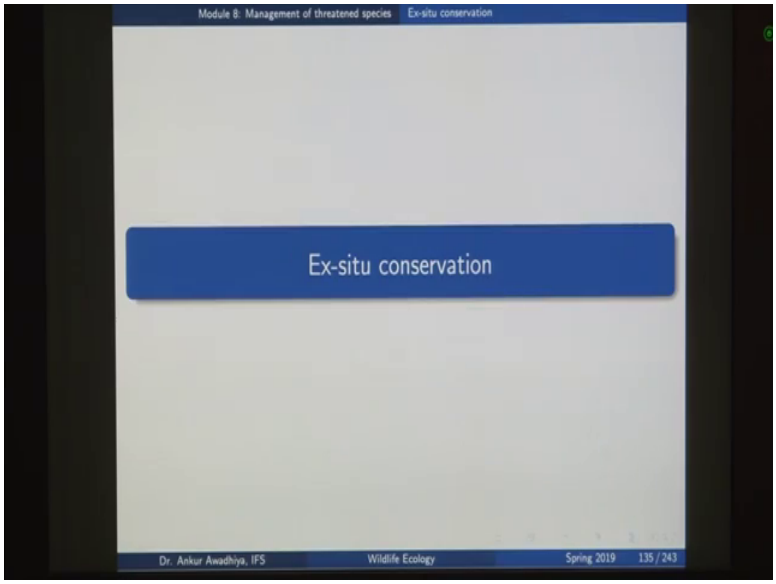
Wildlife Ecology
Dr. Ankur Awadhiya
Department of Biotechnology
Indian Institute of Technology, Kanpur

Lecture - 24
Ex-situ conservation

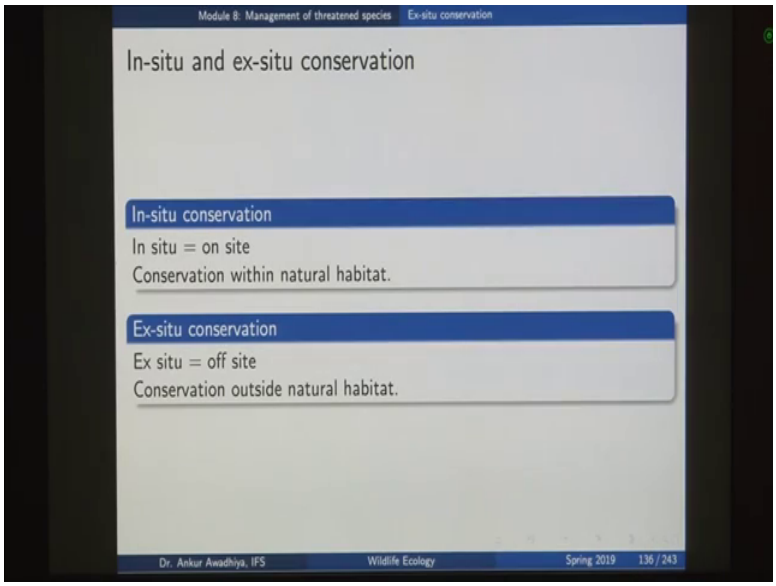
[FL]. We move forward with management of threatened species.

(Refer Slide Time: 00:19)



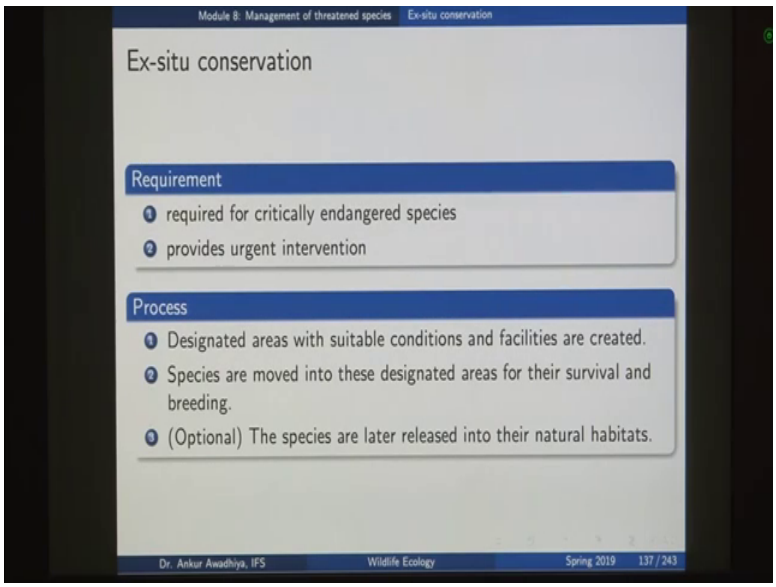
And today, we will have a look at Ex situ conservation.

(Refer Slide Time: 00:20)



Now, we looked in the previous lecture at the differences between in situ and ex situ conservation. Now, in situ as we learn first onsite conservation; conservation within the natural habitat such as construction of reserves national parks or by life sanctuaries. And ex situ conservation is conservation that is off site outside the national environment such as zoos or aquarium.

(Refer Slide Time: 00:46)



So, if we have in situ conservation option that is available with us, why should we go with ex situ conservation? What is the requirements of setting up an example situ

conservation facility? Well, it is required for critically endangered species that require a very heavy amount of attention, because we have very few number of individual that are left, because it provides urgent intervention to these species.

Now, for instance if you have a species that has say around 20,000 individuals left in the world. So, you probably will not require an ex situ conservation facility to conserve that particular species, because that can be taken care of by the in situ conservation facilities. But, suppose you have an individual that has only around 15 individuals that are left in the wild.

Now, those 15 individuals cannot be left in the wild, because in absence of a very large amount of attention to those species, probably those 15 individuals would die off in a very short period of time. Because, probably there are people who want to poach those animals a very good example is that of German rhinoceros. So, we have these rhino we had these rhinoceros rather in Java and such huge was the demand to poach these animals that even though we had very few numbers left. And it was very extensively documented that we have very few numbers people went there and continued the poaching.

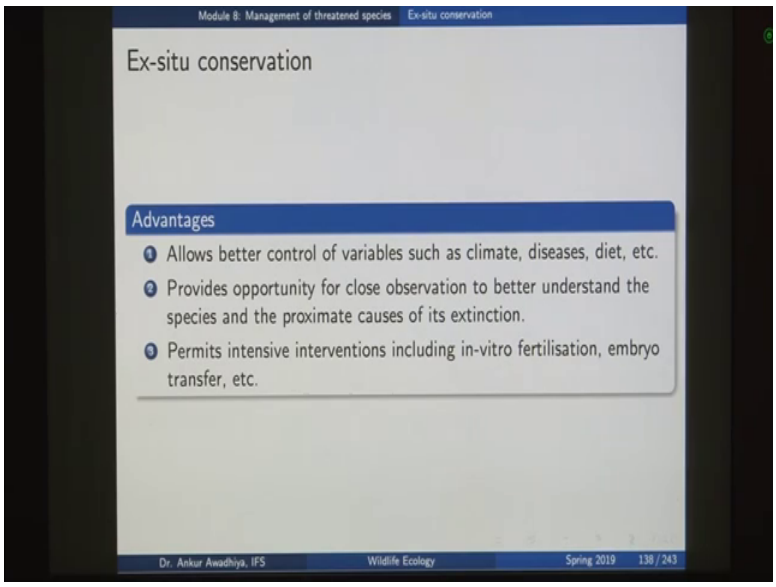
Now, in the case of ex situ conservation, we can take some of these individuals out, and we can give them an extra amount of protection in an extra amount of care we can protect them from all different diseases. So, that at least this species continues to survive. At the same time ex situ conservation also is required so, that you can bring in more funds for the cause of conservation.

So, for instance if people come into a zoo if people get can come to an aquarium and see that there are so, many varieties of fishes that are there are available in this world. So, people would get encouraged towards the cause of conservation. They would become champions of conservation themselves just by observing all these different species. So, that is also another importance of setting up an example situ conservation facility.

Because for those species that are living, very deep inside the forest or very deep inside the oceans it becomes very difficult for a large population to go and visit those species to know more and more about those the species. But, if you can bring some individuals out then they also get a chance to see those individuals.

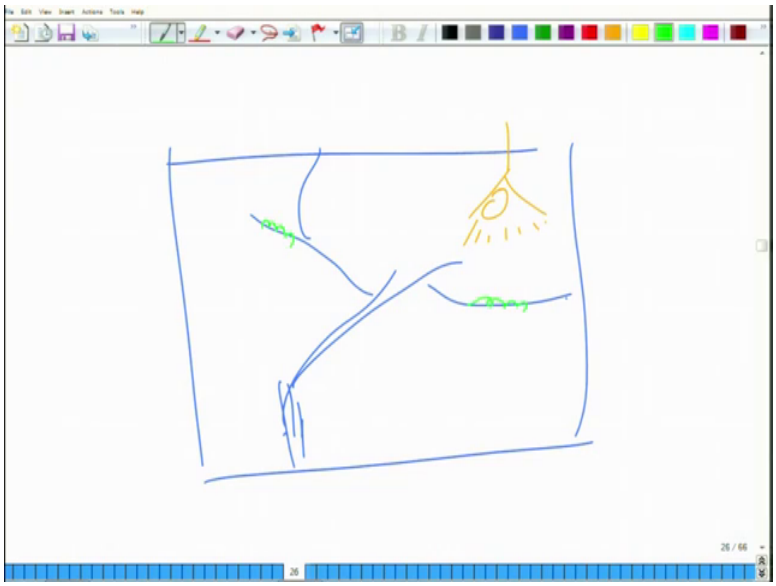
So, what is the process of setting up an example situ conservation facility? Well, first you designate areas with suitable conditions and facilities are created for in those particular areas, then these facilities include things such as feeding, enclosure, veterinary support and so on. Then, you select certain individuals of these species, move them into these designated areas for their survival and reading and if necessary after a while some individuals of these from these conservation facilities can be then taken out and then released into the wild in the in situ conservation areas. So, that is an optional step that can be done in certain situations.

(Refer Slide Time: 04:05)



Now, example ex situ conservation provides certain advantages especially over in situ conservation. It allows better control of variables such as climate, disease, diet and so on. So, for instance if you have a snake species, snakes prefer to live in environments that are neither too hot nor very cold. So, in a snake facility in herpetarium.

(Refer Slide Time: 04:30)



You will see that there is this chamber and this chamber would probably have a small light bulb here. Now, this light bulb not only provides light, but it also provides quite a lot of warmth to the animal, then you will have certain so, some small trees that would be growing here with lots of branches. So, that if you have so, if this particular snake wants to live in a more warmed environment, so, it will probably come and reside here, if it wants if it does not want the warmth it will probably go and reside here.

So, in a very small area you can provide all different sorts of facilities to the animal, different temperature control you can even have things such as humidity control in this area. So, it should not be a very wet, because if it is very wet then probably your snake might get might start getting some fungal infections. It must not be very dry; because in that case it is a skin might start getting cracked. So, in this very small area, you can give a very good amount of climate control.

