titled "The IUCN Red list categories". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section in the top right corner. The main content area is titled "Data Deficient (DD)" and contains the following text:

**Data Deficient (DD)**

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

Many molluscs, fishes, and nocturnal birds and mammals have been evaluated, but could not be listed as Threatened because there was not enough information.

At the bottom of the slide, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

There are some animals for which we do not have enough data..

(Refer Slide Time: 02:08)

The slide is titled "The IUCN Red list categories". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section in the top right corner. The main content area is titled "Not Evaluated (NE)" and contains the following text:

**Not Evaluated (NE)**

A taxon is Not Evaluated when it has not yet been assessed against the criteria.

Most of the world's species, notably all the invertebrates and other small life-forms, fall into this category.

At the bottom of the slide, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

There are some animals for which we have not done the evaluation.

(Refer Slide Time: 02:10)

The slide is titled "Keystone, umbrella, flagship species". It features a table of contents in the top left corner listing modules 1 through 8, and a "Preliminaries" section in the top right corner. The main content area is titled "Keystone species" and contains the following text: "Some species play critical ecological roles that are of greater importance than we would predict from their abundance; these are called keystone species". Below this, it gives an example: "e.g. off-season fruit bearing trees, the purple sea star predating upon the California mussel". A citation "Power et al. 1996" is at the bottom of the text box. The footer of the slide identifies the presenter as "Dr. Ankur Awadhiya, IFS" and the topic as "Wildlife Conservation".

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### Keystone, umbrella, flagship species

#### Keystone species

Some species play critical ecological roles that are of greater importance than we would predict from their abundance; these are called keystone species".  
e.g. off-season fruit bearing trees, the purple sea star predating upon the California mussel

\*Power et al. 1996

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The next important concept was that of keys stone species, umbrella species and flagship species. Now keystone species are those species that are extremely important for the habitat and their importance is much greater than their numerical abundance. So, the example is off season fruit bearing trees such as the ficus tree..

(Refer Slide Time: 02:29)

This slide is identical in layout to the previous one, with the same table of contents and title. The main content area is titled "Umbrella species" and contains the following text: "Species with large home ranges encompassing enough habitats such that their protection automatically provides protection to several other species as well." Below this, it gives an example: "e.g. the tiger, the elephant". The footer remains the same, identifying the presenter as "Dr. Ankur Awadhiya, IFS" and the topic as "Wildlife Conservation".

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### Keystone, umbrella, flagship species

#### Umbrella species

Species with large home ranges encompassing enough habitats such that their protection automatically provides protection to several other species as well.  
e.g. the tiger, the elephant

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Umbrella species are those species that have a very large home range requirement..

(Refer Slide Time: 02:36)



So, when we are talking about an umbrella species, just remember that an umbrella has a very large area. So, this is much greater than my own area. So, an umbrella species is a species that has a very large home range requirement. And so this species is able to protect other species because, when we are protecting this species. A number of other species are also getting protection at the same time, just because they have a very large home range requirement, such as the elephant.

(Refer Slide Time: 03:02)

Module 1: Introduction, Importance, Threats

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## Keystone, umbrella, flagship species

### Flagship species

Well known, charismatic species that have captured the public's heart and won their support and funds for conservation.  
e.g. the giant panda, the humpback whale, the gorilla

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Wildlife Conservation

Next is the flag ship species, now flag ship species is the species that you want to project that are the most charismatic organisms or that are the organism that people want to come and see. So, for example, the giant panda, humpback whale, gorilla, tiger, a number of flowers and so on..

(Refer Slide Time: 03:18)

The slide is titled "Keystone, umbrella, flagship species". It features a table of contents on the left and a "Preliminaries" section on the right. The main content area is titled "Importance" and contains the following text:

Conservation priority for those species that meet all three definitions. They are important for their habitats, their protection automatically protects several other species as well, and they are able to generate enough funding and support for the cause of conservation.  
e.g. the tiger

At the bottom, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

So, the importance is that, if there is a species that is key stone umbrella and flagship at the same time, then that has to be given the most importance..

(Refer Slide Time: 03:29)

The slide is titled "What do you see in a jungle?". It features a table of contents on the left and a "Preliminaries" section on the right. The main content area contains a photograph of a dense forest with tall trees and a thick canopy. Below the photograph, it says "Dr. Ankur Awadhiya 2014 Timelapse". At the bottom, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

Then we went through the outline of the course. In the next lecture, we looked at different forms of biodiversity that we observe in a forest area; so from plants, animals, fungi, microorganisms, everything..

(Refer Slide Time: 03:42)

The slide is titled "What is Biodiversity?". It features a table of contents in the top left corner listing modules 1 through 8. In the top right, under "Preliminaries", it lists "A closer look at Biodiversity", "Economic valuation of biodiversity", and "Threats to biodiversity". The main content area contains a box labeled "Definition" with the text: "Biodiversity is the variety of life in all its forms and at all levels of organisation." The footer identifies the speaker as "Dr. Ankur Awadhiya, IFS" and the topic as "Wildlife Conservation".

And then we came to this definition of biodiversity, it is a variety of life in all its forms and all its levels of organization..

(Refer Slide Time: 03:46)

This slide continues the definition of biodiversity. It has the same header and footer as the previous slide. The main content area has two sections: "in all its forms..." followed by "Plants, vertebrates, invertebrates, fungi, bacteria, and other microorganisms", and "at all levels of organisation..." followed by "the diversity of genes, species and ecosystems".

So, plants vertebrates, invertebrates, everything are involved and we also look at 3 levels of organization genes, species and ecosystems.

(Refer Slide Time: 03:55)

The slide is titled "Species biodiversity". At the top left, there is a table of contents listing modules 1 through 8. At the top right, there is a box titled "Preliminaries" containing "A closer look at Biodiversity", "Economic valuation of biodiversity", and "Threats to biodiversity". The main content area has a blue header "Species biodiversity". Below it, there is a box titled "Species" with the text: "Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups<sup>a</sup>". Below this box, there is a footnote: "<sup>a</sup>Mayr 1942". At the bottom of the slide, there is a footer with "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

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### Species biodiversity

#### Species

Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups<sup>a</sup>

<sup>a</sup>Mayr 1942

#### Species biodiversity

How many species are there, and how are they distributed?

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So, then we talked about what is the species? What is the species biodiversity?

(Refer Slide Time: 03:57)

The slide is titled "Genetic biodiversity". At the top left, there is a table of contents listing modules 1 through 8. At the top right, there is a box titled "Preliminaries" containing "A closer look at Biodiversity", "Economic valuation of biodiversity", and "Threats to biodiversity". The main content area has a blue header "Genetic biodiversity". Below it, there is a box titled "Genes" with the text: "A unit of heredity that is transmitted from parents to offsprings." Below this box, there is another box titled "Genetic biodiversity" with the text: "Diversity of genetic information present at the levels of phyla, families, species, populations and individuals." At the bottom of the slide, there is a footer with "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

Module 1: Introduction, Importance, Threats  
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### Genetic biodiversity

#### Genes

A unit of heredity that is transmitted from parents to offsprings.

#### Genetic biodiversity

Diversity of genetic information present at the levels of phyla, families, species, populations and individuals.

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What is the gene? What is the genetic biodiversity?.

(Refer Slide Time: 03:59)

The slide is titled "Examples of genetic biodiversity". It contains two main sections: "Polymorphism, P" and "Heterozygosity, H".

**Polymorphism, P**  
"the proportion or percentage of genes that are polymorphic"  
A gene is considered polymorphic if the frequency of the most common allele is less than some arbitrary threshold (otherwise it is monomorphic, i.e. lacking in variation). This threshold is usually 95% <sup>a</sup>.

<sup>a</sup>Hartl and Clark 1997

**Heterozygosity, H**  
"the proportion or percentage of genes at which the average individual is heterozygous"

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Now, in this case 2 things are important when we are talking about genetic biodiversity, we have these 2 concepts. Polymorphism, which tells us that when we have different allele, what is the frequency of the most common allele? So, this has to be less than some threshold and that threshold is 95 percent. Your frequency of the most common allele is less than 95 percent, then it is a polymorphic gene, the second was heterozygosity the proportion of or percentage of genes at which the average individual is heterozygous..

(Refer Slide Time: 04:31)

The slide is titled "Ecosystem biodiversity". It contains two main sections: "Ecosystem" and "Ecosystem biodiversity".

**Ecosystem**  
"A group of interacting organisms (usually called a community) and the physical environment they inhabit at a given point in time."

**Ecosystem biodiversity**  
How many ecosystems are there, and how are they distributed?

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Next we talked about eco systems group of interacting organisms and the physical environment. Then ecosystem biodiversity's, how many ecosystems are there and how are they distributed?.

(Refer Slide Time: 04:41)

The slide is titled "Measures of biodiversity". It lists two measures:

- Species richness**: number of species present
- Species evenness**: the distribution of individuals of different species

At the top left, a list of modules is shown: 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. At the top right, a box titled "Preliminaries" contains "A closer look at Biodiversity", "Economic valuation of biodiversity", and "Threats to biodiversity". The footer reads "Dr. Ankur Awadhiya, IFS Wildlife Conservation".

Now, when we talk about species biodiversity, we talk about 2 things species richness and species evenness the number of species that are present and how are they distributed?.

(Refer Slide Time: 04:50)

The slide is titled "Measures of biodiversity". It shows the formula for Simpson's diversity index:

$$D = \frac{1}{\sum_{i=1}^S p_i^2}$$

where

- D is the Simpson's diversity index
- S is the number of species in the area
- $P_i$  is the proportion of the  $i^{th}$  species

At the top left, a list of modules is shown: 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. At the top right, a box titled "Preliminaries" contains "A closer look at Biodiversity", "Economic valuation of biodiversity", and "Threats to biodiversity". The footer reads "Dr. Ankur Awadhiya, IFS Wildlife Conservation".

So, for this we had 2 different indices the Simpson index and the Shannon index.



(Refer Slide Time: 04:56)

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### Measures of biodiversity

#### Shannon's diversity index

$$H = -\sum_{i=1}^S P_i \ln P_i$$

where  
H is the Shannon's diversity index  
S is the number of species in the area  
 $P_i$  is the proportion of the  $i^{\text{th}}$  species

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And for both of these, we talk about the diversity and we talk about the evenness..

(Refer Slide Time: 04:59)

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### Measures of biodiversity

- $\alpha$  biodiversity**  
the diversity that exists within an ecosystem
- $\beta$  biodiversity**  
the diversity that exists among different ecosystems
- $\gamma$  biodiversity**  
the diversity that exists among different geographies

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Now, these are 3 important definitions the measures of biodiversity include the alpha biodiversity, beta biodiversity and the gamma biodiversity. Alpha is diversity that exist, within an ecosystem, beta is diversity that exist among different ecosystems. So, here we are comparing different ecosystems and gamma is at a very large scale that is existing, among different geographies.

(Refer Slide Time: 05:23)

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### Measures of biodiversity: Importance

20

Hunter Jr. M.L. and Gibbs, J.P., 2006. Fundamentals of conservation biology. John Wiley & Sons.

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And then we made use of this example though to say, what is alpha, beta and gamma?.

So for instance, when we talk about this patch in this island, so here we have 2 islands and if you talk about just one patch that is one ecosystem; the diversity that is inside it is alpha biodiversity, when we compare these 2 patches in the same island, we are talking about the beta biodiversity. And we are including this island that is very far apart, then we are talking about the gamma biodiversity because, we are including different geographies.

(Refer Slide Time: 05:53)

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### Biodiversity and spatial scale: Hotspots

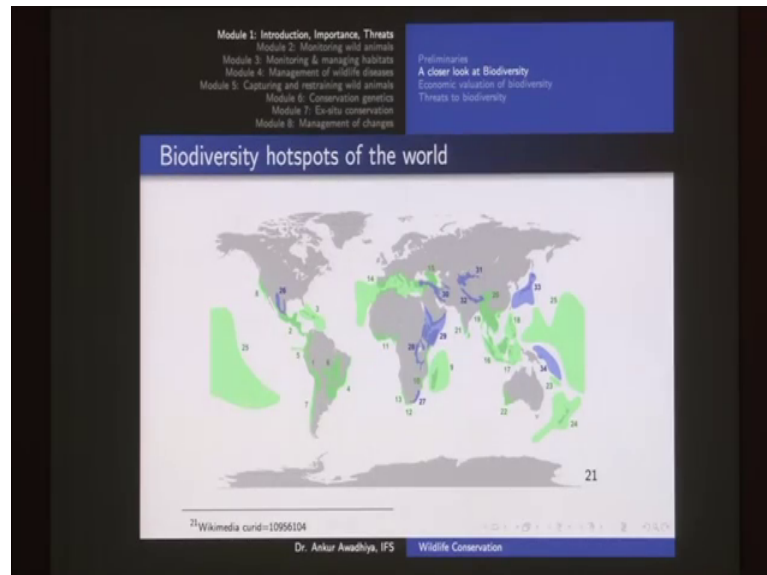
**Definition**  
Biodiversity hotspots are areas with

- 1 high species richness
- 2 high degree of endemism
- 3 high degrees of threat

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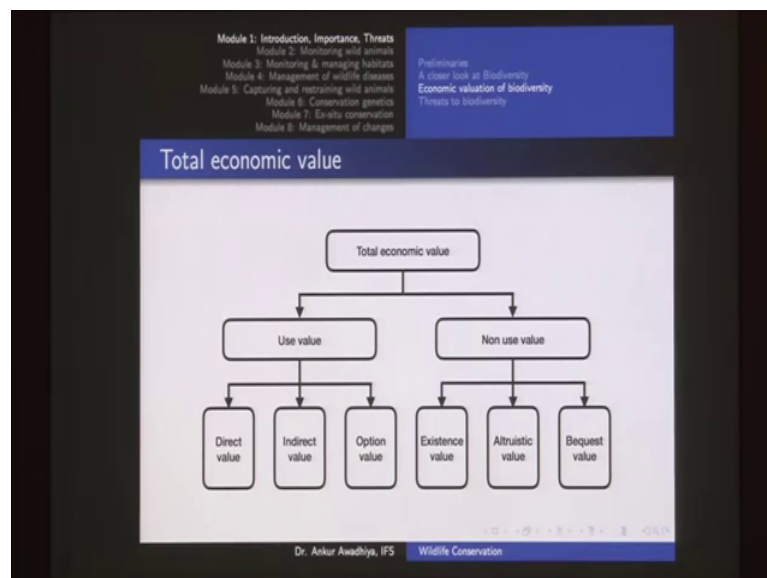
Here we had this concept of hotspots areas with high richness, high endemism and high degree of threat.

(Refer Slide Time: 06:00)



So, these are the biodiversity hotspots that need to be preserved a lot..

(Refer Slide Time: 06:09)



Now, in the next lecture we had economic valuation of biodiversity and this is a very important chart that, you need to remember because, when we talk about total economic value in any case, we include the use value and the nonuse value. So, things that we can use and things that, we cannot use directly. Now in the case of use, we talk about direct

use value, indirect use value and option value. And in the case of nonuse value, we talk about existence value, altruistic value and bequest value..

(Refer Slide Time: 06:38)

The slide is titled "Use value" in a blue header. In the top left corner, there is a list of modules: 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; and Module 8: Management of changes. In the top right corner, there is a box titled "Preliminaries" containing "A closer look at Biodiversity", "Economic valuation of biodiversity", and "Threats to biodiversity". The main content area has a blue box labeled "Definition" with the text "Value arising out of use of the resource". At the bottom, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

So, we looked at the definitions of all of these and these definitions become important the use and nonuse values.

(Refer Slide Time: 06:41)

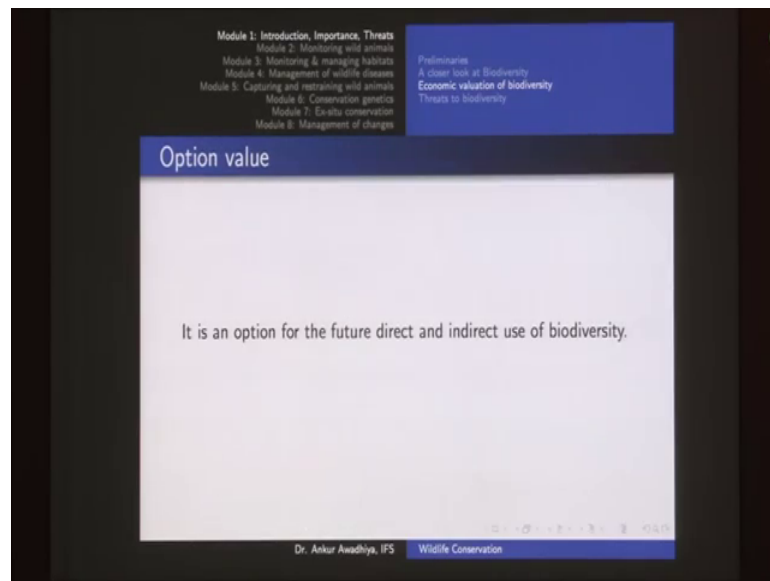
The slide is titled "Direct value" in a blue header. It contains the same module list and preliminary information as the previous slide. The main content area lists "Direct value comprises of:" followed by two categories: 1. consumptive and productive values such as: 1. timber, 2. firewood, 3. medicines, 4. grazing, 5. NTFPs, 6. water, etc.; and 2. non-consumptive values such as: 1. recreation / ecotourism, 2. education and research, 3. human and wildlife habitat, etc. At the bottom, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

Direct values include consumptive values and non consumptive values. So, consumptive values are those, where if you consume this resource the amount of resource in the forest

will go down. Non consumptive resource is that in which, when you use this resource the total amount that is available for the use of someone else remains the same.