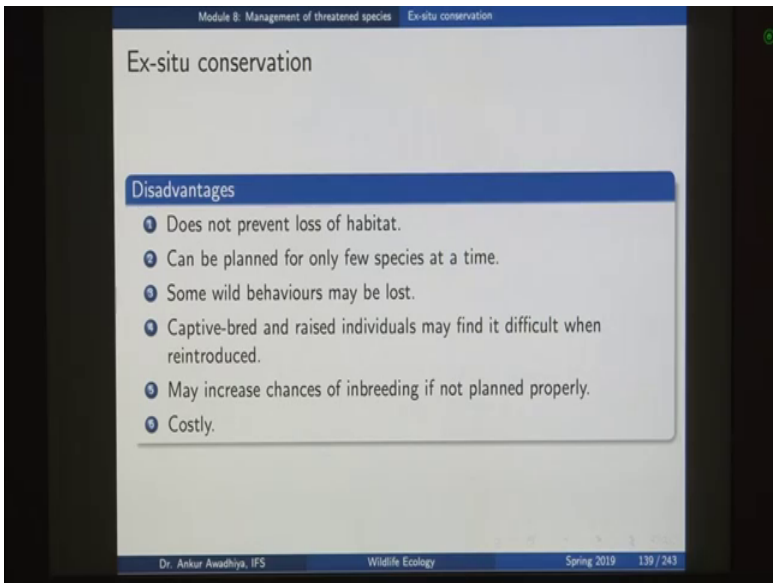
Second, you can have a very good control over diseases and diet. So, you can ensure that your animal is neither overfed nor is it underfed. You can also ensure that your animal is not suffering from any diseases, it does not have any ectoparasites on it is body. So, probably a betaine alien would go and observe these snakes and if there are ectoparasites on it is body. Then, probably it will be given some treatment for that. And that is very crucial if you have very few number of snake of that particular species that are left in the world. So, they need to be given more amount of attention and care.

Secondly, it provides opportunity for close observation to better understand the species and the proximate causes of it is extinction. So, proximate causes are those causes that are nearby, so, the near causes of it is extinction. So, for instance you can observe that in this small area, you see that these particular snakes hunt at say a very particular time.

Suppose, these snakes have a behavior, that they are only doing their hunting say 4 to 5 in the evening. And if that happens and we observe that we have observed this behavior here in the in situ in the ex situ conservation facility, then we can make a correlation that are in situ conservation facilities such as the reserves are not providing good habitats for this particular species. Because, we have our tourists enfold during 4 to 5 pm. And if that be the situation the learning's from the example situ conservation facility, the learning's about the behavior of the species can then be used in the in situ conservation facilities as well. So, that is another advantage of setting up in ex situ conservation facility.

Third it permits intensive interventions including in vitro fertilization, embryo transfer and so on. So, these are intensive interventions. Even, in the case of this particular snake you might go and have a collection of it is eggs collection of the embryos, you might try to put them into hatcheries, you can give individual attention to all the offspring's. So, this is the utility of setting up an ex situ conservation facility or these are the advantages.

(Refer Slide Time: 07:36)



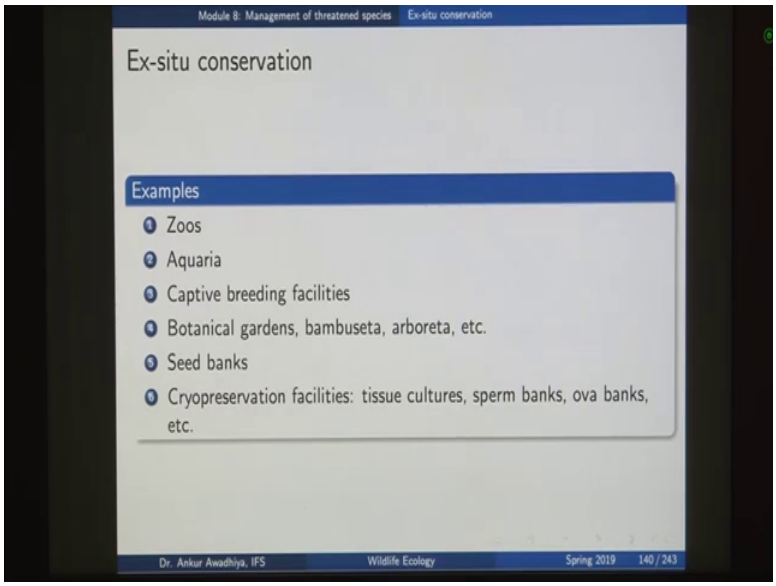
At the same time, the ex situ conservation facility also has a number of disadvantages. It does not prevent loss of habitat, because you are conserving these species in this very

small area, but then it is possible that it is original habitat, gets lost during the process. So, you are conserving these individuals, but the whole habitat became lost and so, now, these animals are destined to live in ex situ conservation forever, because they do not have any habitats left at all.

Second it can be planned for only a few species at a time, it is extremely cost intensive. You cannot have an example situ conservation facility for all the species that are found in a natural habitat. Only a few of them can be brought and given suitable conditions and studied and kept in there ex situ conservation facility. Some wild behaviors may be lost, because even in the case of your snake the snake would not learn how to catch it is prey in the wild situations. Because, it is getting mice that are kept into its chamber at fixed times every day or your tiger might not even learn how to hunt, because it is getting a dead animal that is added carcass that is kept into it is enclosure every day. So, a number of wild behaviors get lost in this process.

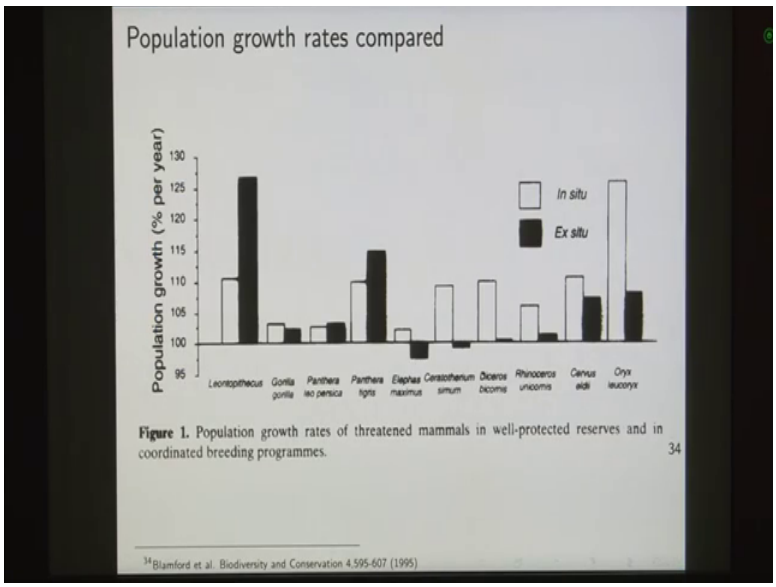
Captive bred and raised individuals may find it difficult when reintroduced, because they have lost a number of their behaviors, it may increase chances of inbreeding if not planned properly. Because, you only have a few number of individuals that are kept in the ex situ conservation facility, again because it is costly and it requires space and it requires a very huge amount of interventions. So, if you have a few number of individuals the mating between those might lead to inbreeding and then as expectedly, it is extremely costly.

(Refer Slide Time: 09:22)



The examples of ex situ conservation include zoos, aquariums, captive breeding facilities, botanical gardens, bambuseta; bambuseta are areas where different bamboo species are grown, arboreta where different tree species are grown, seed banks, cryopreservation facilities, that cater to tissue cultures, sperm banks, ova banks and so on. So, these are all different examples of ex situ conservation facilities.

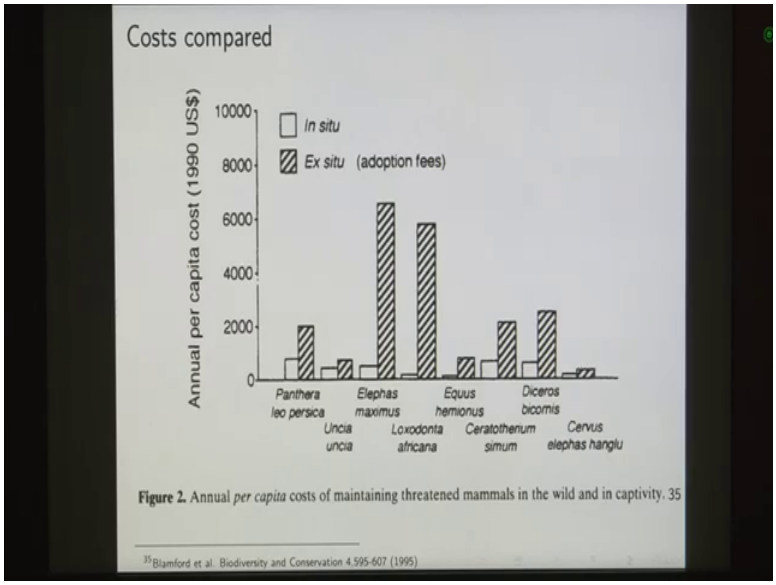
(Refer Slide Time: 09:51)



Now, it is not possible or it is not worthwhile to have an ex situ conservation facility for all the species. So, for instance in this particular paper compared the population growth rates in situ that is in white and in ex situ that is in black conditions for different species.

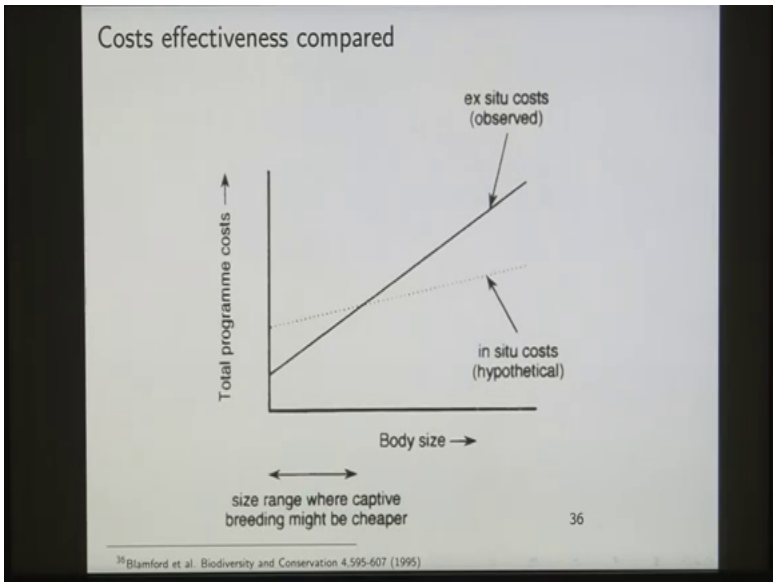
Now, here we observe that for certain species, we see that the example situ conservation facility provides a better environment for the animals. Because, the growth rate in ex situ is much greater than that in the in situ conditions. Whereas, in certain organisms the in situ growth rate is much greater and when you put the animal in an ex situ conservation facility, it does the population does not grow as fast. So, it does not make any sense to keep this animal in the ex situ conservation facility, you will have to go for the in situ conservation facility only.

(Refer Slide Time: 10:39)



Besides, if we compare the cost between in situ and ex situ conservation, we find that normally the cost for the ex situ conservation facility is much greater. For some organisms it is a little greater for some organisms, it is very high whereas, for some organisms it might even be lesser in certain circumstances. So, if you have a very small species. For example, if you have a species of rodents you can grow them in this particular room itself whereas, in the while you would require a forest that needs to be used for that particular purpose.

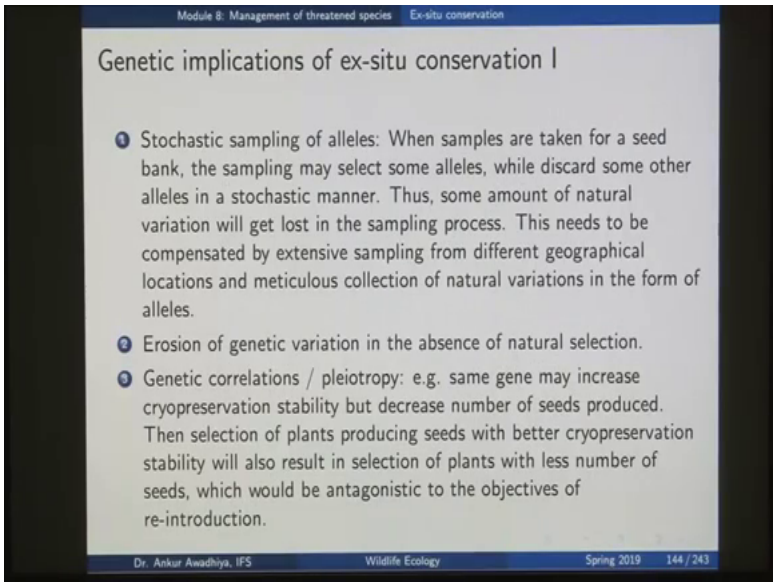
(Refer Slide Time: 11:16)



So, if you compare the cost; the cost have a lot to do with the size of the organism. For organisms with a low body size, the ex situ costs are typically lesser than that of the in situ cost. Whereas, for larger sized organisms the ex situ cost are much greater than that of the in situ cost.

So, typically we can say that this is the size range within which your captive breeding might be cheaper. And in these circumstances if the organism is responding well to captive breeding then ex situ conservation makes a lot of sense as compared to in situ conservation.

(Refer Slide Time: 11:50)



However, we need to note that there are certain genetic implications of ex situ conservation. When is stochastic sampling of alleles, when samples are taken for a seed bank for instance, the sampling may select some alleles while discard some other alleles, in a stochastic manner, in a random manner or in a chance manner. Thus, some amount of national variation will get lost in the sampling process, this needs to be compensated by extensive sampling from different geographical locations and a meticulous collection of natural variations in the form of alleles.

So, what this is saying is that for different organisms, you have some amount of variation that is present between different individuals of the species. So, for instance even in our case different human beings will have different heights, they will have different skin color, different eye color, different color of the hair and so on.

Now, if you are selecting a few individuals for your ex for your ex situ conservation facility, then because by definition it is a very costly process and because by definition you are constrained by the size and you will only keep a very few number of individual into your ex situ conservation facility. So, when you are selecting individuals, then probably are a number of traits will get lost.

So, for instance in the case of tigers, if you look at tigers of Sundarbans; Sundarbans is a very marshy area and tigers have to do a lot of swimming. And so, it is typically seen

that the tigers there are much lighter. As compared to tigers of Madhya Pradesh, which live predominantly in a very dry environment and they also have a very large body size.

Now, if you had if you set up in ex situ conservation facility for say tigers and if you only selected tigers from Sundarbans or only selected tigers from Sundarbans, then the other variations that are present in the national population will get lost. Now, to compensate for that it is essential that, you go out and look at different variations that are present in the population and make an active attempt to bring all those variations into your ex situ conservation facility.

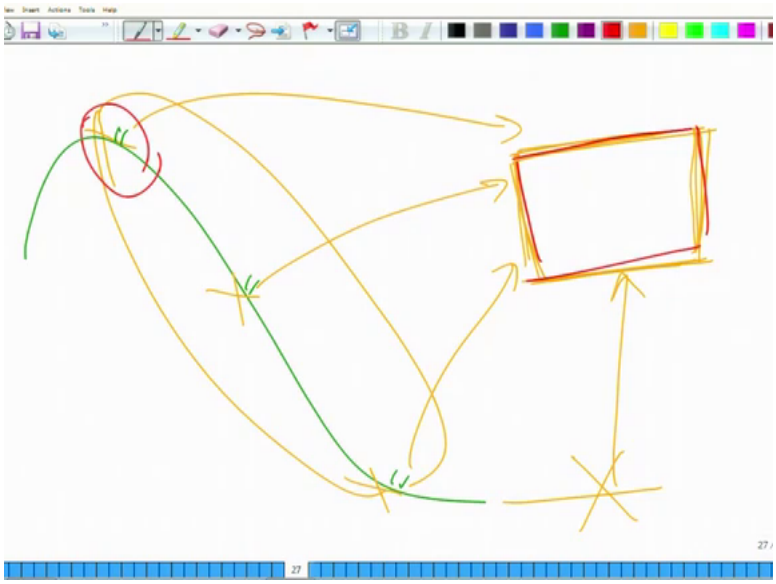
So, that is one generating implication. The second is that you observe erosion of genetic variation in the absence of natural selection. So, in the ex situ conservation facility all the individuals are getting sufficient food, all the individuals are getting sufficient care veterinary care, medicines and so on. So, there would be some amount of genetic variation that becomes lost because you are not actively selecting for those genetic variations as is done in the case of natural selection.

So, for instance in the case of tigers, the natural selection would select for those individuals that are able to hunt properly. Whereas, if you keep your animals in the zoo generation after generation because you are not selecting for those particular variations some of those variations might get lost, after a few generations.

Third is genetic correlations of pure trophy some gene for example, same gene may increase a cryopreservation stability, but decrease the number of seeds produced. Then selection of plants producing seeds with better cryopreservation and stability will also result in selection of plants with less number of seeds, which would be enter going straight to the objectives of reintroduction.

What it says is that when you are setting up an ex situ conservation facility, then the environment that you are providing to the organisms in the ex situ conservation facility are very different from what you are providing in the in situ conservation facility or in their natural habitat.

(Refer Slide Time: 15:24)



So, for instance if you have a plant that is formed in different heights in the mountain, and suppose you are setting up an example situ conservation facility in this particular area. Now, what you are doing is that you started by looking at different variations, you brought all of these plants into your area and then you started growing them. So, you brought these seeds you went ahead and planted those in your ex situ conservation area, and then you took out those plants that were giving out the largest number of seeds and then you store those seeds.

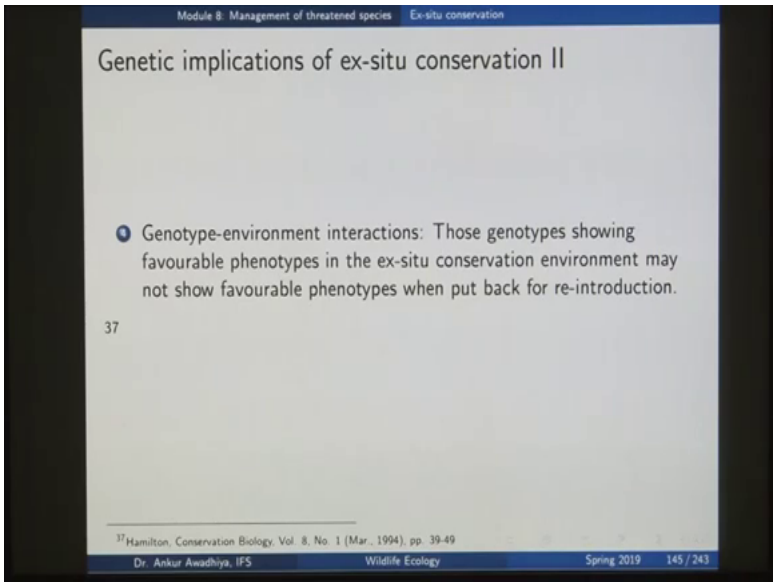
Now, what happens in that case is that because you could you can have a trait, that is regulating the number of seeds that is being produced by the plant and is probably also regulating some other trait. So, by selecting for those plants that are giving out more number of seeds, you are also selecting for some other trait.

Now, that some other trait might not be useful for the plant in a natural conditions. So, probably when you were doing an in situ conservation. So, that particular trait was not being selected, that was not useful to the plants, but when you are shifting it to the ex situ conservation facility. So, in that case that particular trait is now getting selected, because of the pure tropic effect, because the same gene is regulating more than one traits in this organism.

So, if we have a situation of pure tropic then it is possible, that we might be selecting for those traits that are not useful to the plants in the in situ conservation scenario or in the

national habitat. So, later on when we use these seeds and we plant them out in the natural habitat to restock the population, then it is possible that all of these plants would die off. So, that is also another genetic implication of ex situ conservation.

(Refer Slide Time: 17:12)



And the fourth one is the genotype environment interactions. Those genotypes showing favorable phenotypes in the ex-situ conservation environment may not show favorable phenotypes when put backward re-introduction. So, like coming back to our example of these plants that were growing in the hills. Now, probably the environment that you have here is very much correlated with the environment, that you have in this particular area.

Now, your plants grow in these areas, they are not growing in this area. Now, when you are taking these seeds out and you are growing them in your ex situ conservation facility, then it is possible that we are only selected for selecting for those plants, that are able to grow well in this particular environment and not in these particular environments.

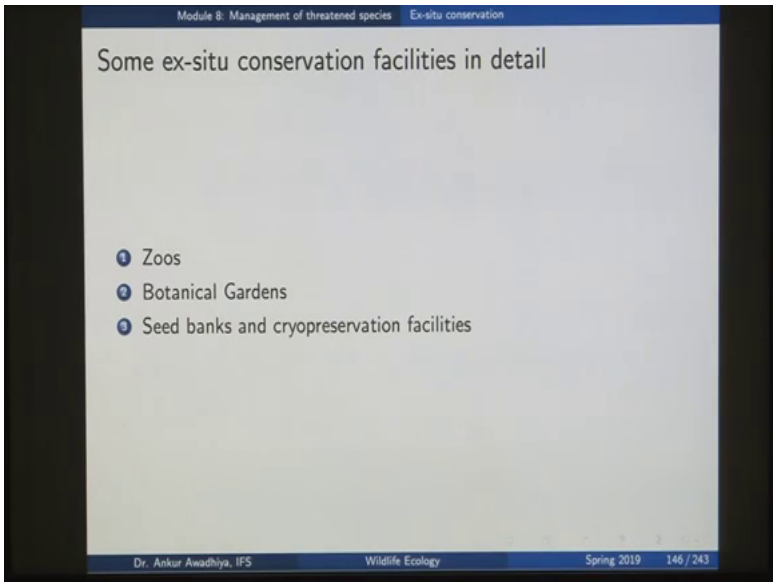
So, later on when you put your plants back into the wild it is possible that they might not show good results, which is because of the genotype environment interactions. So, those genotype types showing favorable phenotypes in the ex-situ conservation environment may not show favorable phenotypes when put back for re-introduction.

It is also possible that when you are looking for say seeds, you are looking for seed production; you want to have those plants that are you know about the most amount of

seeds. When, you are putting them into your environment of ex situ conservation, then they then the number of seeds that are being produced by every individual is very different from one what it would have produced when it was there in it is natural habitat.