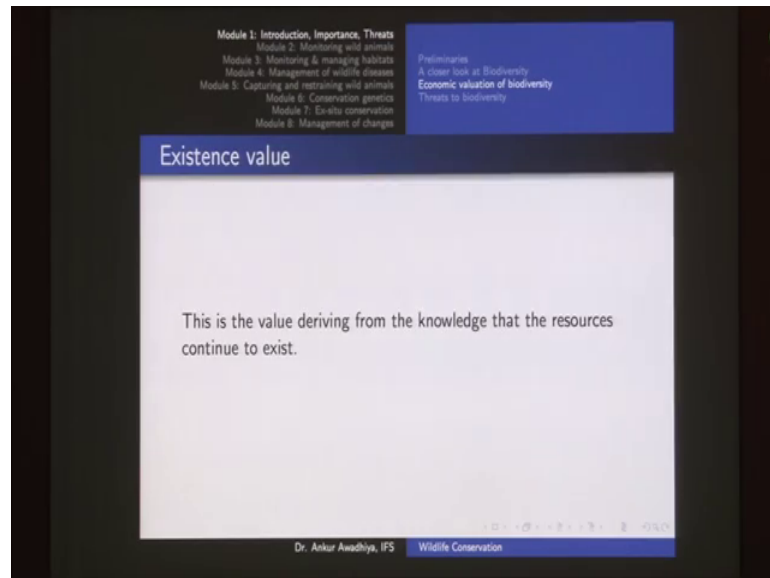
Now, indirect values include watershed benefits, ecosystem services and evolutionary processes. So, we are not directly using these values..

(Refer Slide Time: 07:08)



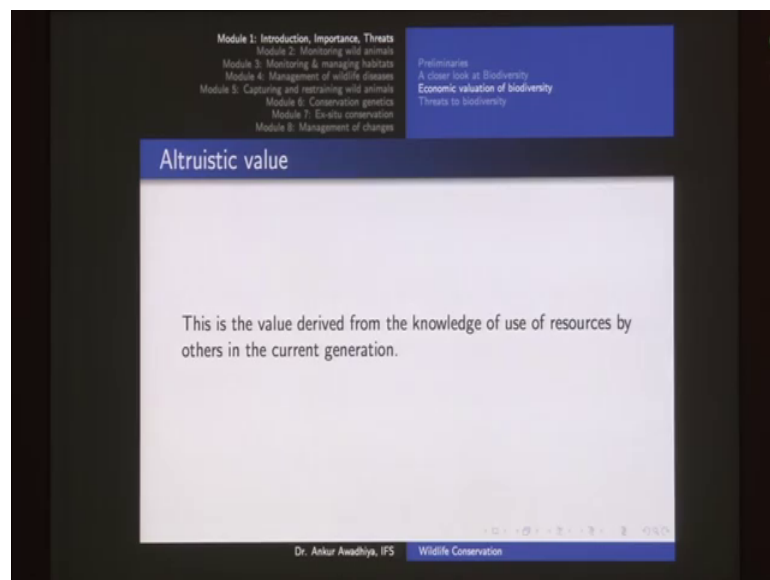
Option value is when we considered the example of booking a flat. So, I do not want to decide whether I should buy flat a or flat b, but at the same time I also want that this both, this option should be available to me after say, 6 months. So, I will pay some amount for these 2 things to be blocked for me and that is known as option value, it is an option for the future direct and indirect use of biodiversity.

(Refer Slide Time: 07:36)



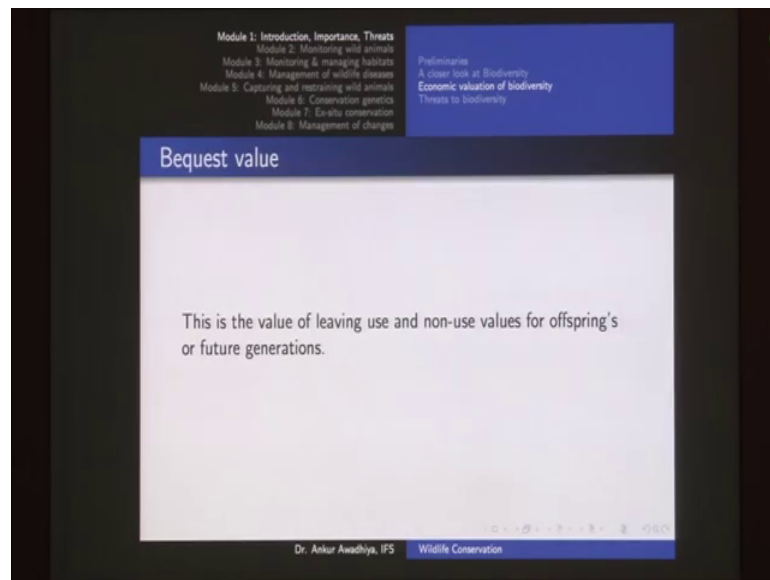
Next we have the existence value existence value is just because something is existing. So, I have a value for it..

(Refer Slide Time: 07:42)



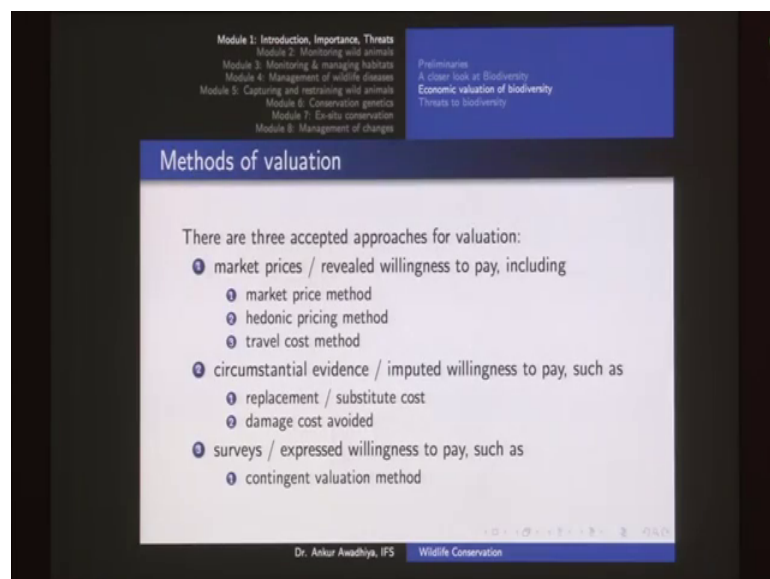
Altruistic value is been someone else of my own generation is using it. So for instance, Marine Drive is there in Mumbai and people from Mumbai or people that are going to Mumbai are able to use it, I am not able to use it, but this Marine Drive still have the value for me because, people from my generation are using it. So, this is an altruistic value..

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Then, we had the bequest value, the value that is there because I am leaving something for my sons and daughters and for my sons and daughters. So, for the offsprings and their offsprings is known as the bequest value..

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Now next, we talked about the methods of valuation. So, there are 3 methods revealed willingness to pay, which is the market price method then, we have imputed willingness to pay such as replacement cost or substitute cost, damage cost avoided and the expressed willingness to pay such as the contingent valuation method. Now in this case

here, you should go through the examples once again. So for instance, in the case of a tsunami barrier when we talk about replacing mangroves with artificial tsunami barriers, we are talking about replacement cost, when we talk about the damage that is avoided, because of our mangroves, we are talking about the damage cost avoided method..

Similarly, when we talk about people coming to a protected area, we are computing the travel cost method and so on. So, these examples become important..

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### Estimating the rate of species loss

According to the island biogeography model (MacArthur and Wilson 1967), species richness,  $S$  of an island is given by

$$S = C \times A^z$$

where  
 $A$  is the size of the island  
 $C, z$  are constants depending on the set of species and the island

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Next lecture was on threats on biodiversity and here we had this formula  $S$  is equal to  $C$  into  $A$  to power of  $z$ . So,  $S$  is the species richness of an island,  $A$  is the area of the island  $C$  and  $z$  are some constraints that need to be figured out..



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### Estimating the rate of species loss

$z$  varies between 0.15 and 0.35.  
Taking  $z = 0.30$ , for an area  $A_1$

$$S_1 = C \times A_1^{0.30}$$

Let the area decrease by 90%:  
 $A_2 = 0.1 \times A_1$   
Then,

$$S_2 = C \times (0.1 \times A_1)^{0.30}$$

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And this is a very important equation, because we used it to figure out the rate of species lost from an area.

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### Estimating the rate of species loss

This gives

$$\frac{S_2}{S_1} = \frac{C \times (0.1 \times A_1)^{0.30}}{C \times A_1^{0.30}}$$
$$\Rightarrow \frac{S_2}{S_1} = 0.1^{0.3}$$
$$\Rightarrow \frac{S_2}{S_1} = 0.5012 \approx 50\%$$

Thus,  $S_2 = \frac{1}{2} \times S_1$   
So, by reducing area by 90%, the species richness becomes halved.

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### Estimating the rate of species loss

The rate at which tropical forests are actually decreasing is  $\approx 1.8\%$  per annum. With the lowest value of  $z$  (0.15), this would translate to an annual loss of 0.27%  
The estimated number of species in tropical forests is 10 million.  
Thus, annual loss of species from tropical forests is given by  
 $10,000,000 \times 0.27 / 100$   
 $= 27,000$  species per year  
And this is the most conservative estimate!  
Similarly, we may estimate the loss from other ecosystems.

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And we also used it to compute, how many species are we losing from our tropical forest. So, we are losing as much as 27000 species per year in a very conservative estimate.

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### Are all species equally susceptible to extinction?

No.  
The susceptibility depends on the rarity of the species, the rarer the species, the more its chances of getting extinct.

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So, next we talked about the susceptibility of species to extinction. So all this species are not equally susceptible to become extinct it depends on the rarity of the species..

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### Why are some species rarer?

Three reasons:

- 1 restriction to an uncommon habitat, e.g. species found in desert springs
- 2 limited geographical range, e.g. those species found in a single lake
- 3 low population densities, e.g. because larger animals require more space

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So, there are 3 common reasons restriction to an uncommon habitat, limited geographical range and low population densities, because of which a species is rare..

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### Factors driving species towards extinction

Acronym HIPPO:

- 1 Habitat loss
- 2 Invasive species
- 3 Pollution
- 4 human over-Population
- 5 Over-harvesting

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Now here, we talked about the 5 factors that lead a species to extinction. So, this is a very important acronym because, it helps us to remember all of these. So, hippo H stands for habitat loss, I stands for invasive species, P is a pollution, the second P is population which talks about the human over population and the last O is over harvesting of resources in the case of over harvesting. For instance, there are we can take out 10

whales from an ocean, but we are taking out 30 whales. So, that becomes an over harvest of resources..

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### Why does a population become extinct?

2 kinds of factors operate at all times

- 1 deterministic factors (acting at large population sizes)
- 2 stochastic factors (more important when the population sizes are smaller)

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Now, there are 2 kinds of factors, because of which a population becomes extinct, we have deterministic factors and we have stochastic factors. Now deterministic factors acted large population sizes, stochastic factors are more important at small population sizes..

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### Extinction factors

Deterministic factors (acting at large population sizes)

- 1 birth rate
- 2 death rate
- 3 population structure

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Now in this case, we looked at different deterministic factors birth rate, death rate and the populations structure especially, if our population is getting old or not.

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The slide is titled 'Extinction factors'. It features a table of contents in the top left corner listing modules 1 through 8. A blue box in the top right corner contains the text 'Preliminaries: A closer look at Biodiversity, Economic valuation of biodiversity, Threats to biodiversity'. The main content area is titled 'Stochastic factors (more important when the population sizes are smaller)' and lists four numbered points: 1. demographic stochasticity including occurrence of probabilistic events such as reproduction, litter size, sex determination, and death; 2. environmental variation and fluctuations; 3. catastrophes such as forest fires and diseases; 4. genetic processes including loss of heterogeneity and inbreeding depression. The footer of the slide identifies the speaker as 'Dr. Ankur Awadhiya, IFS' and the topic as 'Wildlife Conservation'.

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### Extinction factors

#### Stochastic factors (more important when the population sizes are smaller)

- 1 demographic stochasticity including occurrence of probabilistic events such as reproduction, litter size, sex determination, and death
- 2 environmental variation and fluctuations
- 3 catastrophes such as forest fires and diseases
- 4 genetic processes including loss of heterogeneity and inbreeding depression

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Now, stochastic factors are chance factors. So, these are just probabilistic factors that could occur just by chance. So, by chance you could have all the offsprings that are male, you could have very small little sizes, you could have a year that is very hot or year that is very cold or a year in which you get a forest fire or may be a disease outbreak and so on..

(Refer Slide Time: 11:17)

This slide is identical in layout to the previous one, with the same table of contents, preliminary topics, and title. However, the main content area is titled 'Deterministic factors (more important when the population sizes are larger)' and lists two numbered points: 1. deterministic processes such as density dependent mortality on exceeding the carrying capacity of the habitat; 2. migration among populations. The footer remains the same, identifying the speaker as 'Dr. Ankur Awadhiya, IFS' and the topic as 'Wildlife Conservation'.

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### Extinction factors

#### Deterministic factors (more important when the population sizes are larger)

- 1 deterministic processes such as density dependent mortality on exceeding the carrying capacity of the habitat
- 2 migration among populations

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So, these all factors go by the name by the name of stochastic factors..

(Refer Slide Time: 11:18)

The slide is titled "Impact of humans". It lists factors that determine the sensitivity of a species to human impacts. The factors are:

- 1 adaptability and resilience of the species
- 2 human attention: charismatic species like tigers are more sensitive because humans have high demand for their skin, bones and other parts
- 3 ecological overlap between humans and the species: the greater the overlap, the greater the impact
- 4 home range requirements of the species: species requiring larger home ranges are more sensitive to human impacts

At the top left, a list of modules is shown: 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. At the top right, a list of topics is shown: Preliminaries; A closer look at Biodiversity; Economic valuation of biodiversity; Threats to biodiversity. At the bottom, the text "Dr. Ankur Awadhiya, IFS Wildlife Conservation" is visible.

Then the impact of humans: so, the sensitivity of a species would depend on it is adaptability and resilience. It would also depend on whether, this is species is having an ecological overlap with the humans, how much attention the humans are given to it? And the home range it requirements of this species whether it, it can survive in smaller areas or whether it requires very large areas..

(Refer Slide Time: 11:40)

The slide is titled "Population viability analysis". It provides a definition of population viability:

**Definition 1**  
Population viability is the ability of a population to persist, or to avoid extinction. Thus, population viability analysis is an analysis of the viability of a population.

At the top left, a list of modules is shown: 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. At the top right, a list of topics is shown: Preliminaries; A closer look at Biodiversity; Economic valuation of biodiversity; Threats to biodiversity. At the bottom, the text "Dr. Ankur Awadhiya, IFS Wildlife Conservation" is visible.

Now, to evaluate the risk of extinction, we have this method of pollution viability analysis, which is an analysis of the viability of a population or the ability of a population to exist for n number of years..

(Refer Slide Time: 11:56)

The slide is titled "Population viability analysis". It features a blue header with a list of modules on the left and a box on the right. The main content area has a white background with a blue border. At the bottom, there is a footer with the presenter's name and the course title.

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### Population viability analysis

**Definition 2**  
PVA is a process by which the extinction probability of a single species population is assessed<sup>a</sup> by integrating data on the life history, demography and genetics of the species with information on the variability of the environment, diseases, stochasticity, etc., by utilising mathematical models and computer simulations in order to predict whether the population will remain viable or go extinct in a decided time frame under various management options<sup>b</sup>.

<sup>a</sup>Hugh P. Possingham, Michael A. McCarthy and David B. Lindenmayer, Population Viability Analysis, In Encyclopedia of Biodiversity (Second Edition), edited by Simon A. Levin., Academic Press, Waltham, 2013, Pages 210-219, ISBN 9780123847201, <https://doi.org/10.1016/B978-0-12-384719-5.00173-8>  
<sup>b</sup>Bensinger, S.R. and McCullough, D.R., 2002. Population viability analysis. University of Chicago Press.

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Typically we talk about 100 years or the 1000 years and in this case, we go for a mathematical modeling or computer simulation in which, we take all of these deterministic factors and it is stochastic factors, we add data of the life history and demography and genetics of the population and then we ask our simulation to predict, what is going to happen in the next n number of years?

(Refer Slide Time: 12:21)

The slide is a presentation slide with a dark background. At the top, there is a table of contents with two columns. The first column lists modules 1 through 8, with 'Module 2: Monitoring wild animals' highlighted in blue. The second column lists 'Preliminaries' and sub-topics like 'Basics of sampling', 'Distance sampling - I', 'Distance sampling - II', 'Radio-telemetry', and 'Behavioural monitoring'. Below the table of contents, the main title 'Why should we assess wildlife numbers?' is displayed in a blue box. The main content area is a light blue box containing text about the importance of numbers in wildlife management and the Deming cycle. At the bottom, there is a footer with 'Dr. Ankur Awadhiya, IFS' and 'Wildlife Conservation'.

Module 1: Introduction, Importance, Threats	Preliminaries
<b>Module 2: Monitoring wild animals</b>	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: Ex-situ conservation	
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### Why should we assess wildlife numbers?

**Numbers are essential at every stage of management.**  
Management follows the Deming cycle:  
Plan → Do → Check → Act  
And numbers are critically required at all of these stages. We need to know numbers at the planning stage to decide if interventions are required, depending on the management objectives (*Plan*). The management interventions when deployed (*Do*) will affect the number of wildlife, and the efficiency and efficacy of these interventions can easily be evaluated (*Check*) by observing their effects on the numbers of different wildlife.

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In the second module, we had moderating of wild animals. So, we began with the deming cycle. Now deming cycle is important because, it is not only there for wild life management, but in most of the kinds of management and this can be remembered by the acronym of PDCA. So, this also goes by the name PDCA cycle. P is plan do, d is do, c is check and a is act. So, you make a plan, then you implement that plan then, you see whether the plan is working properly or not and after that, you make changes.

So for instance, when we talked about our Sariska crisis, there was earlier a plan, which talked about estimation of tiger numbers through pugmarks. Now, that method was implemented then, there were checks and then later on it was figured out that this method was not working. Because, we lost all of our tigers in the Sariska tiger reserve and so we came up with different sets of prescription in the act part..

So, these days we shifted from the pugmark method into a camera trap method. So, this is a very important, acronym to remember PDCA..



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

### Why should we assess wildlife numbers?

**Numbers are crucial inputs for decision support.** Depending on existing numbers of wildlife, we may need to:

- increase their numbers, if the numbers are getting low
- reduce their numbers, if the numbers are very high, or when there are situations of conflict
- maintain status-quo, if the numbers are adequate

However, we remain ignorant of the actions required of us till we actually know the numbers. Hence, it is necessary to assess wildlife numbers.

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Now next, we had, why should we assist wild life numbers?

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**Preliminaries**  
Basics of sampling  
Distance sampling - I  
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### Why should we assess wildlife numbers?

**Numbers help assess the risk of a population decline / crash.** When the number of individuals is very low, the population might crash due to reasons of:

- 1 demographic stochasticity, such as:
  - 1 chance variations in births and deaths leading to more deaths and less births
  - 2 chance variations in sex ratio resulting in a population with all males or all females
- 2 environmental stochasticity, such as drought, flood, famine or diseases

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Because they are crucial for decisions support.

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Preliminaries  
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Behavioural monitoring

### Why should we assess wildlife numbers?

- ① genetic problems, such as:
  - ① inbreeding depression due to mating of close relatives
  - ② genetic drift of small populations
  - ③ loss of heterozygosity
- ② behavioural problems and Allee effect, such as:
  - ① in the case of pack hunting animals, where individuals are less efficient and may not be able to hunt alone
  - ② when animals are highly dispersed, and so unable to find a mate.

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They help us assist the risk of population decline or crash.

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### Why should we assess wildlife numbers?

Numbers help us plan scenarios and take steps. The steps could be:

- ① adaptation, where the population is made supple enough to respond to changes, or
- ② mitigation, where the causes of change are analysed and addressed

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And they also help us plan scenarios and take steps..

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**Preliminaries**  
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### Do we need numbers or trends?

Actually, we need both.  
Trends are helpful when we need to analyse and address the gross movement of population numbers: whether the population is increasing, decreasing or remaining constant. This is especially important for, say, prey species like chital or sambar, where exact numbers are hard to compute due to their large population sizes.

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Then, we need both numbers and the trends.

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**Preliminaries**  
Basics of sampling  
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### Do we need numbers or trends?

On the other hand, numbers are of crucial importance in cases where the populations have reached critical limits, or when the animal is a priority species. Thus, we need to have census for tigers, Great Indian bustards and dugongs. Mere trends will not suffice!  
It is also important to note that numbers are finer data than trends. With exact numbers, we can easily compute trends. But the information on trends is not sufficient to deduce the exact number of individuals.

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### What demographic information are we trying to get?

As managers and scientists, we are interested in several demographic parameters describing the population, such as:

- 1 **population size**: the number of individuals in the population.
- 2 **population density**: the number of individuals in the population per unit area (generally per hectare or per square kilometre).
- 3 **age pyramid**: the distribution of various age groups in the population.
- 4 **crude birth rate**: the annual number of live births per 1000 individuals.
- 5 **crude death rate**: the annual number of deaths per 1000 individuals.

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So, trends are easy to get, but numbers are more important, when we are talking about very important species or those species in for which, we have very less number of individuals left. Now, when we talk about monitoring these are the demographic information that, we are trying to get size, density, age, pyramid, crude birth rate, crude death rate..

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### What demographic information are we trying to get?

- 1 **general fertility rate**: the annual number of live births per 1000 females of reproductive age.
- 2 **age-specific fertility rate**: the annual number of live births per 1000 females of specific age classes in the reproductive age.
- 3 **total fertility rate**: the average number of live births per female individual completing her reproductive age, if she followed the current age-specific fertility rate of the population.

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Then general fertility rate, age specific fertility rate, total fertility rate..

(Refer Slide Time: 14:04)

The slide is a presentation slide with a dark background. At the top left, there is a table of contents listing modules 1 through 8. Module 2, 'Monitoring wild animals', is highlighted in blue. To the right of the table of contents, there is a blue box titled 'Preliminaries' containing a list of topics: 'Basics of sampling', 'Distance sampling - I', 'Distance sampling - II', 'Radio-telemetry', and 'Behavioural monitoring'. The main title of the slide is 'What demographic information are we trying to get?' in white text on a blue background. Below the title, there is a list of three demographic metrics, each with a blue circular icon containing a white number. The first metric is 'replacement level fertility', the second is 'juvenile mortality rate', and the third is 'life expectancy'. At the bottom of the slide, there is a blue bar with the text 'Dr. Ankur Awadhiya, IFS' and 'Wildlife Conservation'.

Module 1: Introduction, Importance, Threats  
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**Preliminaries**  
Basics of sampling  
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### What demographic information are we trying to get?

- ① **replacement level fertility:** the average number of offsprings that a female individual must produce such that the population is completely replaced for the next generation. The replacement level of fertility  $\geq 2$ .
- ② **juvenile mortality rate:** the annual number of deaths of juveniles per 1000 live births.
- ③ **life expectancy:** the number of years that an average individual in the population at a given age could expect to live, at the present age-specific mortality levels.

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Now, replacement level fertility is important because, this is a very easy concept that, if you have 2 animals, they are breeding, the number of off-springs that they are producing for the next generation. If it is anything that is less than 2; so, for every 2 animals, you are only producing 1 offspring. So, your population will go towards the decline; if it is just equal to 2 then, because there would be some number of animals that die out before reaching a reproductive age. So, this was also not be sufficient. So, it has to be greater than or equal to 2.

Then we talked about juvenile mortality rate, life expectancy and in case of juvenile mortality rate, this is the death of juveniles per 1000 live births, why 1000 live births? Because in this case, there is a an animal that was already born dead, we cannot calculate the juvenile mortality rate, because it died before coming into existence.

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### What demographic information are we trying to get?

- 1 **general fertility rate**: the annual number of live births per 1000 females of reproductive age.
- 2 **age-specific fertility rate**: the annual number of live births per 1000 females of specific age classes in the reproductive age.
- 3 **total fertility rate**: the average number of live births per female individual completing her reproductive age, if she followed the current age-specific fertility rate of the population.

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Whereas in the case of other factors.

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### What demographic information are we trying to get?

As managers and scientists, we are interested in several demographic parameters describing the population, such as:

- 1 **population size**: the number of individuals in the population.
- 2 **population density**: the number of individuals in the population per unit area (generally per hectare or per square kilometre).
- 3 **age pyramid**: the distribution of various age groups in the population.
- 4 **crude birth rate**: the annual number of live births per 1000 individuals.
- 5 **crude death rate**: the annual number of deaths per 1000 individuals.

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So for instance, when we talked about the crude birth rate, it is the number of live births per 1000 individual like individuals..

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### What demographic information are we trying to get?

- ① **general fertility rate:** the annual number of live births per 1000 females of reproductive age.
- ② **age-specific fertility rate:** the annual number of live births per 1000 females of specific age classes in the reproductive age.
- ③ **total fertility rate:** the average number of live births per female individual completing her reproductive age, if she followed the current age-specific fertility rate of the population.

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But in the case of juvenile mortality rate, we are talking about 1000 live births..

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### What demographic information are we trying to get?

- ④ **immigration:** the number of individuals coming into the population from outside populations.
- ⑤ **emigration:** the number of individuals in the population that are going out to outside populations.
- ⑥ **net migration:** immigration - emigration.
- ⑦ **natural increase:** births - deaths.
- ⑧ **population growth:** births + immigration - deaths - emigration.
- ⑨ **population growth rate:** the growth of population expressed as a fraction of the population size over a fixed time. Generally expressed as % per annum.

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Next we had immigration, emigration, migration then natural increase. Natural increases birth minus death and when you increase, when you add your total migration then, it becomes the population growth. So, it is birth minus death plus immigration minus emigration.

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### What are absolute and relative estimates of animal numbers?

Absolute estimates of animal numbers give the size of the population, or its density, by actually looking at the animals, or their cues such as nests. e.g. point counts and distance sampling give absolute estimates of animal numbers. Absolute estimates typically require greater efforts than relative estimates.

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Then, we talked about the population growth rate and then absolute and relative estimates of animal numbers. Now in the case of absolute, estimates of animal numbers, you are actually looking at the animals for their cues..

In the case of relative estimates, you are taking a proxy. For instance, how many animals are you able to capture, in say 10 hours?.

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### What are absolute and relative estimates of animal numbers?

Relative estimates of animal numbers do not count the actual population. Rather, they utilise proxies to estimate animal densities in unknown units. e.g. number of catches per unit effort: while more individuals in the population would mean more catches on putting the same effort, catching, say 2 individuals in three days by putting 10 traps does not permit us to know the actual size of the population.

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This is a relative estimate.



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### What are absolute and relative estimates of animal numbers?

Relative estimates permit comparisons over space and time. Thus, they are useful while doing extensive works where actual number of individuals in the population are not required; rather trends in the population size are all what we are after.

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Now, relative estimate is easier to do it, it permits comparisons over time and space and they are useful, while doing extensive works, when actual number of individuals in the population are not required, but trends are required..

So, we mostly go for relative estimates for things such as the herbivore population. The number of deer in a forest, but in the case of our carnivore population, such as the number of tigers in the forest, you would go for an absolute estimate..

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### What are the common techniques of estimating population abundance?

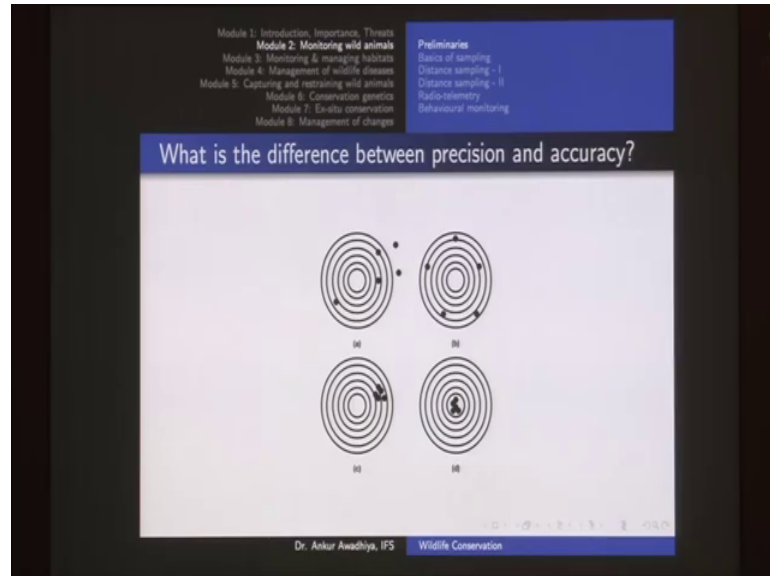
Some common methods of estimating population abundance are:

- 1 complete census
- 2 plot sampling
- 3 distance sampling
- 4 capture-mark-recapture method
- 5 removal method

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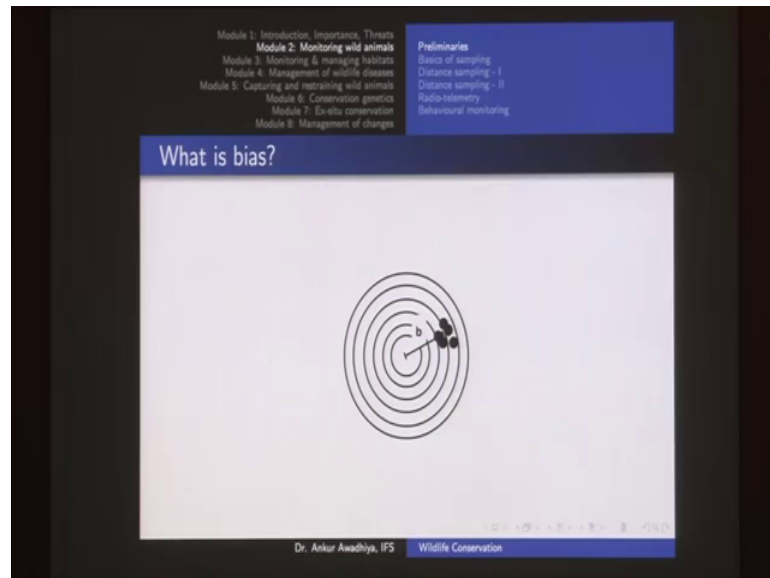
Next we looked at different kinds of methods for the estimation and then we talked about precision and accuracy..

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Now, precision is when you are doing an experiment again and again. How close all your values to each other? So, if they are very close together then, it is a precise value, this is a precise value, but these are not precise values because, your results of the experiment are very far apart from each other then in the case of accuracy, we are asking whether the our experimental results are close to the actual result or to the correct result? So for instance, this would be called an accurate result, but this is not an accurate result..

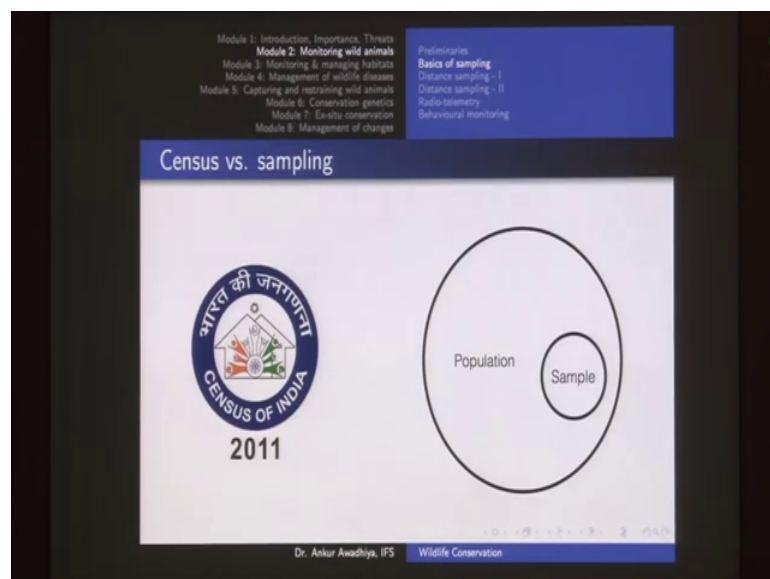
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Now for situations, where we have precision, but not accuracy, we can talk about bias. Now bias is the difference that, we have from the actual value and the center of the precise values..

Now, if you have a bias in your result, you could go for a calibration of the equipment or a calibration of the method.

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Next we talked about the basics of sampling. So here, we had census versus sample. So, in the case of a census, you are going to observe or count each and every animal that is

there in the forest, but in the case of your sampling, you only go for a small portion of that huge population, which is called a sample..

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The slide is titled "Objective of sampling". It features a quote: "to secure a sample which will represent the population and reproduce the important characteristics of the population under study as closely as possible."<sup>23</sup> At the bottom, there is a URL: <http://www.fao.org/docrep/003/x6831e/x6831e12.htm>. The slide is part of a presentation on Wildlife Conservation, with a table of contents visible in the top left corner.

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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."<sup>23</sup>

<sup>23</sup><http://www.fao.org/docrep/003/x6831e/x6831e12.htm>

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The slide is titled "Population". It features a definition: "The word population is defined as the aggregate of units from which a sample is chosen."<sup>24</sup> At the bottom, there is a URL: <http://www.fao.org/docrep/003/x6831e/x6831e12.htm>. The slide is part of a presentation on Wildlife Conservation, with a table of contents visible in the top left corner.

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Population

"The word population is defined as the aggregate of units from which a sample is chosen."<sup>24</sup>

<sup>24</sup><http://www.fao.org/docrep/003/x6831e/x6831e12.htm>

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So, we want to have most of the characteristics of the census with as little effort and time as possible..

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### 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."<sup>25</sup>

<sup>25</sup><http://www.fao.org/docrep/003/x6831e/x6831e12.htm>

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### Sampling frame

"A list of sampling units will be called a 'frame'."<sup>26</sup>

<sup>26</sup><http://www.fao.org/docrep/003/x6831e/x6831e12.htm>

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## Sample

"One or more sampling units selected from a population according to some specified procedure will constitute a sample."<sup>27</sup>

<sup>27</sup><http://www.fao.org/docrep/003/x6831e/x6831E12.htm>

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## Sampling intensity

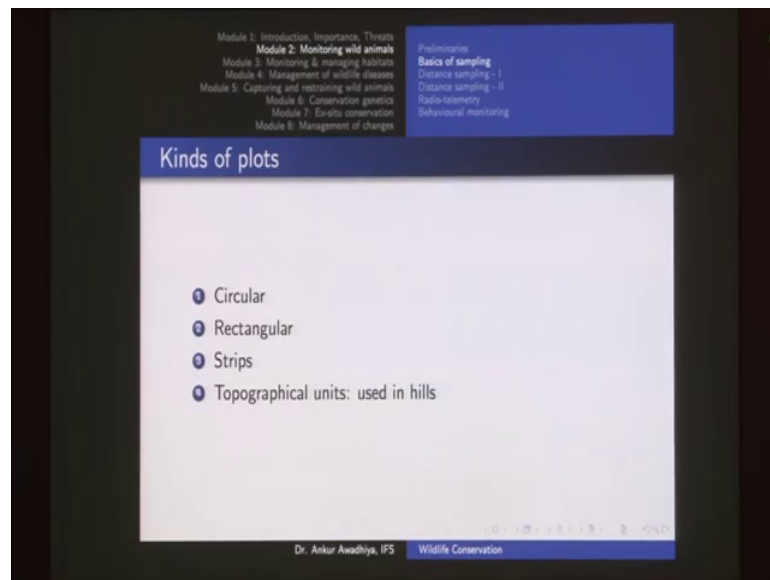
"Intensity of sampling is defined as the ratio of the number of units in the sample to the number of units in the population."<sup>28</sup>

<sup>28</sup><http://www.fao.org/docrep/003/x6831e/x6831E12.htm>

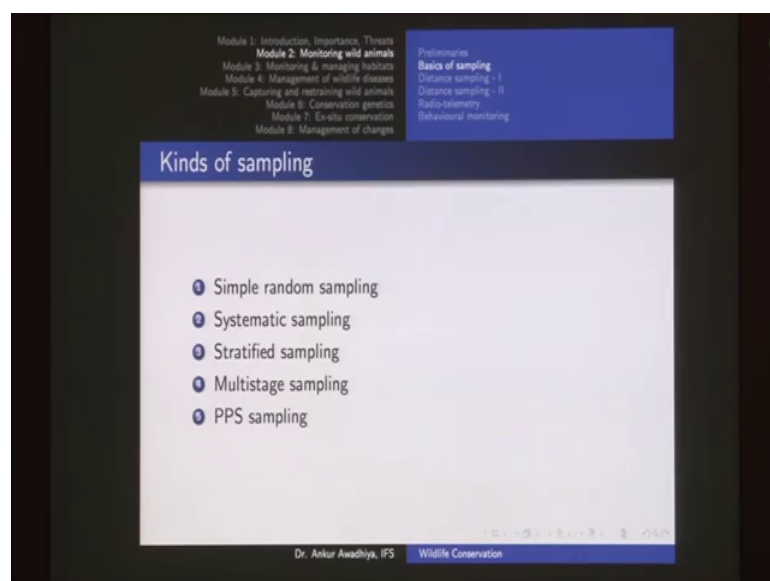
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Now, we had all these definitions, so the definitions are important..