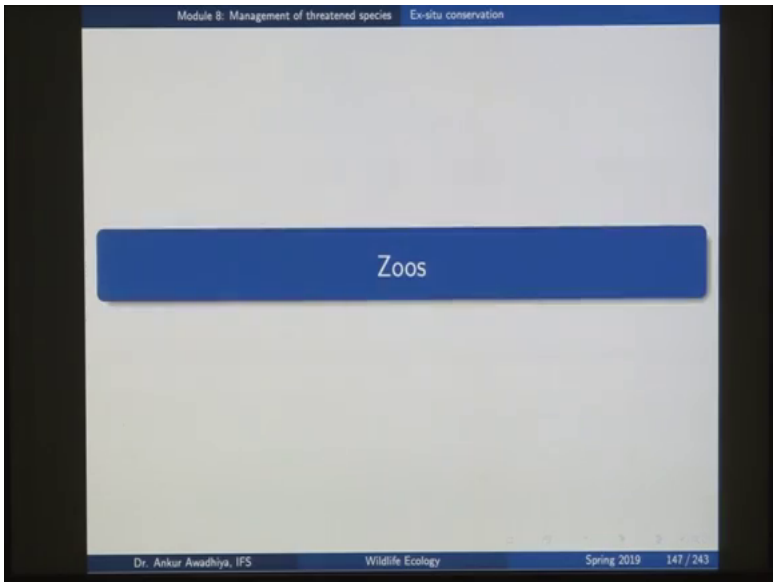
So, by because of this genotype environment interaction you might be selecting for a wrong individual or an individual that is not the best fit for release when it is released back into the environment. So, that is also another implication.

(Refer Slide Time: 19:04)



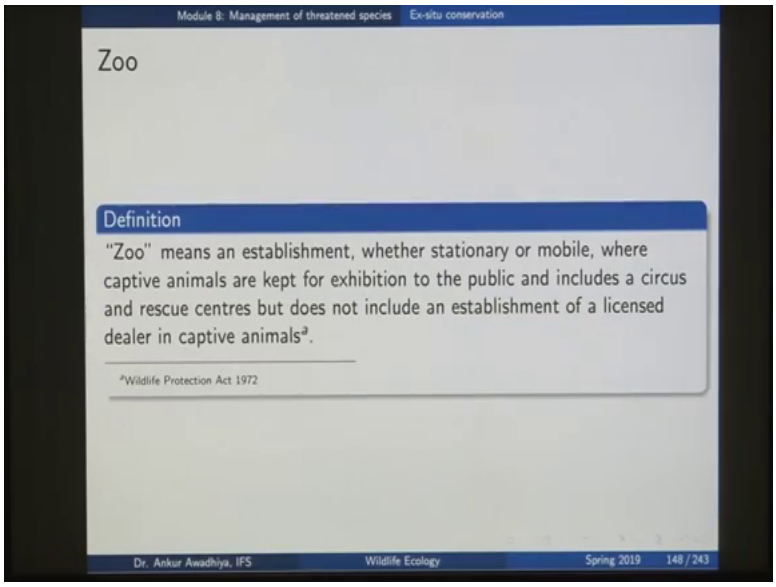
Now, we will look at three ex-situ conservation facilities in detail. These are zoos, botanical gardens, and seed banks and cryopreservation facilities. To understand what these example situ conservation facilities are how do they work what do we do there?

(Refer Slide Time: 19:17)



So, we begin with Zoos.

(Refer Slide Time: 19:20)



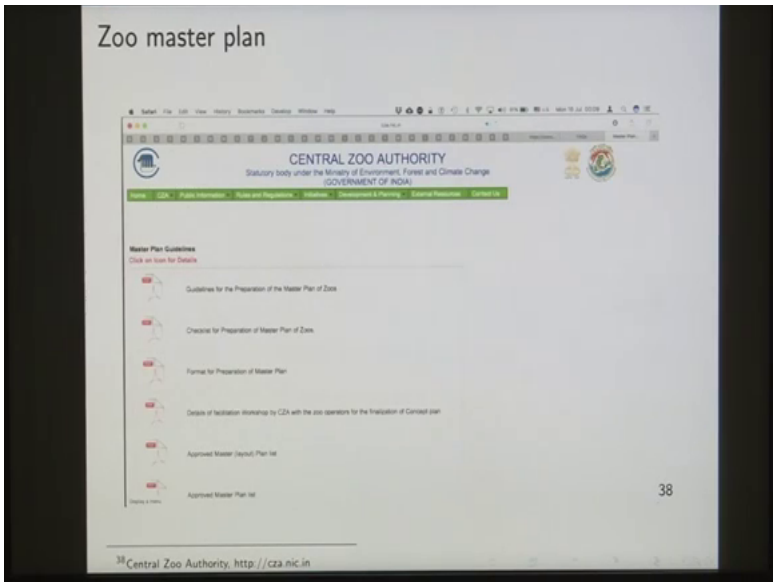
Now, zoos are defined as, "zoo" means an establishment, whether stationary or mobile, where captive animals are kept for exhibition to the public and includes a circus and rescue centers, but does not include an establishment of a licensed dealer in captive animals. Now, this is the definition of zoo under the wildlife protection at 1972.

So, zoo is any establishment, it can be stationary or it can be mobile. So, you can even have mobile zoos where animals are taken from one place to the other place. And in this

establishment captive animals are kept for exhibition to the public. So, the main purpose is to show them to the public and it includes a circus and rescue centers.

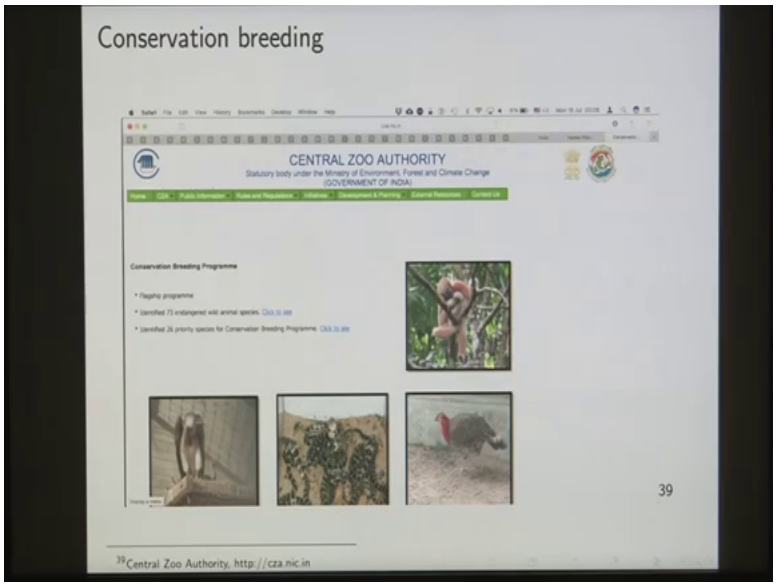
So, if you have a circus by definition is a zoo and will be regulated by the same rules as govern the zoos and it also includes the rescue centers. So, rescue centers are areas where you bring animals that are say diseased or say that are suffering from some injuries or that have strayed out and you bring them into an area to treat those animals and probably later release them into the wild or probably keep them there in captivity for a very long time. So, rescue centers are also zoos under this definition. And it does not include an establishment of a licensed dealer in captive animals.

(Refer Slide Time: 20:49)



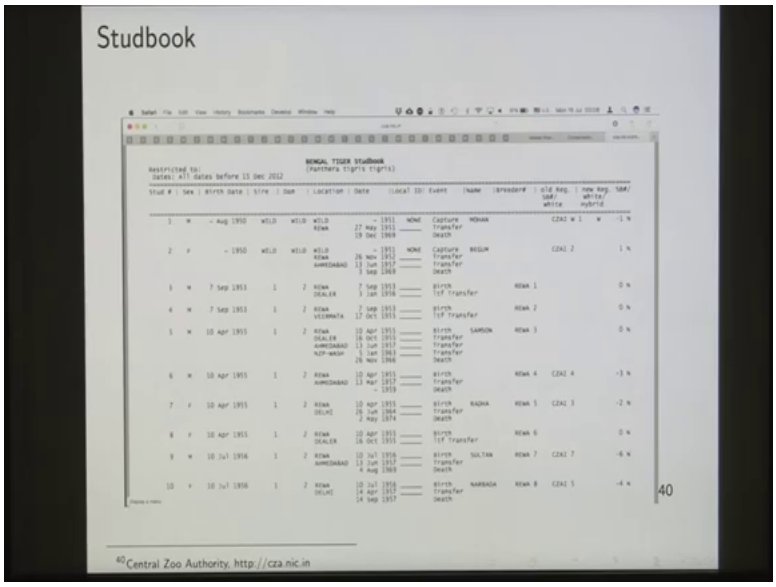
Now, zoos are governed using master plans. So, master plan is a document that will tell you what are the facilities that are available? What are the objectives of management and what are we and how are we going to attain those objectives of management?

(Refer Slide Time: 21:07)



So, zoos are governed under master plan. A number of zoos are involved in conservation breeding. So, conservation breeding is where you do some amount of captive breeding of the animals to conserve their species.

(Refer Slide Time: 21:21)

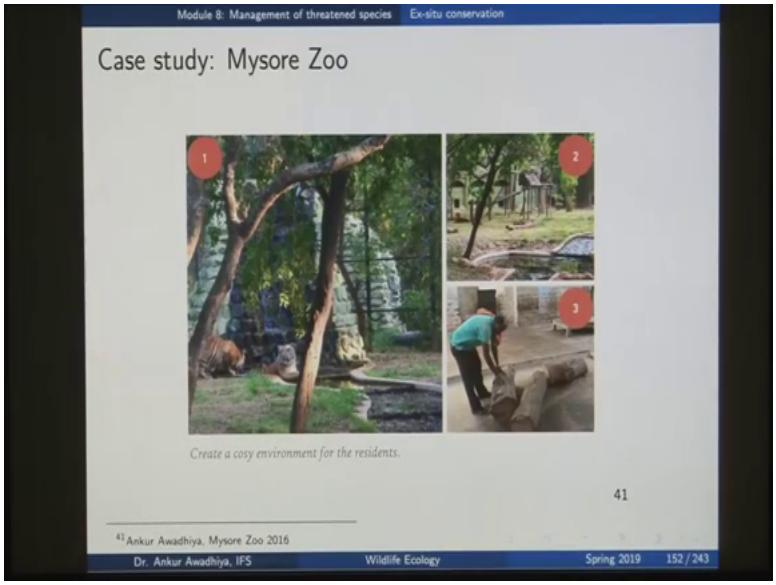


And for these conservation breeding's there are also stud books that are maintained. So, stud book is a document that tells you, the genetic ancestry of any particular individual. Now, these are important to ensure that you do not breed between individuals that are very closely related to each other.

So, to prevent situations of inbreeding depression you maintain these documents, which tell you that for any particular individual who was it is mother, who was it is father, who were was the mothers, relatives, I mean. So, in the case of the mother who was the father of the mother who was the mother of the mother, in the case of the father who was the mother of the father who was the father of the father and so on.