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Then we talked about different kinds of plots and different kinds of sampling. Now in this case, the definitions here are important here as well. So, in the case of simple random sampling, we have a situation in which, every individual has an equal probability of being a part of the sample. So, example things like lotteries..

In the case of systematic sampling, we go with a formula. So, this formula could be say every fourth animal needs to be a part of the sample. So, that would be a systematic sampling in the case of a stratified sampling, we would divide our whole population or

the whole sampling frame into a number of strata. So, those strata's will be very much homogenous..

So for instance, if you want to have an estimate of the total number of animals in your forest, you can divide your total area into the areas that are hilly, the areas that are planes, the areas that are wet lands and the and you then go and figure out the animal densities, in each and every of these areas then, multiply them with their areas to get the total figures. So, that would be known as a stratified sampling because, in this case whenever you are taking any strata. So, whenever you are taking things like grasslands. So, the figure of grassland would be the same everywhere in the grassland, but it will not be the same as the figure in the or hills. So, stratified sampling increases your accuracy..

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### Simple random sampling

"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 simple random sampling."<sup>29</sup>  
Selection: lottery, random numbers

<sup>29</sup><http://www.iao.org/docrep/003/X6831e/X6831E12.htm>

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### 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."<sup>30</sup>

<sup>30</sup><http://www.fao.org/docrep/003/x6831e/x6831E12.htm>

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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."<sup>31</sup>

<sup>31</sup><http://www.fao.org/docrep/003/x6831e/x6831E12.htm>

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Then we had things like multistage sampling in which, you take two or more stages for your sample. And we also had probability proportional to size sampling in which, the probability of getting into a sample depends on the importance or the size of the variable under study..

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### Multistage sampling

"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."<sup>32</sup>

<sup>32</sup><http://www.fao.org/docrep/003/x6831e/x6831E12.htm>

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### PPS sampling

"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'."<sup>33</sup>

<sup>33</sup><http://www.fao.org/docrep/003/x6831e/x6831E12.htm>

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### Measuring animal density through complete census

Density of animals can be calculated as:

$$D = \frac{N}{A}$$

where  
 $D$  is the density of animals  
 $N$  is the count of animals as found through census, and  
 $A$  is the area of the region under study.

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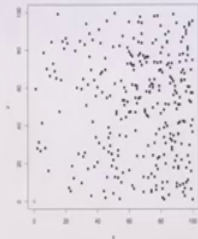
Next we talked about distance sampling. So, distance sampling starts with our basic formula of density of animals, number of animals per unit area.

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### Hypothetical distribution of animals



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### Measuring animal through complete census

To illustrate, let us consider the animals represented as dots. The area under study is  $100\text{ m} \times 100\text{ m}$ , or 1 hectare.  
If we counted all the animals, and found the total number as  $N = 205$ , then knowing  $A = 1\text{ Ha}$ , we shall calculate density as

$$D = \frac{205}{1} = 205 \text{ animals per hectare}$$

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Now, then we have hypothetical distribution of animals, we could go with a complete senses in which, we will get your densities number by area..

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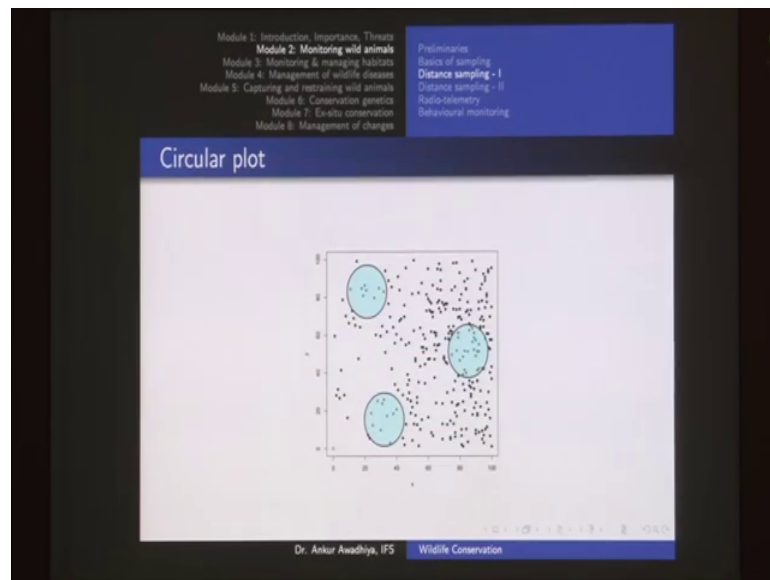
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### Strip plot



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Or we could go for a sample in the form of a strip plot or in the form of a circular plot.

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**Use of sample plots**

To illustrate, let us consider the use of strip plots. Suppose we take  $k$  strips each of length  $l$  and half-width  $w$ . Then, area of one strip plot will be  $2w \times l$ , and the total area of all the strip plots will be

$$a = k \times 2w \times l$$

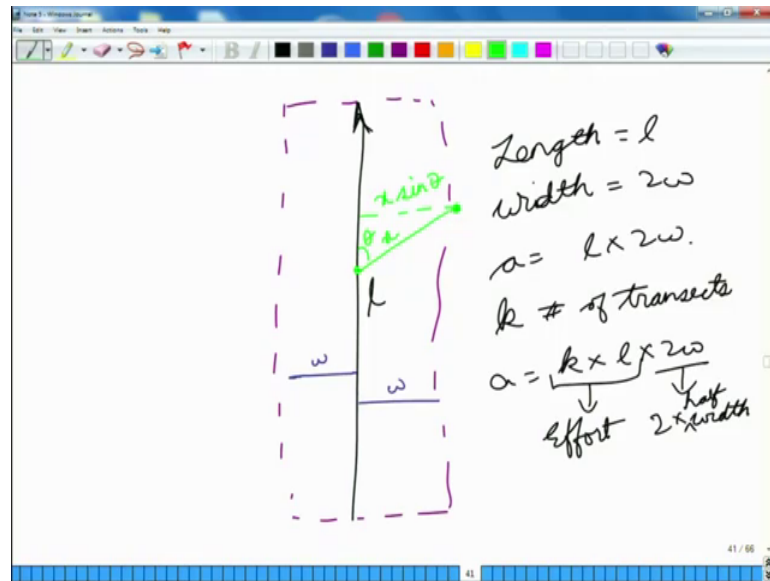
If  $n$  animals are counted in this area  $a$ , then the density of animals in the sample plots can be given as:

$$d = \frac{n}{a}$$

Now, when we go for a strip plot; A strip plot is the most commonly used plot and it is mostly used in the form of transects. So in the case of a transect, you move on a straight line, you look on your right, you look on your left. So, that it becomes a strip..

Now, in the case of sample plots, the area of the sample plot will be given by this value. So,  $l$  is the length that you are walking then  $2w$ , because  $w$  refers to the half width. So, the total width of the strip would be  $2$  into  $w$ .

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So, essentially what we are doing here? Is that you are moving on a straight line. So, this is the length of  $l$ , then you are taking a width  $w$  on your right and a width  $w$  on your left..

So, the total area of this strip would be the width of this strip multiplied with the length of the strip. So in this case, your length is  $l$  the width is thrice of  $w$ . So, the area becomes  $l$  into  $2w$  and if you take  $k$  number of transects. We have the area that is given by  $k$  into  $l$  into  $2w$  that is  $k$  into the area of each strip..

Now,  $k$  into  $l$  is the total length that you have want. So, this is something that is also known as effort. So, effort into twice width or twice of half width, becomes your total area of transect. So, you have this formula, if you observed  $n$  number of animals then you divide  $n$  divided by this value,  $k$  into  $2w$  into  $l$  to get the total density of animals, in your forest..

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### Use of sample plots

We estimate that the density of animals in our region of interest is the same as the density of animals discerned from the sample plots:

$$\hat{D} = d = \frac{n}{a}$$

Now, the estimate of total animals in the area of interest  $A$  will be:

$$\hat{N} = \hat{D} \times A = \frac{n}{k \times 2w \times l} \times A = \frac{nA}{2wL}$$

where  $L$  is the total length traversed, also called effort:

$$\text{Effort, } L = k \times l$$

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Now, in this case, effort refers to the total distance that you have walked, which is  $k$  into small  $l$ , we also represent this by capital  $L$ .

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### Why do we use hats in $\hat{N}$ and $\hat{D}$ ?

We use hats to differentiate the quantities that are estimated from quantities that are measured or counted.

Thus, while  $N$  would represent the actual count of animals as found in a census,  $\hat{N}$  represents the total count of animals as was estimated through our sampling exercise.

Similarly, while  $D$  would represent the actual density of animals as found using a census count with the total area of the region of interest,  $\hat{D}$  represents the estimate of density of animals as found through a sampling exercise.

While  $N$  and  $D$  are the accurate values,  $\hat{N}$  and  $\hat{D}$ , being estimates, may or may not be accurate.

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The next concept was why do we use hats? So, if there is something that you are actually observing then it will be a very correct number, but in the case of estimates, we differentiate between estimates and the correct values by giving the estimates a hat..

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### How is distance sampling different from plot sampling?

Plot sampling assumes that all the animals in the sample plots are detected and counted. This may or may not be a correct assumption, as shown in figure on the next slide.

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So, how is distance sampling from the different from the plot sampling?.

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### The question of detectability

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When we are moving in the forest, then there are situations in which, there would be an animal that has come inside the grasses or maybe it is standing behind a tree. So, we will not be able to detect that animal..



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### Distance sampling

Distance sampling takes this factor of non-detection into account by considering that not all animals in the transect are detected. Then it tries to estimate the number of animals that were missed in the counting exercise to get a better estimate of animal count or density.

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So, we have a probability of detection of animals and when we incorporate that we get into the distance sampling..

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### Distance sampling

The estimate is given as:

$$\hat{n} = \frac{n}{\hat{p}}$$

where  
 $\hat{n}$  is the corrected estimate of animal numbers,  
 $n$  is the uncorrected estimate of animal numbers as found in the sample plot by considering that all the animals in the plot have been detected, and  
 $\hat{p}$  is the estimate of the probability of detection of animals.

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So, the probability of detection is given by p hat. So, if you are observing n animals and if you have this value of p hat, the correct number of animals will be n divided by p hat.

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### Distance sampling

The estimate is given as:

$$\hat{n} = \frac{n}{\hat{p}}$$

where

$\hat{n}$  is the corrected estimate of animal numbers,  
 $n$  is the uncorrected estimate of animal numbers as found in the sample plot by considering that all the animals in the plot have been detected, and  
 $\hat{p}$  is the estimate of the probability of detection of animals.

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So then, we had this example, if  $\hat{p}$  is 0.75 and if you are observing say 30 animals. So, the correct number of animals will be  $n$  divided by  $\hat{p}$ , which is thirty divided by 0.75, which is 40. So, this is an important concept  $\hat{p}$ .

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### Distance sampling

There is one other prominent distinction between plot sampling and distance sampling: the width of the strips. Since plot sampling assumes that all the animals inside the strip get detected and counted, the width of the strips must invariably be small so that this assumption remains valid. This is because the probability of detection of animals goes on decreasing with distance from the transect line. For the plot sampling assumption of full detectability to hold true, the distance from the transect line, therefore, cannot be large.

On the other hand, since distance sampling assumes that not all animals will be detected, the strips can be much wider. For every width of the strip, there will be some  $\hat{p}$ , which can be estimated.

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### Distance sampling formula derivation

For plot sampling, we had estimated the number of animals as:

$$\hat{N} = \hat{D} \times A$$
$$\Rightarrow \hat{N} = \frac{n}{k \times 2w \times l} \times A$$
$$\Rightarrow \hat{N} = \frac{nA}{2wL}$$

where  $L$  is the total length traversed, also called effort:

$$L = k \times l$$

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So, next is, the width of the strips can be very large; in the case of distance sampling, because we will have a different  $\hat{p}$ ..

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### Distance sampling formula derivation

For the corresponding equation for distance sampling, we replace  $D$  with  $\hat{D} = \frac{\hat{D}}{\hat{p}}$ , or  $n$  with  $\hat{n} = \frac{n}{\hat{p}}$  to get:

$$\hat{N} = \frac{nA}{2wL\hat{p}}$$

All that remains now to use this equation is an estimate of  $\hat{p}$ .

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Now, in the case of distance sampling, the previous formula, we divided by  $\hat{p}$  and then to get the number of animals, we have multiply it with the total area of the forest..

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### Estimation of $\hat{p}$

To estimate  $\hat{p}$ , we begin by tabulating the number of animals observed at different distances from the transect line.

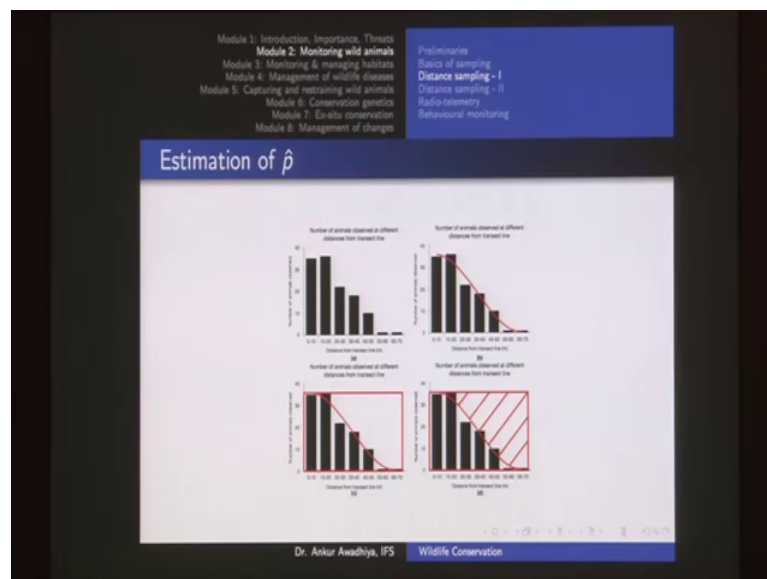
Table: Table of the number of animals detected at different distances from the transect line.

Distance from transect line (m)	Number of animals observed
0 - 10	35
10 - 20	35
20 - 30	22
...	...
60 - 70	1

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So, how do we determine  $\hat{p}$  hat?

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We determine  $\hat{p}$  hat by plotting the number of animals with different distances then, we make a curve and then the area of that is under the curve divided by the area that is under the rectangle gives us the  $\hat{p}$  hat..

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### Estimation of $\hat{p}$

The total number of animals in the strip of width 70 m will be given by the area under the rectangle. On the other hand, the actual number of animals detected in the strip of width 70 m is given by the area under the fitted curve. The ratio of these areas will give the probability of detection:

$$\hat{p} = \frac{\text{Area under the fitted curve}}{\text{Area under the rectangle}}$$

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Area under the fitted curve divided by area under the rectangle.

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### Estimation of $\hat{p}$

- ❶ If animals are small and barely visible, as in the case of mice in a field, the curve will drop suddenly, since while the animals on the transect will be visible, those even a small distance away will not be detected. In such a scenario, if we considered a large strip width, a very small fraction of animals in that strip will get detected, and we'll have  $\hat{p} \ll 1$ .

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### What does $\hat{p}$ depend on?

Under field conditions,  $\hat{p}$  is often an extremely tricky quantity to estimate, since it is affected by several factors, many of which may not even be under our control. Some factors influencing  $\hat{p}$  are listed below:

- ❶ **The characteristics of the terrain:** Flat, clear terrains are easier to work with, since they provide little scope for animals to hide while providing the observer a large field of view. On the other hand, animals may not be seen in tall grasslands, thick bushes or undulating terrains. Thus, the terrain may have a large bearing on the value of  $\hat{p}$ .

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Now, we talked about the estimation of  $\hat{p}$  in different areas. So, what this  $\hat{p}$  depend on? So, there are a number of factors on which, your  $\hat{p}$  hat would depend. It would depend on the characteristics of the terrain, whether it is flat.

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### What does $\hat{p}$ depend on?

- ❷ **The nature of the transect exercise:** Vehicular transects may result in larger number of detections than walking transects, not only because they provide a higher vantage point of observation, but also because the animals, habituated to vehicles by their park experiences, often feel more comfortable and do not run away.
- ❸ **The nature of the transect:** Transects on areas that are more frequented by animals will have larger detection probabilities. Examples include some trails and roads.

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Whether it is undulating the nature of the transect exercise whether you are walking on foot whether you are walking, whether you are moving in a vehicle, the nature of the transect. ...