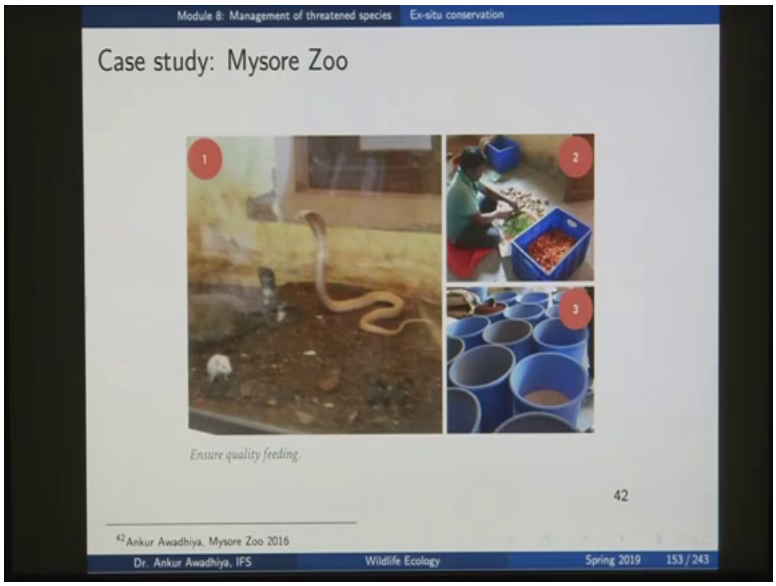
So, it maintains a genetic ancestry of all the animals. And so, if you observe, if you want to conduct captive breeding between 2 individuals and if you find that both of these individuals, share a share an ancestor in the near past, so, in that case you will not go for a breeding between these individuals. Now, as a now to understand what we do in a zoo we will look at the case study of Mysore Zoo.

(Refer Slide Time: 22:28)



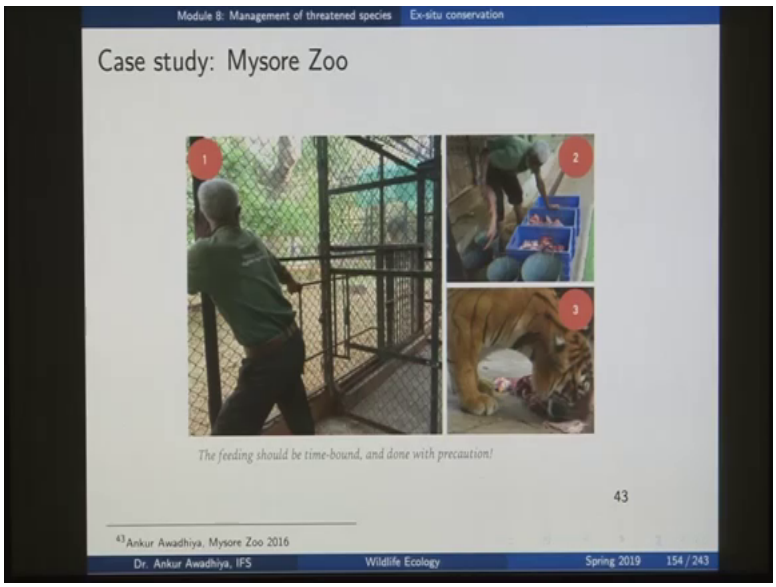
Now, in a zoo the animals are provided with conditions that best suit their requirements and that best suit their behaviors. For instance in the case of these tigers, they are given a plain area that has ample number of trees to provide shade, that has these grasses, that has this waterfall to provide cooling comfort. In the case of their enclosures they are given these logs. So, that they are scratching behavior that they normally show in the wild to mark their the territories and so on are also maintained in these areas.

(Refer Slide Time: 23:02)



Feeding is a very important part of maintaining a of maintaining any animal and so, like these cobras are being given these white colored mice that are bred for this for this purpose, then you also maintain a very good amount of sanitation in your area. So, that all the fruits and vegetables that are brought for different animals are washed, cleaned, cut and then served to the animals.

(Refer Slide Time: 23:31)

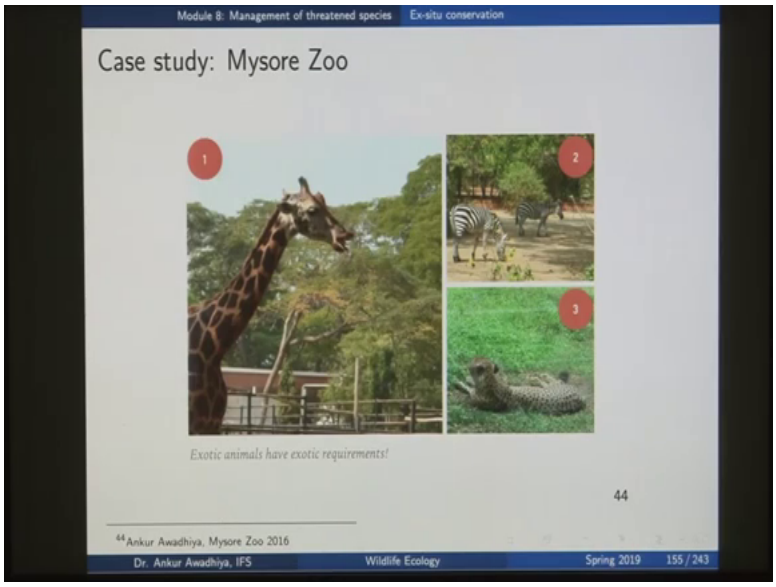


And then feeding is done in a very timely manner and it is done with a lot of precaution. So, this is showing this, this is the outer portion of the inclusion of a tiger and here we

have this gate and this person is opening up this gate so, that the animal can get inside. And inside you have already put the meat that needs to be given to the tiger. So, when you open this gate from outside, the animal is able to reach to the inside room and is able to feed.

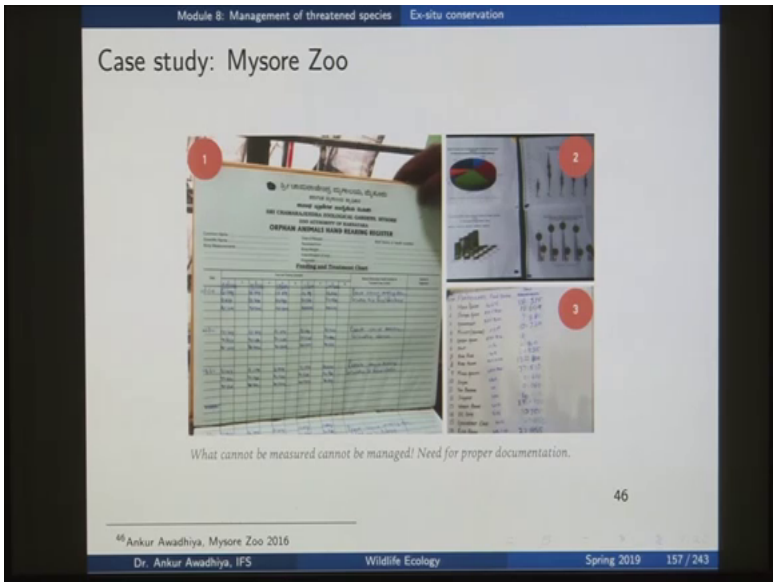
Now, these feeding times the amount of feed that needs to be given the timing of the feed, the regularity of the feed, all are very carefully governed in a zoo.

(Refer Slide Time: 24:11)



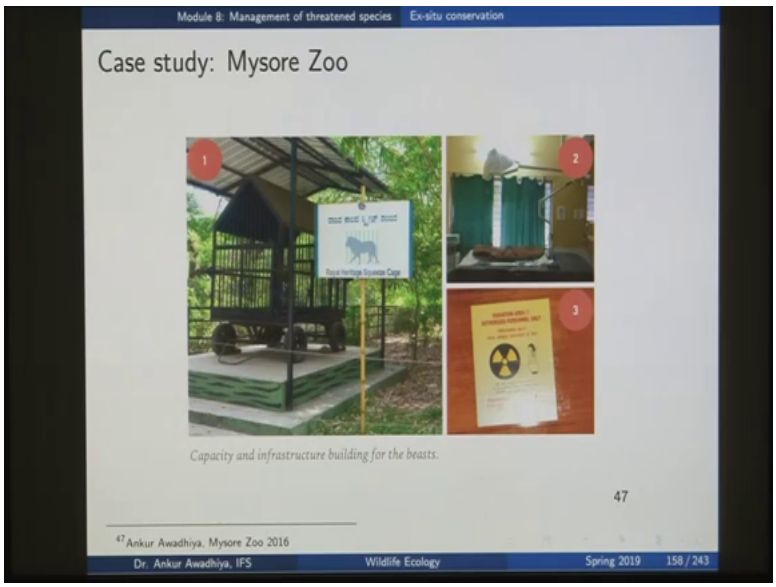
And this is done not only for the indigenous animals, but also in the case of exotic animals, they have very exotic requirements. So, a number of plants that a giraffe eats are may not be available in India. So, giraffe might be given some special food too care of it is territory requirements, similarly for zebras for cheetahs and so on.

(Refer Slide Time: 24:33)



And all of these are maintained in the form of a documentation. So, the feed charts will be maintained, when an animal was treated in a veterinary facility, what was it treated for what kinds of diseases did it have what are the kinds of vaccinations that are given to this and when are all properly documented.

(Refer Slide Time: 24:54)

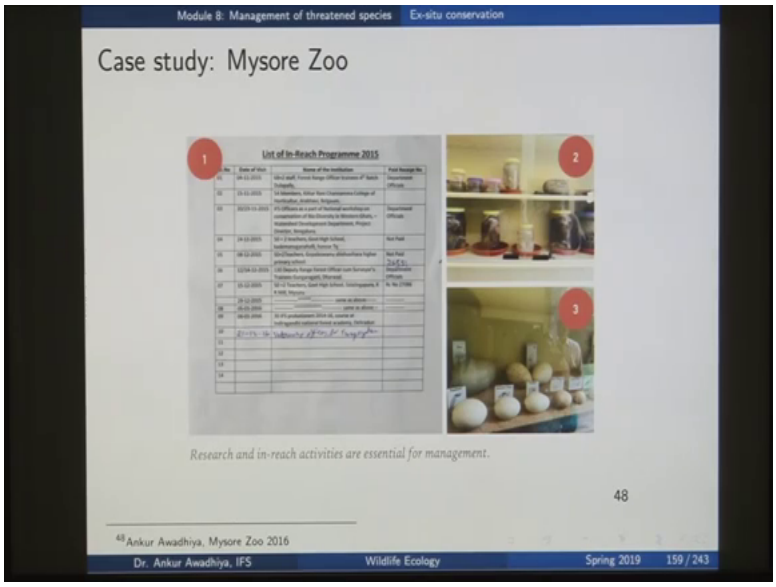


And then you also have a number of facilities for providing better veterinary care to these animals. So, we looked at this example of a squeeze cage. So, in a squeeze cage the animal is brought inside to this cage and then these balls are then moved together. So,

that the animal gets squeezed between the walls and then you can very easily handle this animal, if you want to take out a blood sample for laboratory analysis or if you want to give it some injection of an antibiotic or so on.

So, it can be handled in that way. You also have facilities for doing X-rays of animals for performing surgeries on these animals, you have an operating theatre and so on. So, all these different facilities are maintained for the benefit of these animals.