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### What does $\hat{p}$ depend on?

- ❶ **Local traditions:** In areas where locals feed animals, the animals might come closer to the observer, facilitating their detection.
- ❷ **The characteristics of the animals:** Some animals are bold; they approach the observer. Some animals are shy; they avoid the observer. Some animals may have a keen sense of sight, sound or smell; others may not. The characteristics of the animals under observation have a large bearing on the value of  $\hat{p}$ .

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The local traditions, the characteristics of the animals.

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### What does $\hat{p}$ depend on?

- ❸ **The colour of the dress worn by the observer:** Bright colours will make the observer easily detectable by the animals. While some shy animals might move away (facilitating their detection due to movement) or freeze (hampering their detection due to absence of movement), some other bold animals might approach the observer (facilitating their detection).
- ❹ **The perfume worn by the observer:** Since many animals have a keen sense of smell, perfume will affect the detectability of the observer, resulting in similar effects as listed above.
- ❺ **The food eaten by the observer:** Many foods leave a trace scent, which might be sensed by the animals, affecting  $\hat{p}$ .

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The colour of dress that you are wearing, the perfume that you are wearing.

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### What does $\hat{p}$ depend on?

- ④ **The mental state and fatigue of the observer:** Under conditions of mental stress or fatigue, an observer might not take note of all the animals, affecting the estimate of detectability of the animals.
- ⑩ **The size of the observer group:** When there are more observers, there are more number of eyes that could facilitate the detection of animals. On the other hand, if the group members talk, the sound could signal the animals, affecting their detectability, besides hampering the concentration of the observers.

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The food that you are that you have eaten; the mental state and fatigue of the observer the size of the group.

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### What does $\hat{p}$ depend on?

- ⑪ **The direction of wind:** When wind blows from the observer(s) towards the animals, human scent quickly reaches the animals. On the other had, when wind blows from the animals towards the observer(s), then the human scent does not reach the animals fast. Animals react to scent; hence the direction of wind may also affect the  $\hat{p}$ .
- ⑫ **The weather on the day of observation:** Overcast skies will give very different results from clear skies, since weather impacts the activity of animals. When animals are more active and keep moving, they are easily detected.

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The direction of wind, the weather on the day of observation and n number of other factors as well. So,  $\hat{p}$  is something that is tricky to determine.



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### Flavours of distance sampling

There are several flavours of distance sampling, such as:

**Line transect versus point transect:** In a line transect, the observer(s) move along a straight line to observe animals on both sides of the line. Point transects are line transects of length zero. In point transects, the observer(s) observe animals by standing at a point.

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So, next we had distance sampling 2. So here, we talked about different flavors. So, this line transect versus point transect..

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### Flavours of distance sampling

**Perpendicular distance versus radial distance:** Some distance sampling protocols measure perpendicular distance from the transect line; others measure the radial distance (as in point transects) or radial distance along with angles (to derive perpendicular distance later using the trigonometric formula  $d = l \times \sin(\theta)$ ).

**Exact distance versus grouped distance:** When using a laser rangefinder, we get exact distance to an animal. At times, as in surveys with aeroplanes, we mark wing struts of the aircraft to give an estimate of grouped distances (like 0 - 50 m, 50 - 100 m, 100 - 150 m, and so on).

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So, in the case of point transect, you have circular plots then you have perpendicular distance versus radial distance. So, you can when you are observing an animal somewhere. So, you can and this is your position. So, you can directly, take this distance say, this is x and you can measure this angle theta or you can directly put it as x into sin

theta, which is the perpendicular distance of the animal with respect to your transect line..

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The slide is titled "Flavours of distance sampling". It contains two main sections of text. The first section, "Individual objects versus clusters", explains that solitary animals are recorded as individual objects, while animals in groups are recorded as clusters with their size. The second section, "Direct sightings versus indirect cues", notes that animals can be directly seen (e.g., elephants) or inferred from indirect cues like dung pellets, nests, or songs. The slide is part of a presentation by Dr. Ankur Awadhiya, IFS, on Wildlife Conservation. A table of contents is visible in the top left corner, listing modules from Introduction to Management of changes. A sidebar on the top right lists topics like Preliminaries, Basics of sampling, and Distance sampling - I and II.

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### Flavours of distance sampling

**Individual objects versus clusters:** When animals are solitary, they are recorded as individual objects. When animals occur in groups, they are recorded as clusters, along with the size of each cluster (number of animals in the cluster).

**Direct sightings versus indirect cues:** At times, animals might be directly seen. e.g. elephants.  
On other occasions, the presence of animals may have to be inferred from indirect cues such as dung pellets, nests or songs.

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Next we talked about exact distance versus group distance, then individual objects versus clusters. Direct sightings versus indirect cues active detection on the field versus passive detection with camera traps..

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This slide is also titled "Flavours of distance sampling". It focuses on the comparison between "Active detection on the field" and "passive detection with camera traps". It states that in active detection, observers move along the transect to observe animals directly. In passive detection, camera traps are set up to record animals as they pass by, with the data later used to estimate the number of animals. The slide is part of the same presentation by Dr. Ankur Awadhiya, IFS, on Wildlife Conservation. The table of contents and sidebar are identical to the previous slide.

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### Flavours of distance sampling

**Active detection on the field versus passive detection with camera traps:** In active detection, the observers move along the transect to directly observe the animals.  
On other occasions, camera traps may be set up in the field to record the animals when they pass by, and this information (about the location of camera traps and the animals detected at different times) may later be utilised to compute an estimate of the number of animals.

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Direct sightings versus indirect cues active detection, on the field versus passive detection with camera traps.

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### Detection function, $g(x)$

Detection function  $g(x)$  is a representation of the probability of detection of an animal at distance  $x$  from the transect line. The detection function generalises the curve we drew earlier. While the curve we drew tells us the number of animals detected at different distances, whose numerical value shall be different in each study,  $g(x)$  gives the probability of detection in a scaled fashion:

$$0 \leq g(x) \leq 1$$

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Then we talked about the detection function.

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### Detection function, $g(x)$

This scaling is done in a manner that  $g(0) = 1$ . In other words, the probability of detecting an animal at zero distance from the transect line is 1. Or, that any animal on the transect line itself will always be detected, and never missed. A smooth curve is plotted over the frequency distribution, and scaled to ensure that  $g(0) = 1$ .

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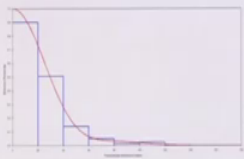
Now, in the case of detection function, you scale your value of  $p$  to. So, as to get  $g$  at 0 is equal to 1, which means that any animal that is there on transect has a 100 percent probability of getting detected..

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### Detection function, $g(x)$



Since  $g(x)$  is unknown and needs to be estimated, we may represent it as  $\hat{g}(x)$ .

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### How do we calculate $\hat{p}$ from $\hat{g}(x)$ ?

Since  $\hat{p}$  is the estimate of probability of detecting an animal, we can compute it for any width  $w$  by finding the area under the curve of  $\hat{g}(x)$  (which represents the probability of detecting all the animals present in a width  $w$ ) and dividing it by the area under the rectangle of height  $g(0)$  (which represents the probability of detecting all the animals present in a width  $w$  when the detection probability is 100%, since  $g(0) = 1$ ).

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Now, we use this to be able to compute our  $\hat{p}$  hat..

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### Why do we need to model $g(x)$ ?

Since the true  $g(x)$  is unknown to us, we need to model it to estimate  $\hat{g}(x)$ . This is typically done by fitting models to the obtained data.

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So, when we want to perform our are computations in a computer then this equation becomes very important..

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### Characteristics of a good model of $g(x)$

There are 4 characteristics of a good model of  $g(x)$ :

- 1 **Robustness:** The model should be able to fit a variety of possible shapes for  $g(x)$ .
- 2 **Shape criterion:** The curve should not fall rapidly near  $x = 0$ , since animals are typically equally detectable till a small distance from the transect line.  
Graphically, it would mean that the curve of  $g(x)$  should have a shoulder at  $g(0)$ .  
Mathematically, it can be represented by the criterion:  
 $g'(0) = 0$ , meaning that the slope of  $g(x)$  at  $x = 0$  is zero.

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Now, there are 4 characteristics for a good model of  $g(x)$ . One is robustness, one is shape criterion..

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### Characteristics of a good model of $g(x)$

- 1 **Pooling robustness:** The model should work even when there are several unrecognised factors affecting detectability.
- 1 **Estimator efficiency:** The model should give a precise estimate of density.

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Pooling robustness and also the estimator efficiency.

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### What are model's key functions and adjustment functions?

The detection function  $\hat{g}(x)$  is represented as a sum of two functions:

- 1 **Key function:** This dictates the basic shape of the detection function.
- 1 **Adjustment function:** This 'adjusts' the detection function to enable it to explain minor fluctuations as observed in the obtained data.

Thus, we may write:

$$\hat{g}(x) = \text{Key function} + \text{Adjustment function}$$

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And when we are computing  $g$  of  $x$  then there are 2 functions that, we need to keep in mind. One is the key function, which tells us the basic shape of the detection function and the second is the adjustment function, which adjust are  $g$  of  $x$ , so as to include, any small fluctuations that are there in the data..

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### What are the different key functions available in *Distance* software?

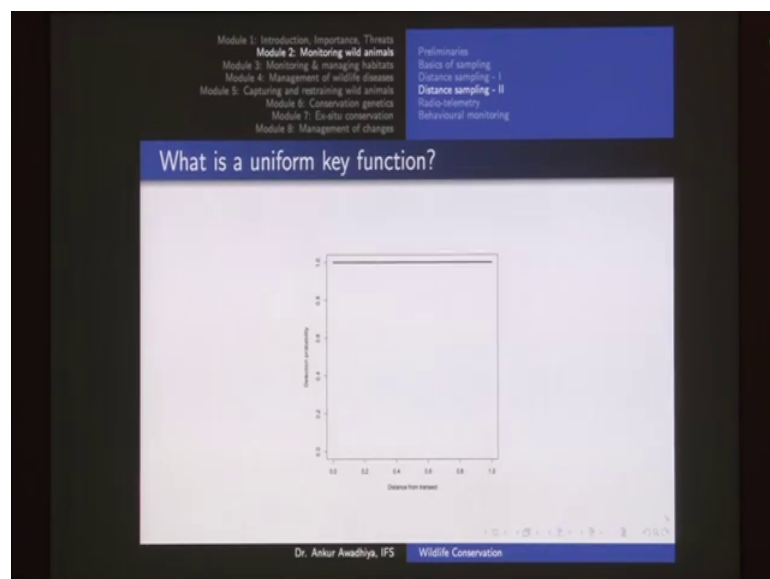
The *Distance* software has 4 key functions:

- 1 uniform
- 2 half-normal
- 3 hazard rate
- 4 negative exponential

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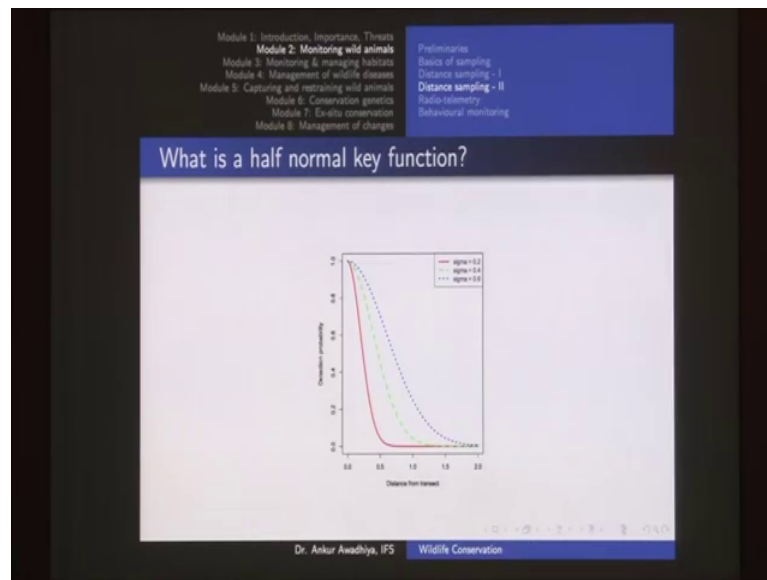
Now, there are 4 important key function, that you should remember uniform, half normal, hazard rate and negative exponentials. These are the 4 different key functions that are available in our software..

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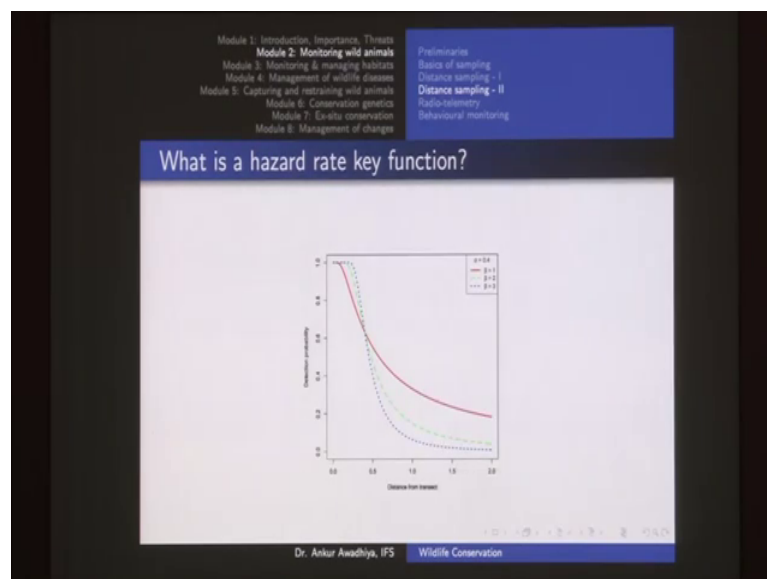
Now, uniform function is when your probability of detection is the same everywhere. So, a good example would be a elephants that are there in the grasslands. So, even if they are very far away, you will be able to see those..

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Now, the second is the half normal key function, which is half of the bell shaped curve. So, if we do it on the other side as well, we will get a bell shaped curve and then we take half of it. So, we get the half normal key function.

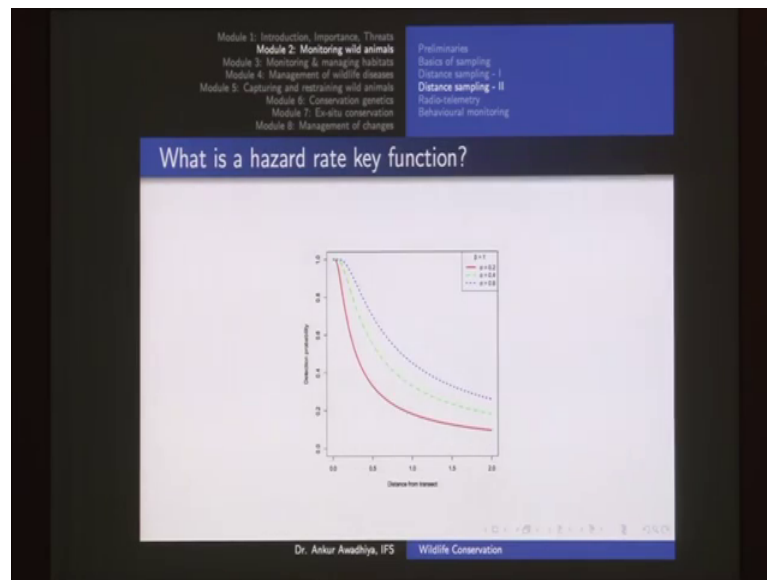
(Refer Slide Time: 26:37)



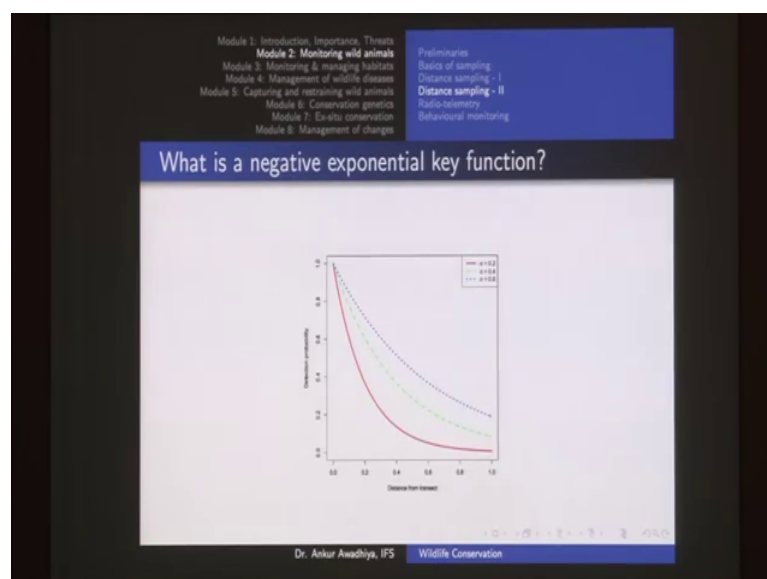
Next is the hazard rate key function and the hazard rate key function, we have a small shoulder that is near  $x$  is equal to 0 and then it rapidly drops down and an example includes, the animals that have a flight distance. So, if you go any closer to them, there are they will run and they will be detected..



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Next is the hazard rate key function. So, hazard rate is what we have talked about. Next, we have the negative exponential key function, which right a at 0, it starts going down..

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### How do adjustment functions work?

Adjustment functions are added to key functions to make them more robust, that is, able to fit a variety of shapes for  $g(x)$ . In this case, we write:

$$\hat{g}(x) = \text{Key function} + \text{Key function} \times \text{Series}$$

where the series is typically of the form:

$$\text{Series} = \alpha_1 \times \text{term}_1 + \alpha_2 \times \text{term}_2 + \alpha_3 \times \text{term}_3 + \dots$$

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So, your  $g(x)$  is given by key function plus key function into some series, which is the adjustment function..