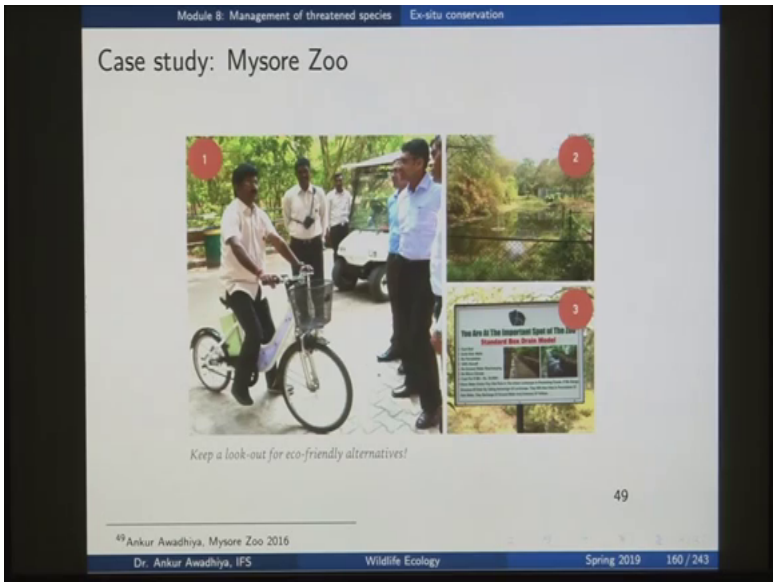
(Refer Slide Time: 25:40)



Then, not only are these animals provided with these facilities, but also their behavior is also studied in these ex situ conservation facilities. So, research becomes an integral part of in ex situ conservation facility. So, that we learn more and more about these animals and these learning's can be made use of in the in situ conservation facilities as well. And not only is research done, but at the same time enrich is also done.

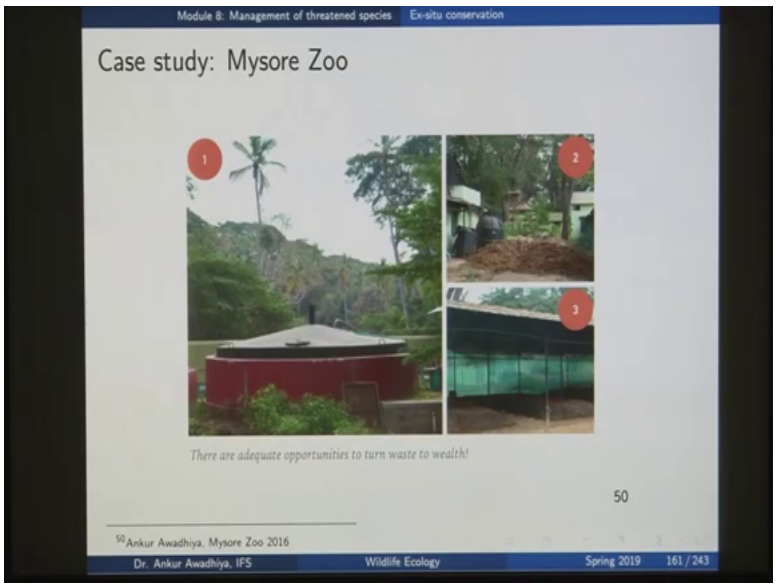
So, you also call experts from different areas and you ask them what more can be done for these animals, you also maintain a number of samples for these animals. So, a number of embryos that were aborted or the shells of the eggs of different birds from which the young ones have had they are also kept here in a curated manner.

(Refer Slide Time: 26:31)



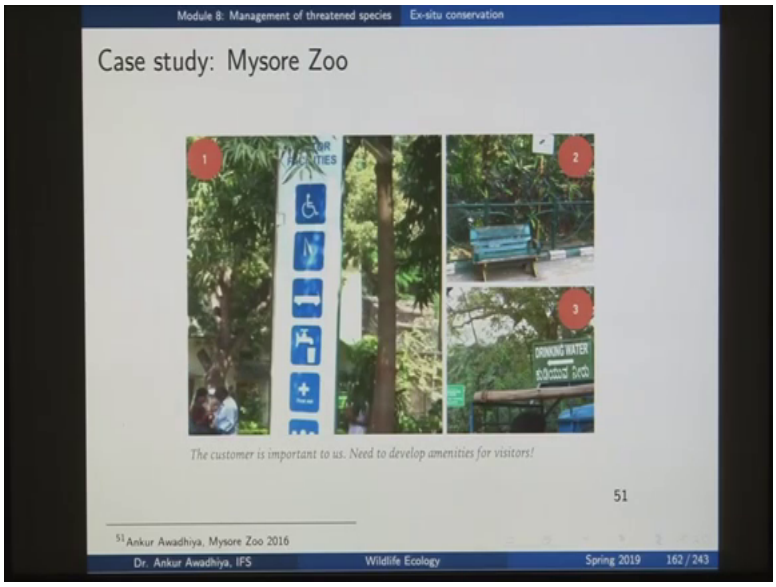
At the same time ex situ conservation facilities play a very important role as areas where we can look out for ecofriendly alternatives. So, the they also become areas for experiment, if you observe that there is certain some ecofriendly mode of transport that you can use in these areas and probably some of these learning's can also be translated back into the in situ conservation facilities.

(Refer Slide Time: 26:55)



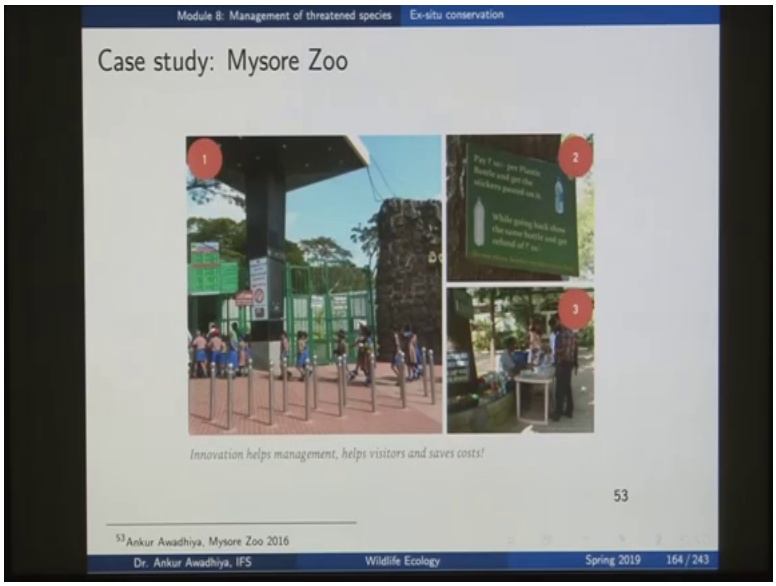
Then, we also work on a number of other projects such as how to convert say dung into manure, how to reduce the parasitic load, that is there in the dung. So, that it can be made use of in other places and so on such other activities are also done.

(Refer Slide Time: 27:13)



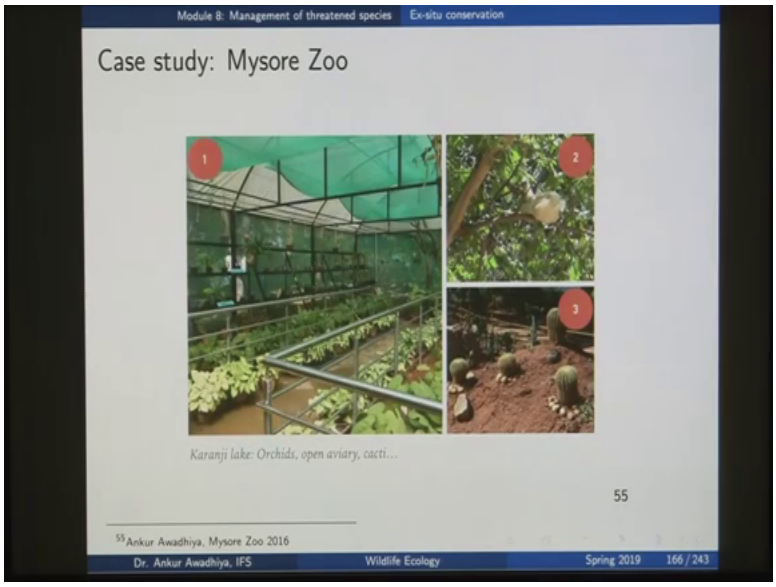
Now, a very important role of zoo is that they permit people to come and visit and observe the animals. So, caning of people also becomes a very important part. So, for instance you will observe these notices. So, you have disabled friendly environments, you have even wheelchairs that are available in these areas, you have facilities for drinking water, you have facilities for doctors, you have facilities for golf carts. So, that people can move in these areas, you have places for people to sit and so on. So, the ex situ conservation facilities also need to cater not just to the needs of the animals, but also to the needs of the human beings.

(Refer Slide Time: 27:58)



And in that case image building, revenue, ticketing also play a very important part.

(Refer Slide Time: 28:04)

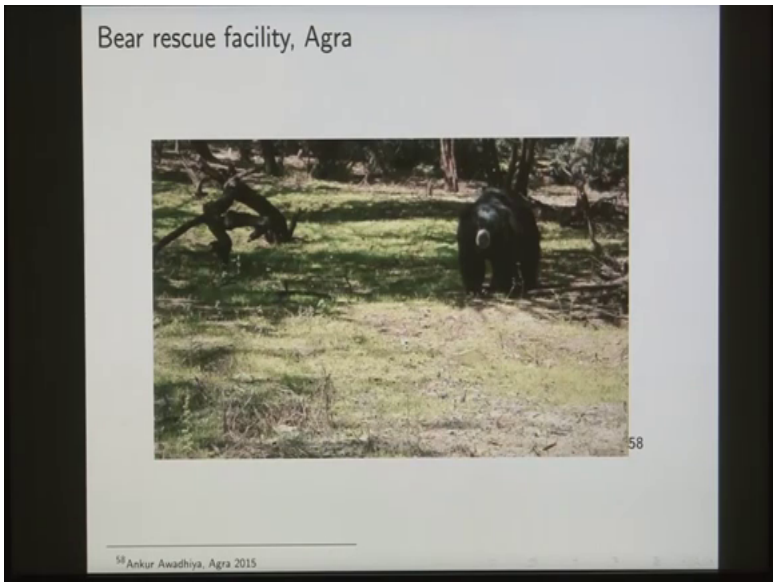


Also in the case of ex situ conservation facilities, you can also have facilities such as these areas where you grow, where you cultivate orchids or an in house aviary or an open aviary, on an area where you have cultivation of cacti. So, all these cactuses are brought from different areas and they are cultivated in this area. So, that you are able to conserve this cactuses well. So, different organisms are kept in the ex situ conservation facilities for their conservation.