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### What are the commonly deployed adjustment functions?

Two kinds of adjustment functions are commonly used: cosine and polynomial.

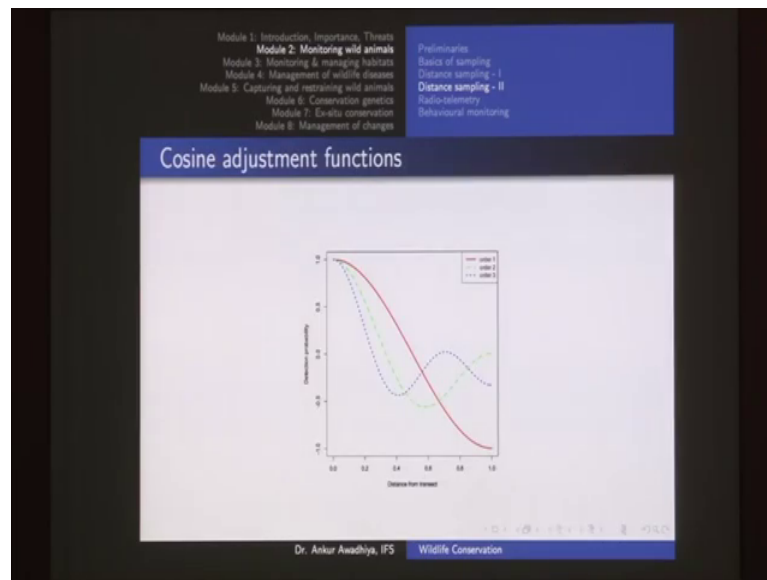
Cosine adjustment functions are of the form

$$\sum_{\alpha=1}^{\infty} \alpha_{\alpha} \times \cos\left(\frac{\sigma \pi y}{w}\right)$$

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And we normally have used two kinds of adjustment functions.

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One is the cosine adjustment function.

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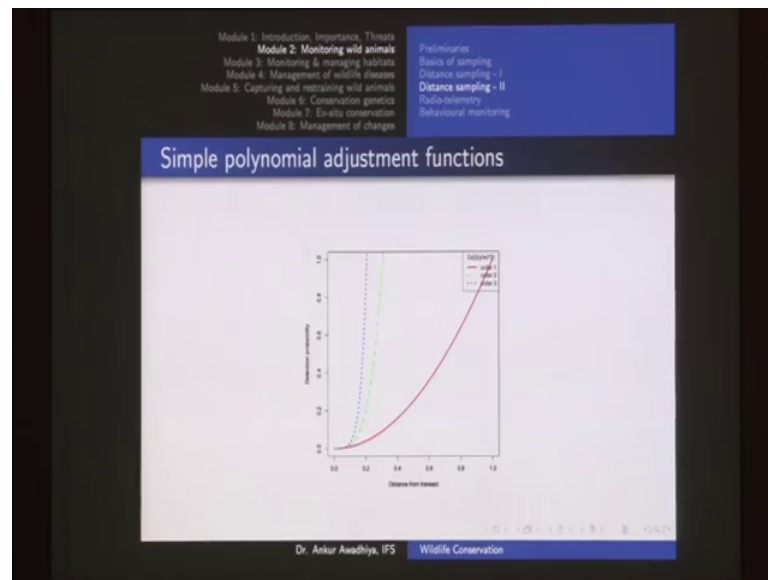
### Simple polynomial adjustment functions

Simple polynomial adjustment functions are of the form

$$\sum_{o=1}^O \alpha_o \times \left(\frac{y}{w}\right)^{2o}$$

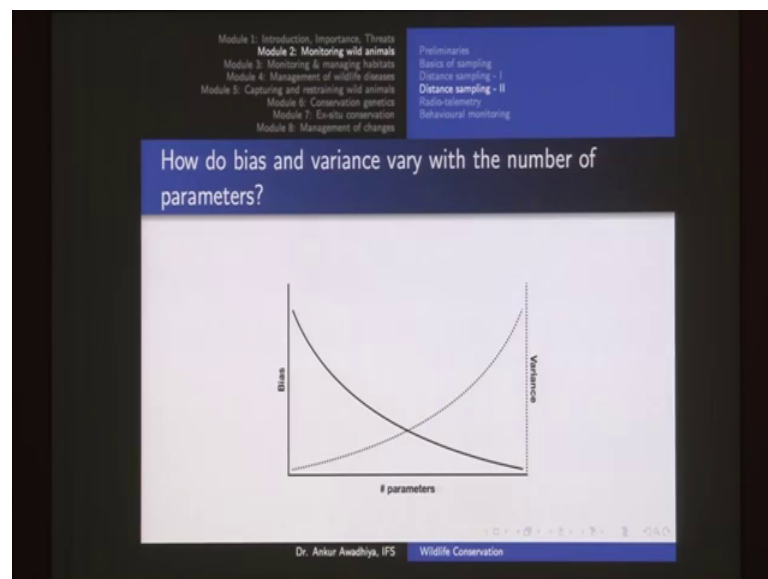
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And the second one is a simple polynomial adjustment function..

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Now, this is an important concept, when we increase the number of parameters. The bias decreases because, with more number of parameters, the more amount of corrections that you are doing to your  $g$  of  $x$ , all this smaller fluctuations are taken care of so, the bias reduces, but at the same time, the variance increase. The variable increase because, when you are adjusting your function to include all these smaller values, then the amount of noise in the data is also being computed..

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### How many parameters should we target?

If the number of parameters is very less, the detection function will not be robust enough to explain all the data. On the other hand, as the number of parameters increases, the robustness increases as the detection function becomes more flexible to explain the data. However, at very large number of parameters, we might be forcing the model to explain the noise present in the data, which will not serve any purpose.

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So, we should go for a mid value of these parameters.

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### How many parameters should we target?

Similarly, when the number of parameters is very large, the model will have a lot of variance. This variance will go on reducing as the number of parameters is reduced. Thus, it is best to go with a model with an intermediate number of parameters.

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### What do we mean by truncation?

Truncation is the process of removing such data from the analysis as are leading to high variance and poor fit, since they have a low signal : noise ratio.  
We typically truncate around 5-10% of the observations (those that are very far from the transect line) in order to improve the fit of the model.

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And then, we had this concept of truncation. So, truncation means that we typically remove 5 to 10 percent of observations, that are very far from the transect line, because these are those observations for which our distance computations or the angular computations will not be very correct. So, the amount of noise is high..

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### How do we assess a model's performance?

There are three easy assessments of a model's performance:

- 1 likelihood
- 2 AIC
- 3 absolute measures of model fit

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Now, there are 3 easy parameters of assessing a models performance. So, these are 3 mathematical methods, one is the likelihood. What is the likelihood that your function is correct? The second is AIC, which stands for akaike information criterion, which tells us

with just one number, what is the likelihood of your function being correct and the third one is there absolute measure of model fit.

So, these are 3 assessments of model performance..

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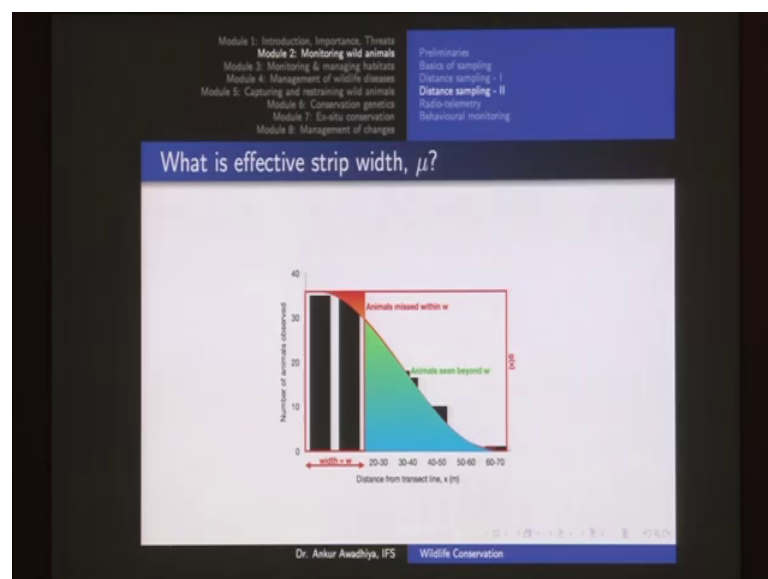
### What is effective strip width, $\mu$ ?

The effective strip width,  $\mu$  is defined as the distance at which as many objects are seen beyond  $\mu$  as are missed within  $\mu$ . For every strip-width  $w$ , if we drew a straight line parallel to the  $y$  axis, it would divide the curve of  $g(x)$  and the rectangle into two parts. The above part, to the left, as represented by the orange-red colour in the figure, would represent the animals that were missed within the strip-width  $w$ . Similarly, the below part, to the right, as represented by the blue-green colour in the figure, would represent the animals that would be seen beyond the strip-width  $w$ .

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Then we talked about effective strip width.

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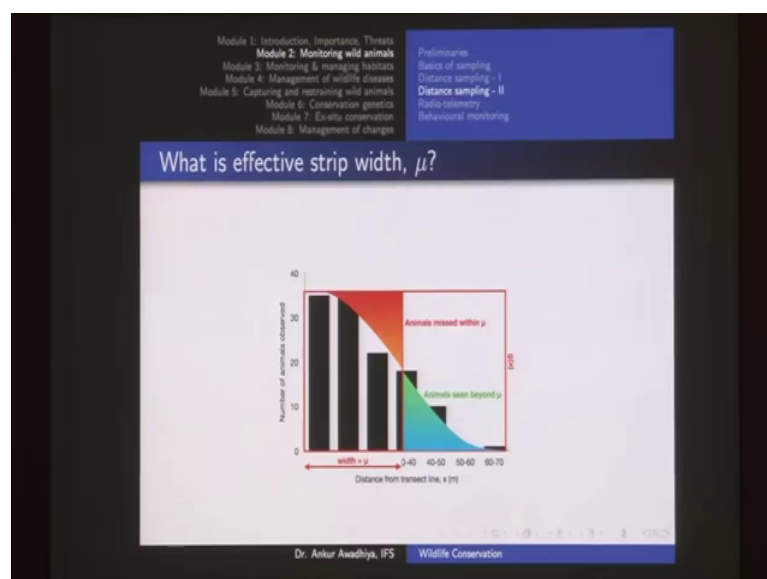
### What is effective strip width, $\mu$ ?

As we keep increasing  $w$ , we'll reach a stage where the number of animals missed within  $w$  will equal the number of animals seen beyond  $w$ . The strip width  $w$  in this case will be called the effective strip width,  $\hat{\mu}$ .

The effective strip width  $\hat{\mu}$  can be found computationally. It is then utilised in a modified distance sampling formula to estimate the number of animals.

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So, effective strip width is computed in a manner so that, at this particular width, the number of animals that you have missed out within  $\mu$  is the same as the number of animals that you would have detected beyond  $\mu$ . So, in that case if you take just this width and put it into your formula, you will get the value of the total number of animals..



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### Summing up

$$\hat{N} = \frac{nA}{2wL\hat{p}} = \frac{nA}{2\hat{\mu}L}$$
$$\hat{D} = \frac{n}{2wL\hat{p}} = \frac{n}{2\hat{\mu}L}$$

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So, then we got to these formula. So, these are the formula of the number of animals and the density estimates of animals..

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### Preliminaries

**Word roots**

- Tele = distant
- metron = measurement

**Definition**

Telemetry is the process of recording and transmitting the readings of an instrument (measurement). Radio telemetry is telemetry done using radio waves.

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Next we talked about radio telemetry. So, it has uses radio waves to do measurements at a distance..

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The slide is titled "Radio telemetry". It features a navigation menu on the top left with modules 1 through 8, and a top right section with "Preliminaries" and "Radio-telemetry". The main content area has a blue header "Radio telemetry". Below it, a box labeled "Definition" states: "Radio telemetry in the context of wildlife management refers to the tracking of wild animals through the use of sensors, transmitters and receivers." Another box labeled "Three formats" lists: 1. VHF radio tracking, 2. GPS tracking, and 3. GPS + satellite combination tracking. The footer includes "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

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### Radio telemetry

**Definition**  
Radio telemetry in the context of wildlife management refers to the tracking of wild animals through the use of sensors, transmitters and receivers.

**Three formats**

- 1 VHF radio tracking
- 2 GPS tracking
- 3 GPS + satellite combination tracking

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And we talked about 3 different phase, VHF radio tracking, which is very high frequency then, we looked at GPS tracking, which is global positioning system and then GPS plus satellite combination tracking..

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The slide is titled "Telecommunication". It features the same navigation menu as the previous slide. The main content area has a blue header "Telecommunication". Below it, text states: "It consists of three parts:". A list follows: 1. Transmitter, 2. Receiving antenna, and 3. Receiver. The footer is identical to the previous slide.

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### Telecommunication

It consists of three parts:

- 1 Transmitter
- 2 Receiving antenna
- 3 Receiver

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So, there are 3 parts, transmitter, receiving antenna and the receiver..

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### Transmitter

The transmitter is fitted to the animal through a collar. It transmits radio signals in the very high frequency spectrum.

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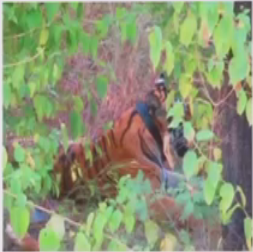
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### Transmitter



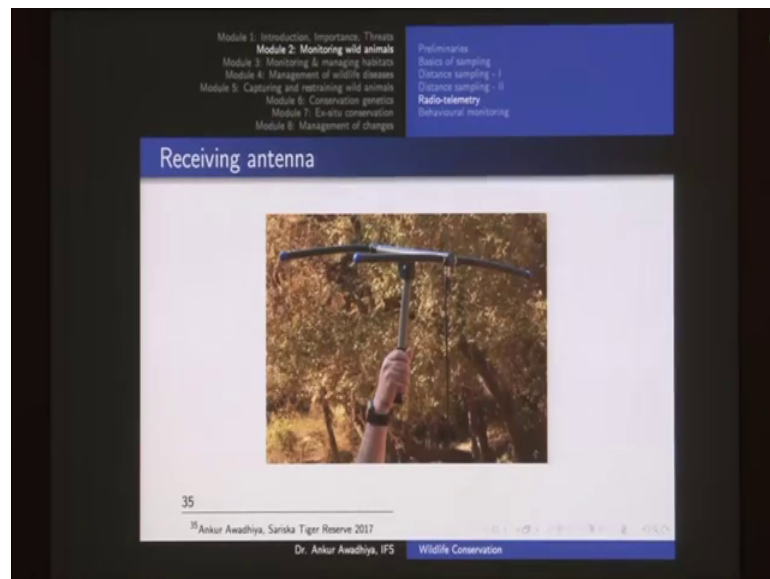
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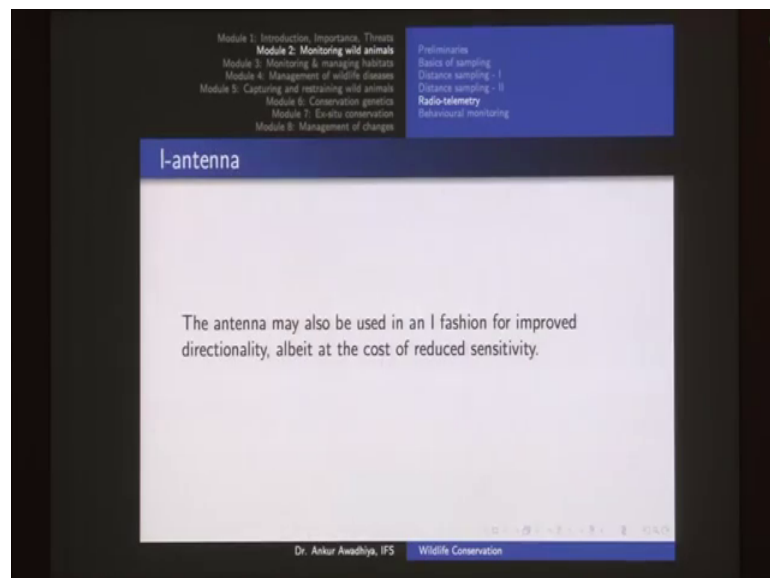
So, we talked about all of these.

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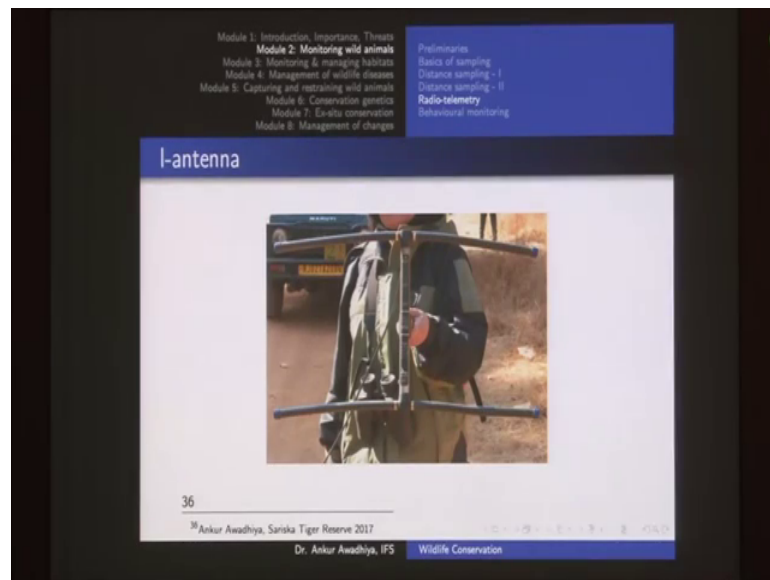
In the case of transmit of the receiving antenna, we normally go for a Yagi antenna..

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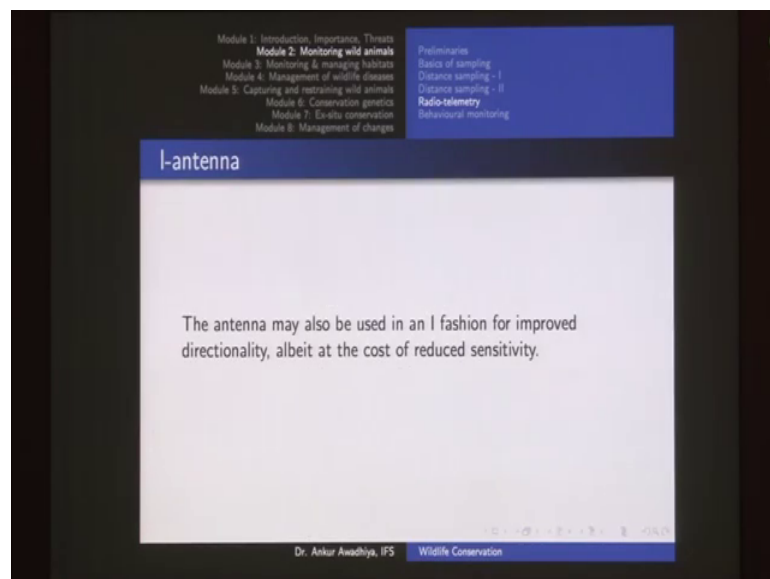
And this antenna can be used in this fashion..

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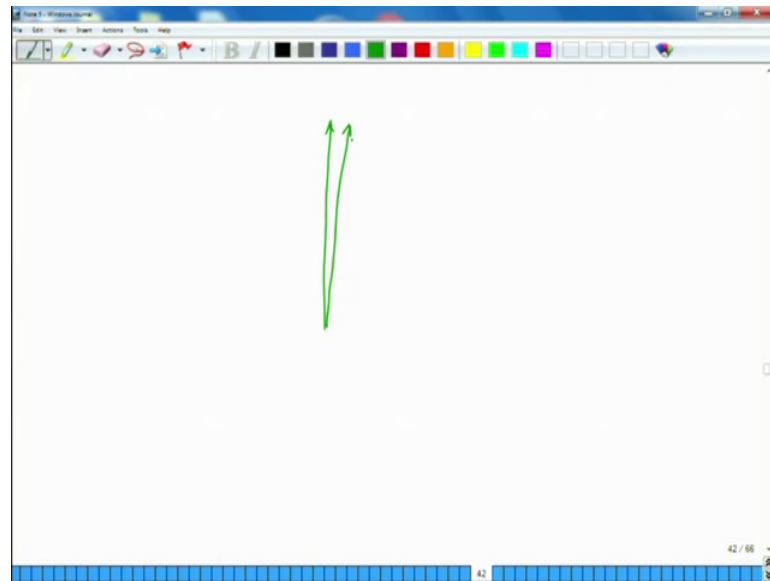
Or it can be used in the I fashion.

(Refer Slide Time: 30:03)



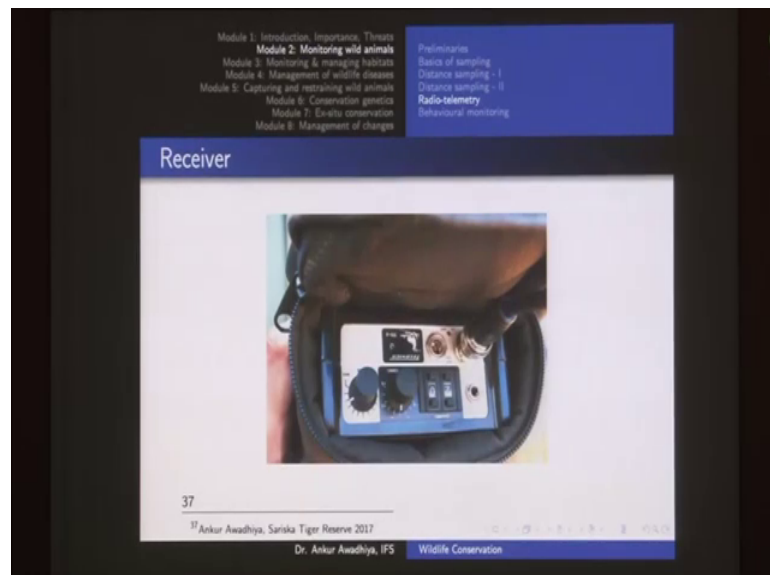
Now, when you go for an I fashion, this is used, when you are already very closed to the animal, because in this fashion, your directionality is very good, but the sensitivity is not that good.

(Refer Slide Time: 30:13)

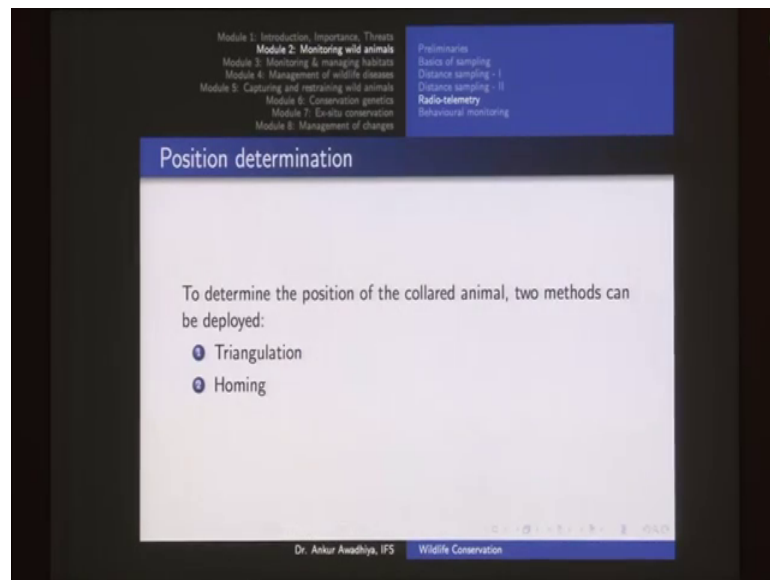


Which means, that when you are using your antenna in the I fashion you can tell whether your animal is here or whether your animal is here. So, it gives a very good directionality, but the problem is that you cannot use it at a greater distance, because the amount of sensitivity that this fashion gives you is very less.

(Refer Slide Time: 30:29)

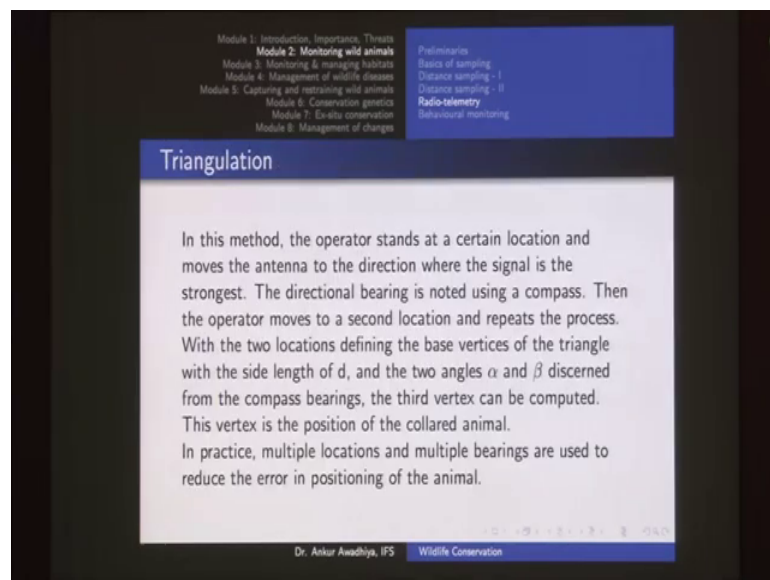


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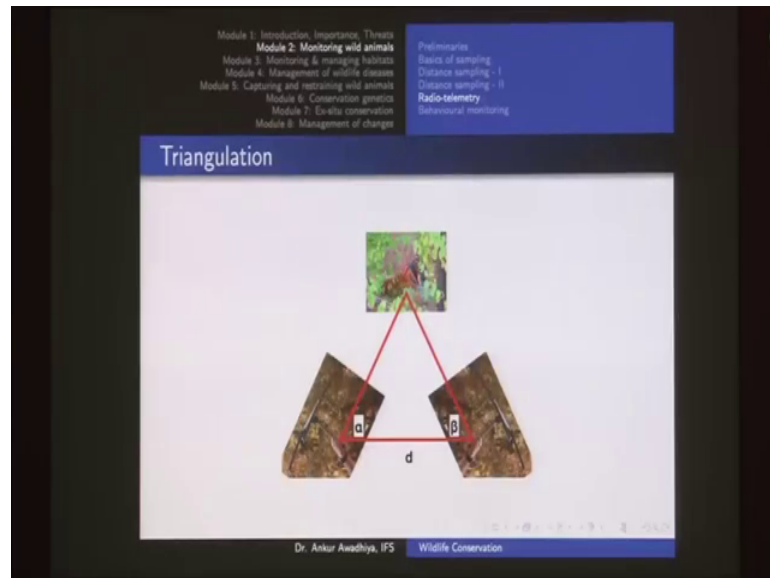
Next we talked about the receiver, different (Refer Time: 30:32) to your signal to noise values that are computed using digital signal processing.

(Refer Slide Time: 30:41)



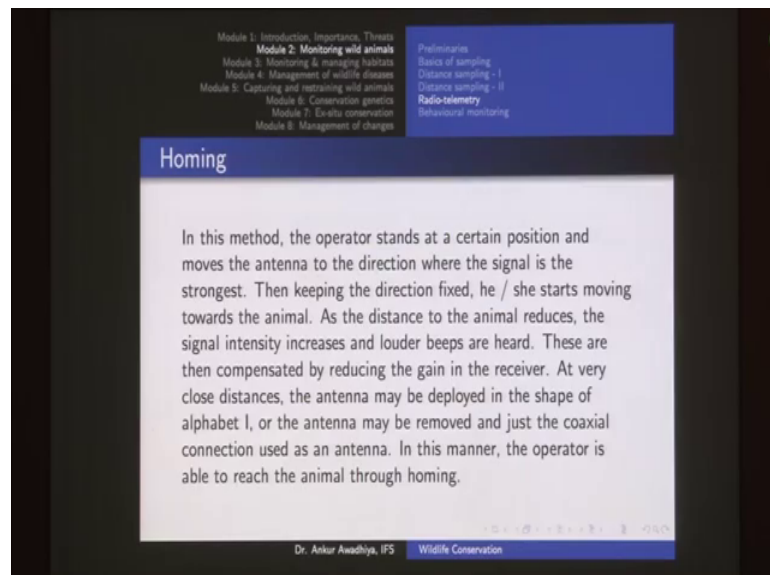
And there are 2 ways of determining the position of the animal.

(Refer Slide Time: 30:42)



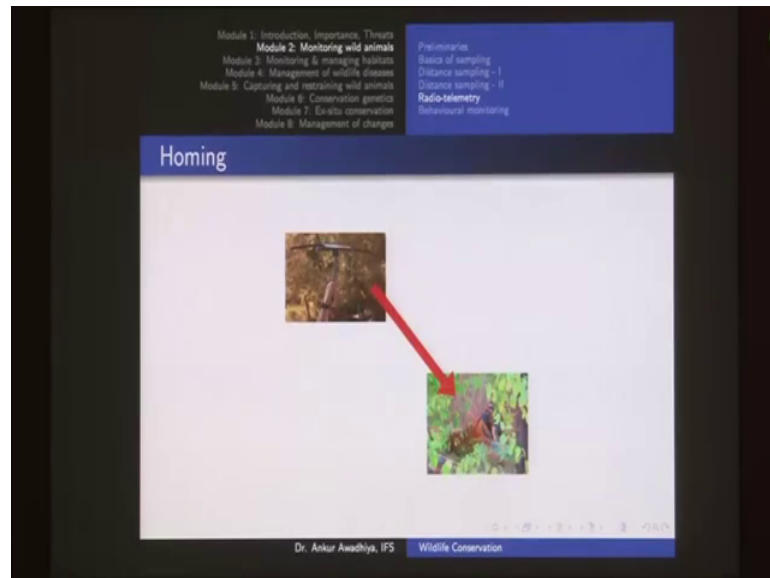
One is triangulation. So in the case of triangulation, you take 2 readings. So, you know these 2 points and at both of these points, you take the reading of the bearing of the animal with respect to that line and with that you can triangulate the position of the animal..

(Refer Slide Time: 30:58)



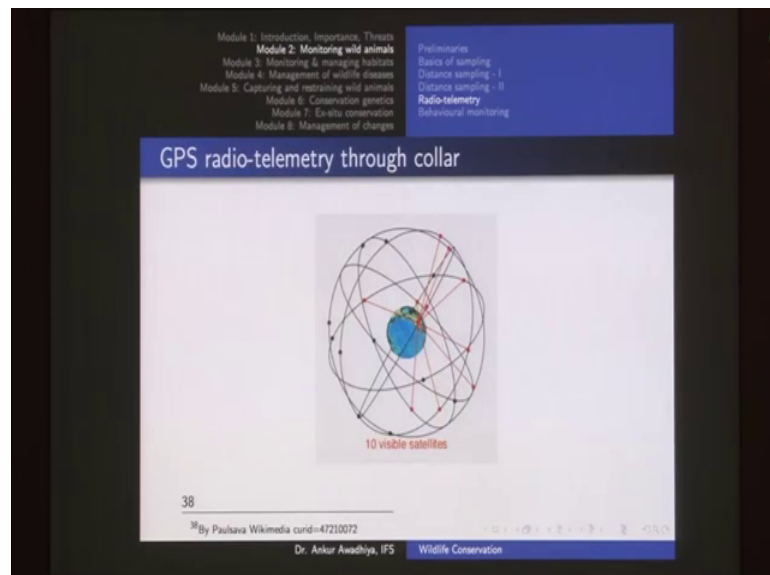


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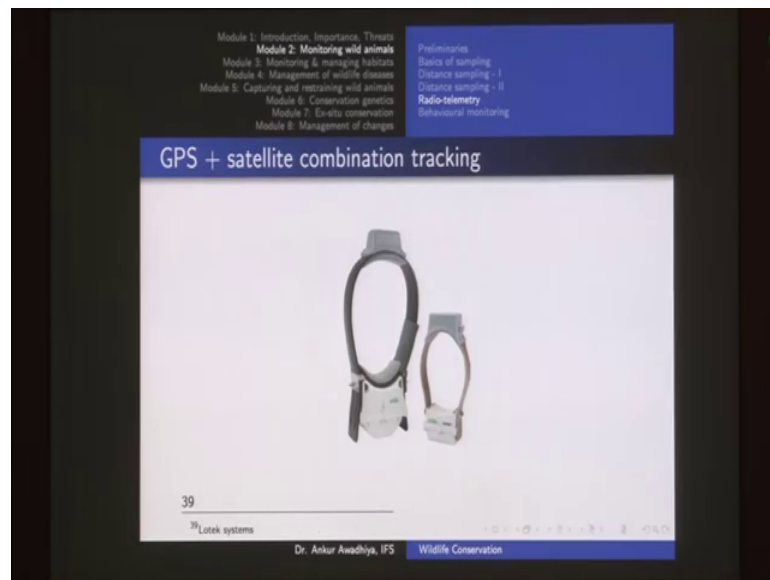


And the second method is homing. So, in the case of homing, you just take your antenna, get the direction then start moving towards the animal, when you are very close to the animal, you shift from this fashion to I fashion, for an improved directionality and slowly and steadily, you will reach the animal..

(Refer Slide Time: 31:15)

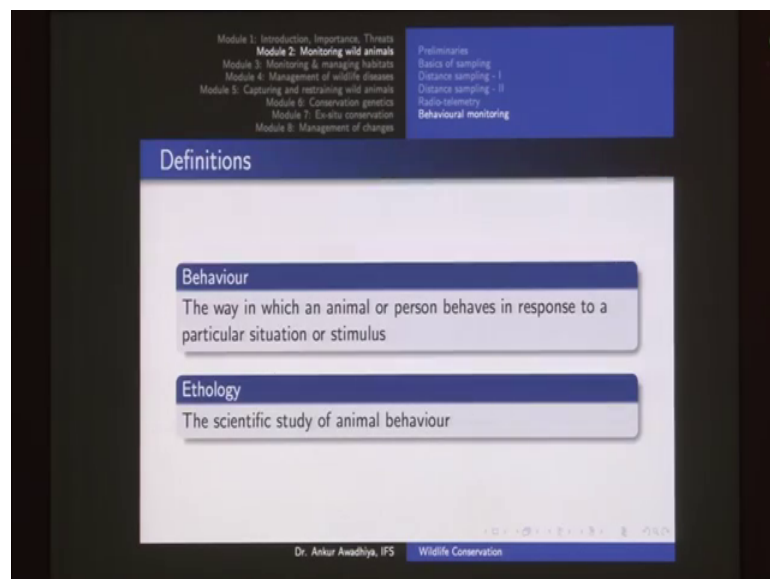


(Refer Slide Time: 31:16)



Next is GPS radio telemetry that we talked about.

(Refer Slide Time: 31:21)



The last one was behavior monitoring. So, behavior is the way in which, an animal or person behaves in response to a particular stimulus or a situation..

Now, the scientific study of animal behavior is called ethology..

(Refer Slide Time: 31:31)

The slide is titled "Some topics of study" and lists the following topics:

- ① foraging behaviours
- ② anti-predator behaviours
- ③ social behaviours
- ④ mating behaviours, etc.

The slide also features a navigation menu on the left with the following items:

- 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: In-situ conservation
- Module 8: Management of changes

On the right side, there is a sub-menu for "Behavioural monitoring" with the following items:

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

At the bottom, the slide is attributed to "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

Now, these are some topics of study.

(Refer Slide Time: 31:32)

The slide is titled "Why ethology for conservation?" and contains a text box titled "Early warnings" with the following content:

The behaviour of animals often provides the first clues or early warnings of environmental degradation. This indication helps the manager to take pre-emptive steps.  
e.g. disruption in swimming behaviour of minnows indicates pesticide pollution in the water body.