(Refer Slide Time: 28:36)

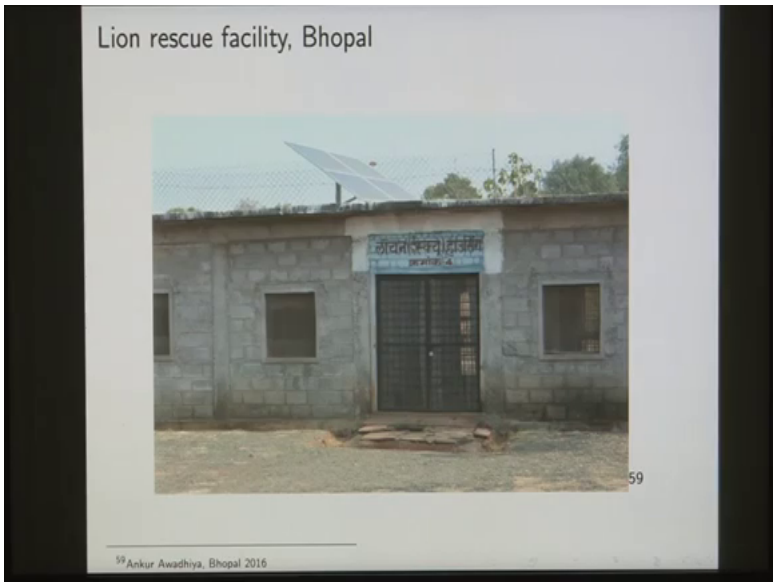
Now, zoos also include the rescue centers. So, an example of a rescue center is this rescue center at Agra. This is the bear rescue facility, in which any bears that are orphaned or that have been rescued from calendars are brought to this area.

(Refer Slide Time: 28:55)



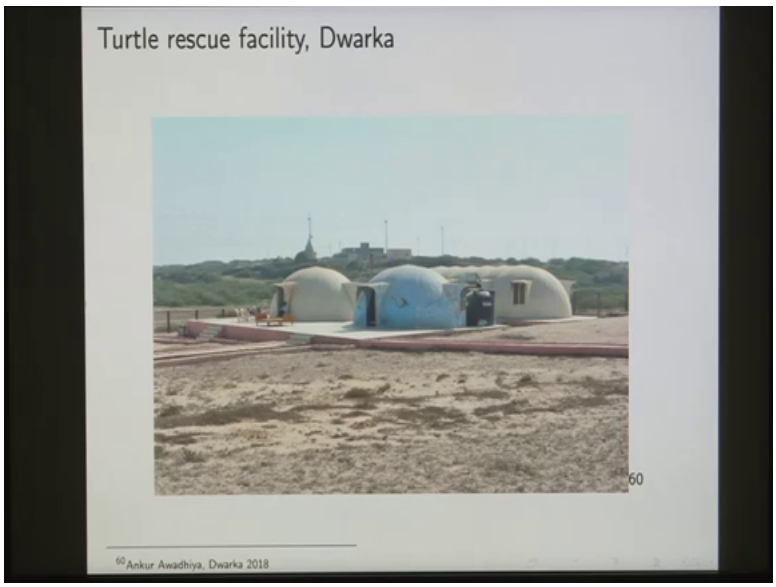
They provided large enclosures in which they can lead their life they are provided with ample amount of food and care and nutrition and so on.

(Refer Slide Time: 29:08)



Another rescue facility is that of the line rescue facility, that is there in Bhopal or a turtle rescue facility that is there in Dwaraka.

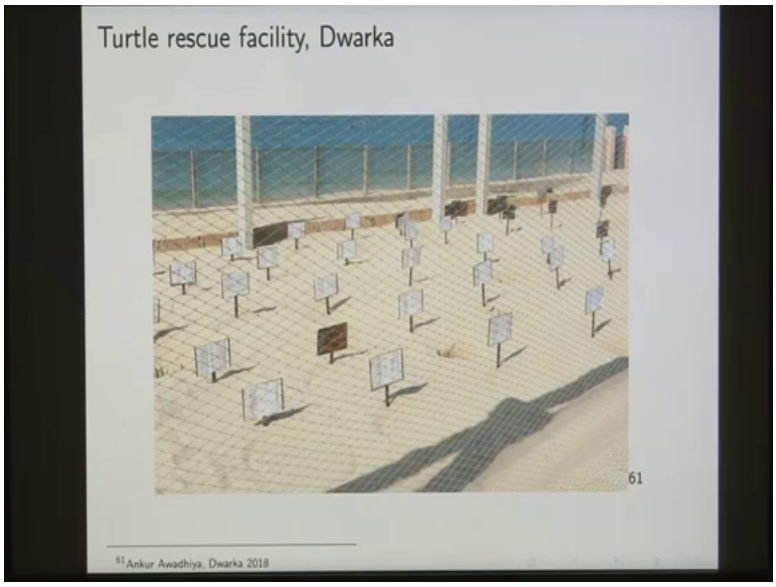
(Refer Slide Time: 29:12)



Now, in this rescue facility the eggs of the turtles are brought to these rescue facilities, because turtles have this habit that they come to the sea beaches and there they make a nests and there they lay their eggs.

Now, with time we have observed that there are a number of Street dogs or Puryear dogs that come into these nests and eat up the eggs. So, when that happens the population of turtles suffers a decline.

(Refer Slide Time: 29:46)



Now, to avoid that what people do in this rescue facility is that they bring the eggs from the sea beaches and then in this covered enclosure where you have these wire meshes all around. So, that dogs cannot enter into this area there they make a hole in the form of the nest and there they keep all these eggs inside these areas. And once the turtles have has so, then they are moved into these in house areas. So, that they can grow to a particular size and after that they are released back into the seas.

(Refer Slide Time: 30:22)

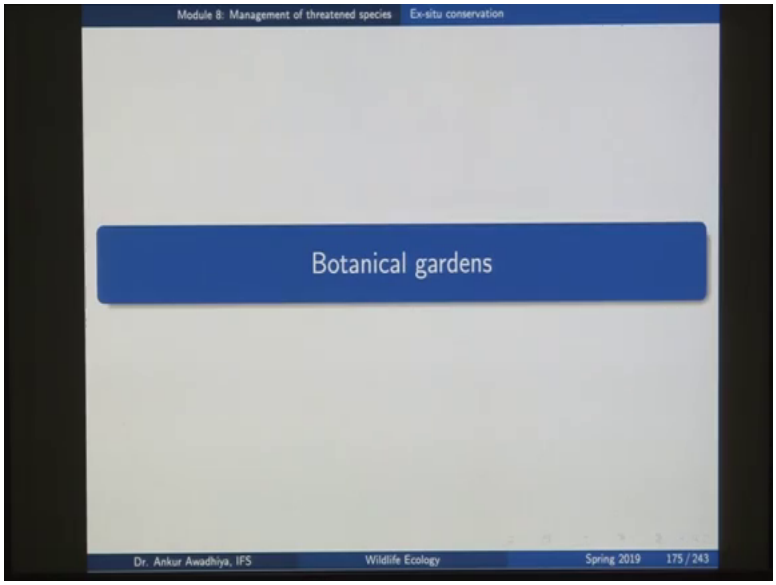
Now, in the zoos it is also important that you need to pay a very huge amount of it of attention to the behavior of the animals. Here what we are observing is a stereotyped behavior, what this elephant is doing is that it is just moving right and left in this repetitive manner, because it is getting a sense of boredom.

(Refer Slide Time: 30:48)

Now, when that happens you need to provide the animal with certain amount of behavioral enrichment, this animal should have something to do. So, behavioral

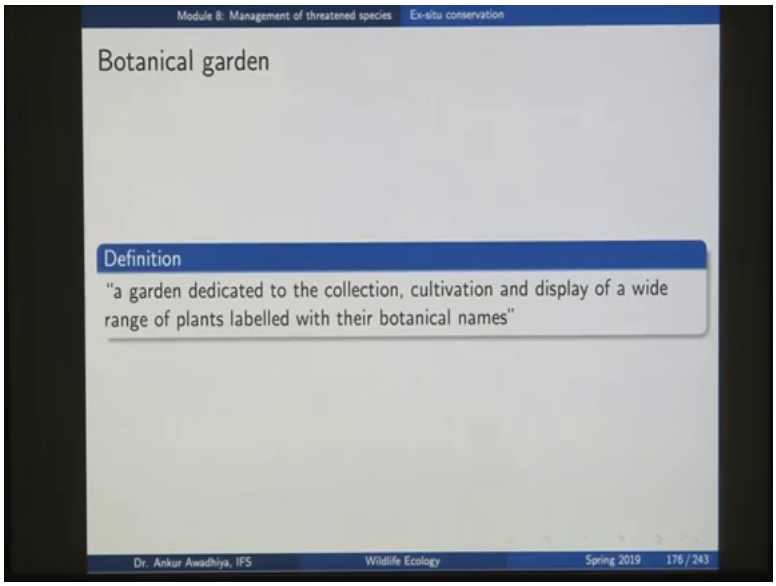
enrichment also forms a very important part of the zoos as part of the ex situ conservation measures.

(Refer Slide Time: 31:02)



Now, the second ex situ conservation facility that will observe is a Botanical garden.

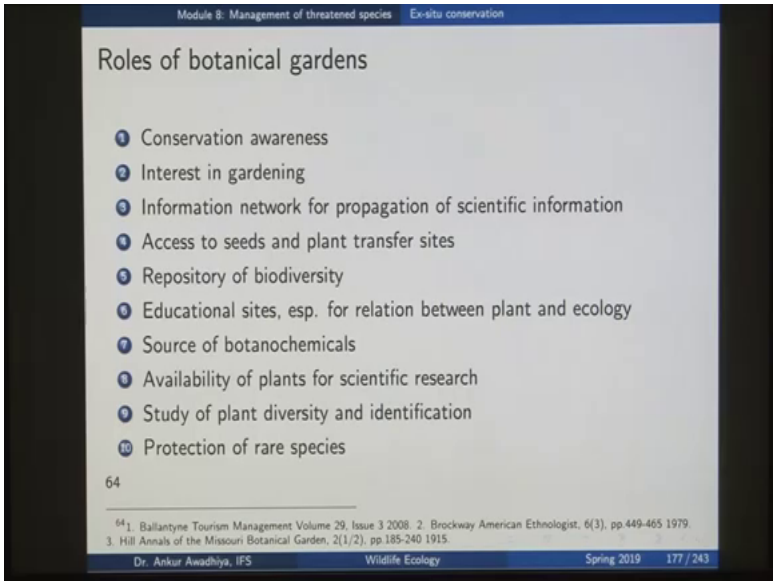
(Refer Slide Time: 31:05)



A Botanical garden is a garden dedicated to the collection, cultivation and display of a wide range of plants labeled with their botanical names. So, here you bring plants from the from different areas you cultivate them and you display them along with the botanical

names. So, that there can be some amount of research there can be some amount of education that people can have if they come and visit these botanical gardens.