The slide also features a navigation menu on the left with the following items:

- 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: In-situ conservation
- Module 8: Management of changes

On the right side, there is a sub-menu for "Behavioural monitoring" with the following items:

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

At the bottom, the slide is attributed to "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

And these are important for conservation as early warnings for making of a effective reserves..

(Refer Slide Time: 31:36)

Module 1: Introduction, Importance, Threats  
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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**

## Why ethology for conservation?

### Effective reserves

The conservation of endangered species requires that we know enough about their natural behaviours to develop effective reserves and protection measures, accommodating the natural behaviours. e.g. migratory patterns, home range size, food demands, reproductive behaviour, etc. decide which areas require protection, thus indicating the extent of conservation reserves.

Dr. Ankur Awadhiya, IFS Wildlife Conservation

(Refer Slide Time: 31:37)

Module 1: Introduction, Importance, Threats  
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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**

## Why ethology for conservation?

### Captive breeding

Basic behavioural knowledge of reproductive behaviour helps improve success of captive breeding. e.g. free choice of pair mate in biparental species helps enhance reproductive success, as in Californian condors.

Dr. Ankur Awadhiya, IFS Wildlife Conservation

For captive breeding..

(Refer Slide Time: 31:38)

The slide is titled "Why ethology for conservation?". It features a table of contents in the top left corner with modules 1 through 8, where "Module 2: Monitoring wild animals" is highlighted. To the right of the table of contents is a blue box containing the text: "Preliminaries", "Basics of sampling", "Distance sampling - I", "Distance sampling - II", "Radio-telemetry", and "Behavioural monitoring". The main content area of the slide has a blue header "Countering sibicide / infanticide" and contains the text: "Species showing sibicide or infanticide can be better managed by separating infants for their protection. Also highlights the importance of conserving males in big cats." At the bottom of the slide, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

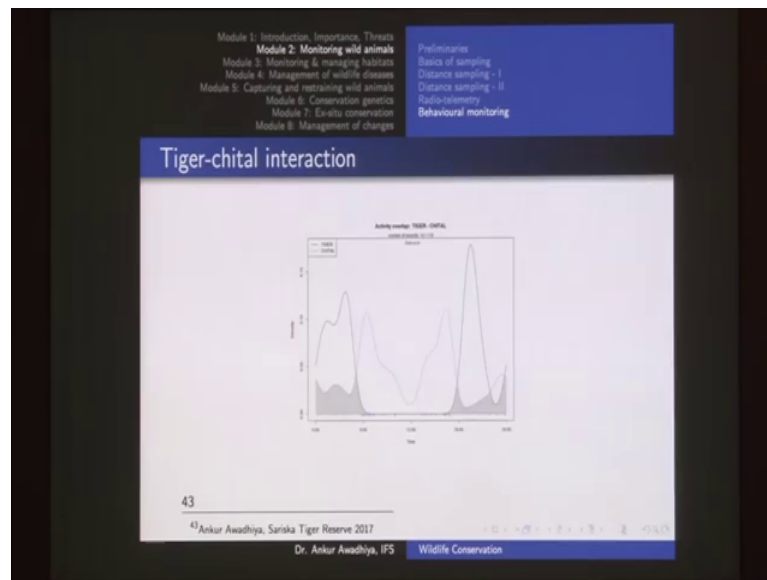
Countering sibicide or infanticide..

(Refer Slide Time: 31:39)

The slide is titled "Why ethology for conservation?". It features a table of contents in the top left corner with modules 1 through 8, where "Module 2: Monitoring wild animals" is highlighted. To the right of the table of contents is a blue box containing the text: "Preliminaries", "Basics of sampling", "Distance sampling - I", "Distance sampling - II", "Radio-telemetry", and "Behavioural monitoring". The main content area of the slide has a blue header "Utilising territoriality" and contains the text: "Nest predation and brood parasitism can be tackled by deploying territorial species for protection. e.g. pearly-eyed thrushes". At the bottom of the slide, it says "Dr. Ankur Awadhiya, IFS" and "Wildlife Conservation".

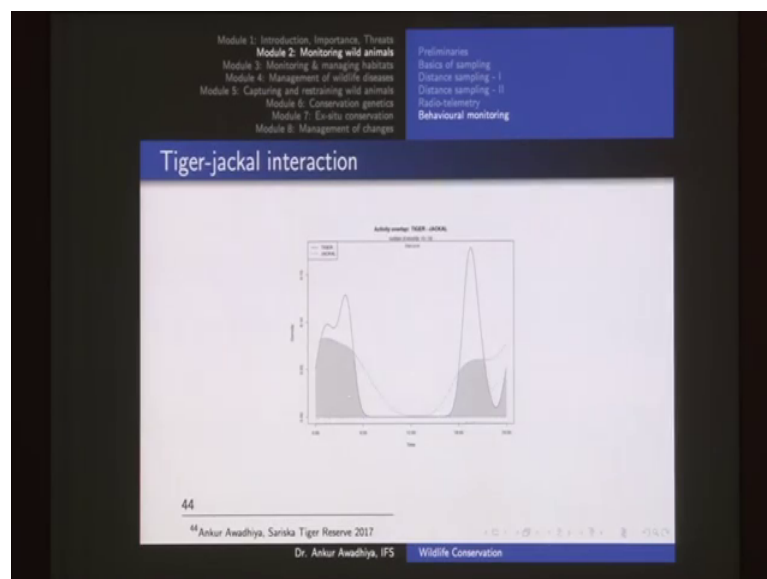
Utilizing territoriality. Now then we had reproductive separation imprinting that needs to be remove translocation, reducing human impact and as management indicators.

(Refer Slide Time: 31:54)



So, we talked about activity patterns of different animals. So here, we have a predator and a prey activity pattern. So, there is a very less amount of overlap between both of these..

(Refer Slide Time: 32:03)



But we if we look at 2 different predators then, there would be a higher level of overlap.

(Refer Slide Time: 32:07)

The slide is titled 'Ethograms' in a blue header. It contains a definition: 'An ethogram is an inventory of behaviours exhibited by an animal during a behaviour exercise.' The slide is part of a presentation on 'Wildlife Conservation' by 'Dr. Ankur Awadhiya, IFS'. A table of contents is visible in the top left, and a list of topics is in the top right.

Module 1: Introduction, Importance, Threats  
**Module 2: Monitoring wild animals**  
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Module 7: Ex-situ conservation  
Module 8: Management of changes

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

## Ethograms

An ethogram is an inventory of behaviours exhibited by an animal during a behaviour exercise.

Dr. Ankur Awadhiya, IFS Wildlife Conservation

Then ethogram is an inventory of behaviors that is exhibited by an animal during a behavior exercise..

(Refer Slide Time: 32:12)

The slide is titled 'Making ethograms' in a blue header. It lists five steps for creating an ethogram, numbered 1 to 5. The slide is part of a presentation on 'Wildlife Conservation' by 'Dr. Ankur Awadhiya, IFS'. A table of contents is visible in the top left, and a list of topics is in the top right.

Module 1: Introduction, Importance, Threats  
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Module 7: Ex-situ conservation  
Module 8: Management of changes

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

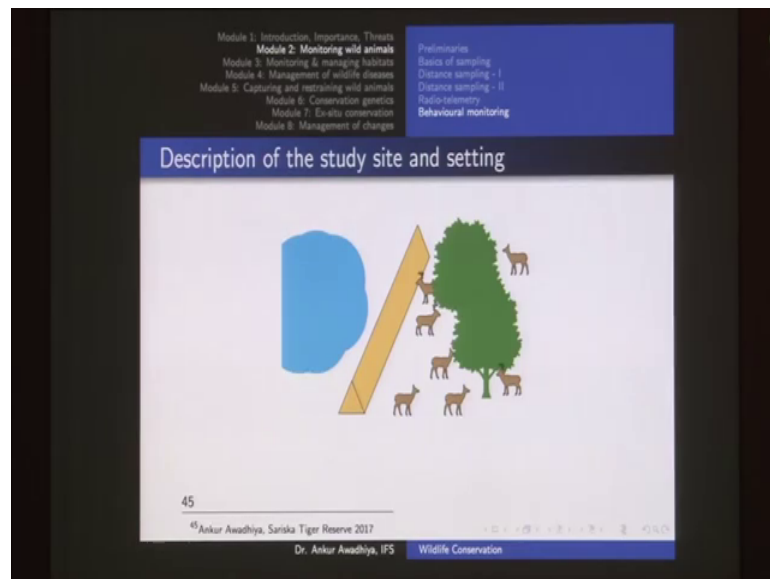
## Making ethograms

- 1 Description of study site
- 2 Defining behaviours
- 3 Scan sampling
- 4 Focal animal study
- 5 Time budget analysis

Dr. Ankur Awadhiya, IFS Wildlife Conservation

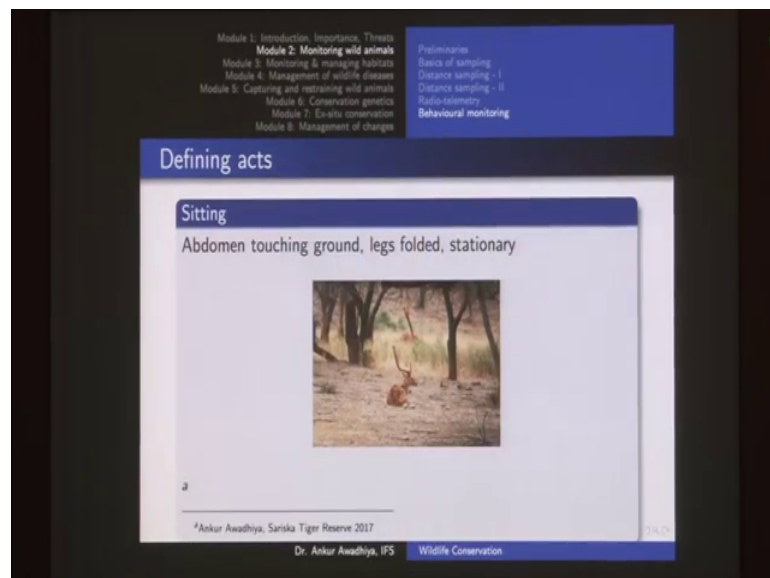
And then we talked about 2 methods.

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One is a scan sampling, one is a focal animal study..

(Refer Slide Time: 32:19)



So, we defined a number of acts such as sitting



(Refer Slide Time: 32:21)


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

### Defining acts

#### Standing

All hooves touching ground, legs straight, animal stationary, a sub-dominant interval during walking or feeding



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Standing..

(Refer Slide Time: 32:22)


Module 1: Introduction, Importance, Threats  
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Preliminaries  
Basics of sampling  
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Distance sampling - II  
Radio-telemetry  
Behavioural monitoring

### Defining acts

#### Walking

Animal moving at slow pace with at least one hoof touching ground at all times



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Walking..

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Module 1: Introduction, Importance, Threats  
**Module 2: Monitoring wild animals**  
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Module 4: Management of wildlife diseases  
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Module 6: Conservation genetics  
Module 7: Ex-situ conservation  
Module 8: Management of changes

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

### Defining acts

#### Looking

Animal stationary, ears raised in alert position, actively looking around



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Looking..

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Module 1: Introduction, Importance, Threats  
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Module 6: Conservation genetics  
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Module 8: Management of changes

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

### Defining acts

#### Feeding

Mouth towards ground, eating grass



<sup>3</sup>Ankur Awadhiya, Sariska Tiger Reserve 2017  
Dr. Ankur Awadhiya, IFS Wildlife Conservation

Feeding..

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

### Defining acts

#### Running

Animal moving at fast pace with at least some times where all hooves are above ground



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Running..

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Module 1: Introduction, Importance, Threats  
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Module 7: Ex-situ conservation  
Module 8: Management of changes

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

### Defining acts

#### Auto-grooming

Scratching or licking some part of own body



<sup>1</sup>Ankur Awadhiya, Sariska Tiger Reserve 2017  
Dr. Ankur Awadhiya, IFS Wildlife Conservation

Auto-grooming and allo-grooming. Now, auto-grooming and allo-grooming are important, because in the case of auto grooming. The animal is licking or scratching some parts of its own body. So, it is trying to clean itself or it is trying to make its appearance look better..

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Module 1: Introduction, Importance, Threats  
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Module 8: Management of changes

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

### Defining acts

#### Allo-grooming

Scratching or licking some part of other's body



<sup>3</sup>Ankur Awadhiya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhiya, IFS Wildlife Conservation

In the case of allo-grooming, it is doing this with some other animals. So for instance, when you observe an animal that is say. So for instance, if this animal had some parasites on it is body and if there is some other animal that is removing those parasite, it would also be an indication of allo-grooming because, it is grooming some other animal, whereas, if this animal had a parasite on it is own body and when it is trying to remove that parasite. So for instance: when a bird is doing a preening, so that would be called as auto grooming..

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Module 1: Introduction, Importance, Threats  
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Module 6: Conservation genetics  
Module 7: Ex-situ conservation  
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Preliminaries  
Basics of sampling  
Distance sampling - I  
Distance sampling - II  
Radio-telemetry  
**Behavioural monitoring**

### Scan sampling

In the scan sampling method, we noted the beginning time of observation, and then scanned the complete group, noting the activities that different individuals were displaying.

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

## Focal animal study

Obs: Ankur Awadhiya	Date: 06/12/2017	Weather: Cloudy
TR: Sansika	Range: Sansika	Beat: Kamikavas
Location: Water hole	Start: 15:14 hours	End: 15:47 hours
Species: Chital	Terrain: Flat	

### Individual 1: Adult male

S. No.	Behaviour	Start	End	Time spent
1	Feeding	15:14:40	15:15:05	25s
2	Walking	15:15:05	15:15:27	22s
19	Walking	15:19:30	15:20:00	30s
20	Running	15:20:00		

### Individual 2: Adult male

S. No.	Behaviour	Start	End	Time spent
1	Looking	15:24:43	15:25:59	1m 16s
2	Walking	15:25:59	15:26:09	10s
19	Walking	15:31:01	15:31:20	19s
20	Feeding	15:31:20		

### Individual 6: Juvenile female

S. No.	Behaviour	Start	End	Time spent
1	Feeding	15:41:59	15:43:20	1m 21s
2	Walking	15:43:20	15:43:45	25s
19	Feeding	15:46:45	15:46:47	2s
20	Walking	15:46:47		

Navigation icons: back, forward, search, etc.

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Now, we talked about scan sampling and focal animal sampling..

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- Module 1: Introduction, Importance, Threats
- Module 2: Monitoring wild animals**
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- Preliminaries
- Basics of sampling
- Distance sampling - I
- Distance sampling - II
- Radio-telemetry
- Behavioural monitoring**

## Time budget table

Table: Summary of times spent by individuals on different activities

Activity	Individual 1: Adult male	Individual 2: Adult male	Individual 3: Sub-adult female
Feeding	135s	151s	71s
Walking	135s	43s	35s
Looking	20s	3m 21s	39s
Running	0	0	0
Auto-grooming	0	2s	0
Standing	30s	0	0
Time spent	5m 20s	6m 37s	2m 25s

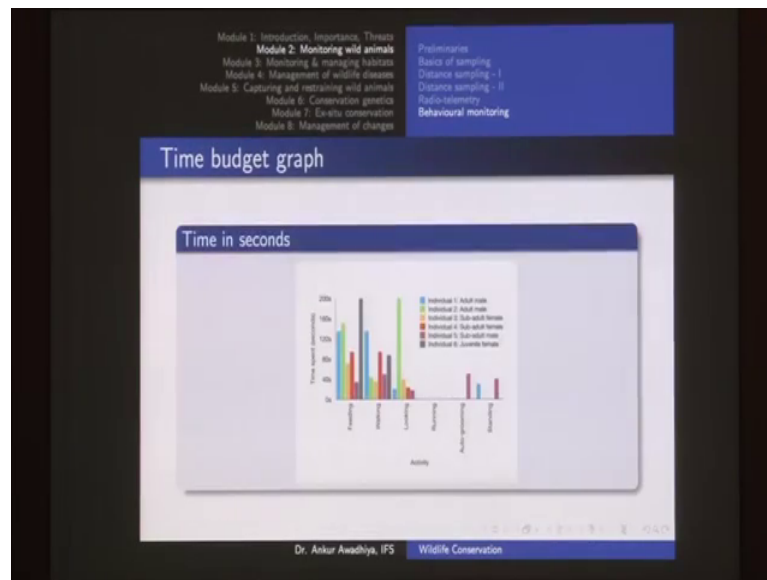
  

Activity	Individual 4: Sub-adult female	Individual 5: Sub-adult male	Individual 6: Juvenile female
Feeding	94s	34s	3m 21s
Walking	94s	49s	87s
Looking	23s	17s	0
Running	0	0	0
Auto-grooming	0	50s	0
Standing	0	40s	0
Time spent	3m 31s	3m 10s	4m 48s

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Wildlife Conservation

(Refer Slide Time: 33:14)



Time budget graph.

(Refer Slide Time: 33:16)

Some observations

- 1 Dominant behaviours: feeding, walking, looking
- 2 Juveniles spend less time looking than adults and sub-adults, possibly because of parental protection
- 3 Sub-adult male spent considerable time in auto-grooming

In this way, ethograms and time-budget analyses can help us record and understand the behaviours of animals.

Dr. Ankur Awadhiya, IFS Wildlife Conservation

And then, you also looked at what kinds of observation we can make? So for instance, we can look at dominant behaviors. Behaviors that are different between different age groups or may be different positions of animals, the animals that are closer to the periphery, the animals that are closer to the core area, then sub adult males. So, differences between sub adults and adults. So, all these things are things that can be observed using behavioral monitoring.

So, let us end it here. So, this is the first part of the revision class and tomorrow we will move up with the other lectures.

Thank you for your attention. [FL].