(Refer Slide Time: 31:35)

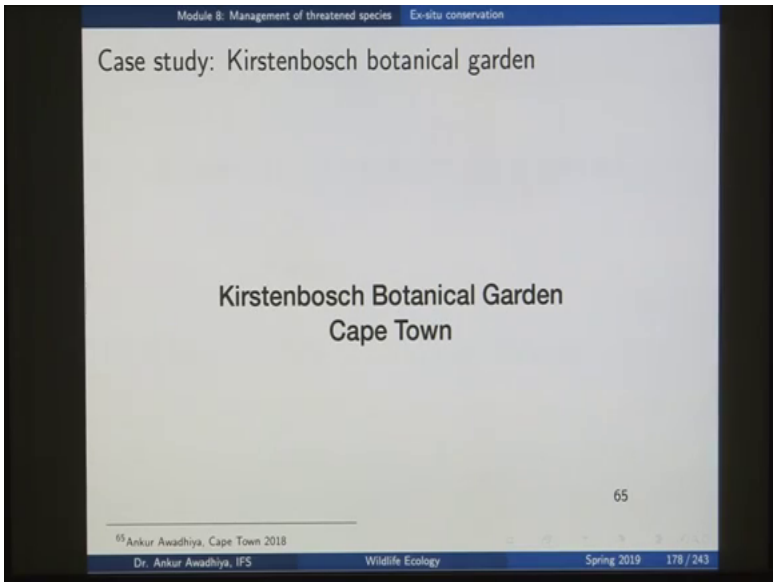


These botanical gardens play a number of roles, they help in conservation awareness, they help to develop this interest in gardening, information network for propagation of scientific information, access to seeds and plant transfer sites, repository of biodiversity, educational sites, especially for relation between plants and ecology, sources of botanochemicals.

So, some amount of research can also be done on different plant chemicals that are there in the botanical garden, availability of plants for scientific research, study of plant diversity and identification. So, for people who are interested in or art learning, the sciences of taxonomy and systematics a botanical gardening plays a very important role, because you can visit these areas and look at trees their different adaptations, their the patterns of their leaves, the patterns of their branches and so on.

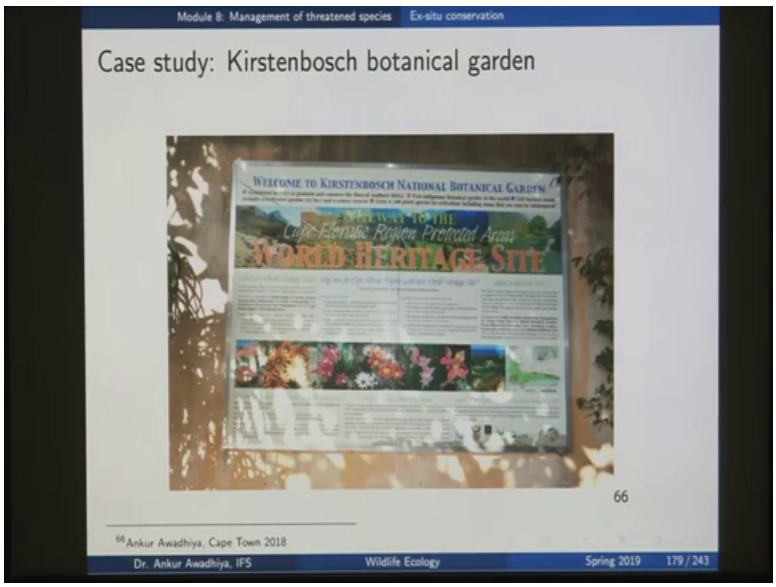
So, that you are able to make a sense of how to identify a particular species? And they also play a very important role in the protection of rare species, because here you are providing a very controlled environment to the rare species when you are cultivating them. So, the rare species will also get sufficient amount of nutrition, fertilizers, water and so on.

(Refer Slide Time: 32:52)



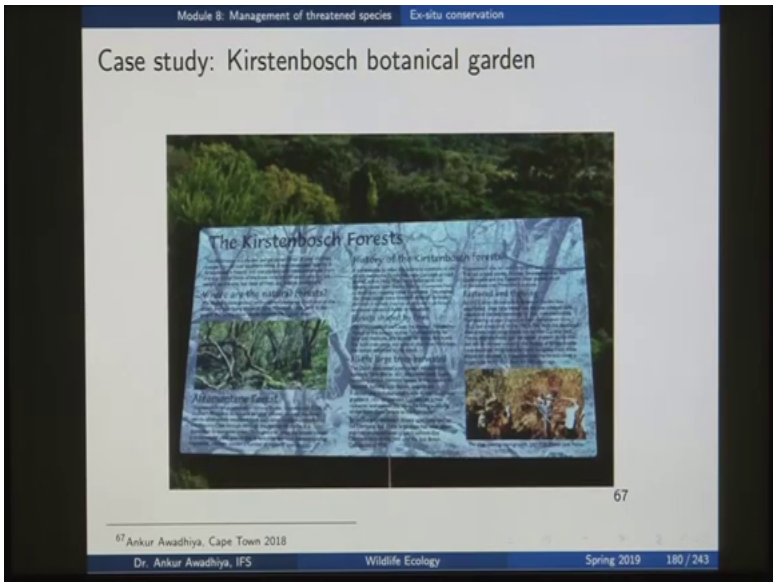
Now, to know what a botanical garden looks like will have a look at the case study of Kirstenbosch Botanical Garden, which is there in cape town.

(Refer Slide Time: 32:57)



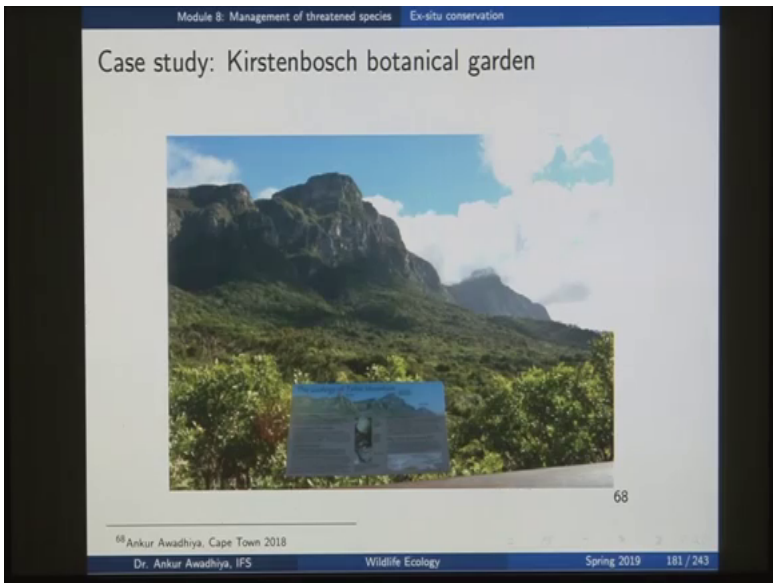
Now, Kirstenbosch happens to be a world heritage site.

(Refer Slide Time: 33:01)



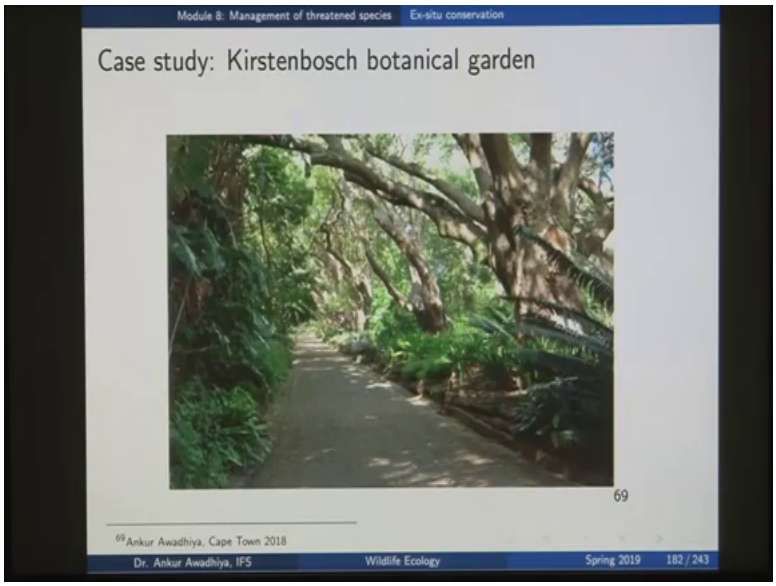
So, it has these Kirstenbosch forests which are very unique to that particular ecosystem, they go by the name of Flynn boss forest.

(Refer Slide Time: 33:13)



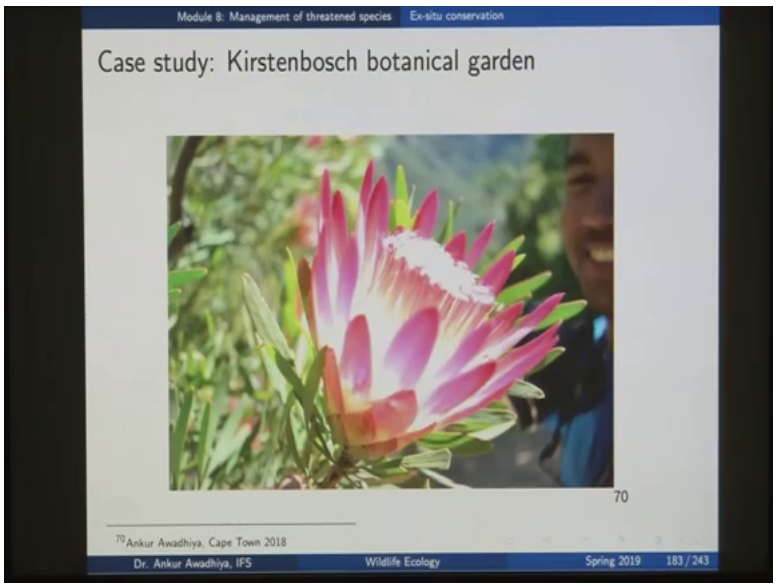
And, in this case the botanical gardens are set up in a location, where you can have a variety of habitats. So, here you have these hills and then you also have this and then you have the plane lands. So, all of these different areas provide of a wide variety of habitats for the plants to grow.

(Refer Slide Time: 33:34)



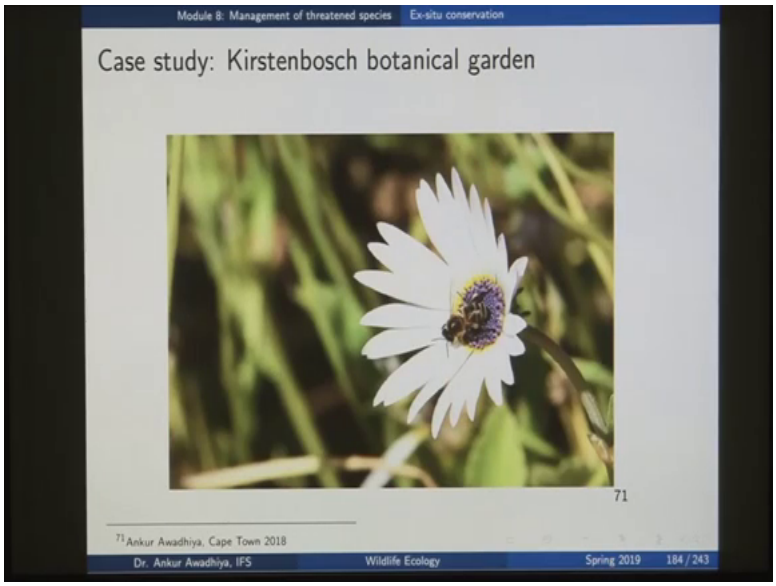
And after cultivation these plants are also made of label for exhibitions. So, this is one exhibit in which you have this road and you can take a walk on this road and you can look at different plants and all of these plants are labeled with their names. So, you can understand what kind of plants grows in what particular habitat conditions and so on.

(Refer Slide Time: 33:55)



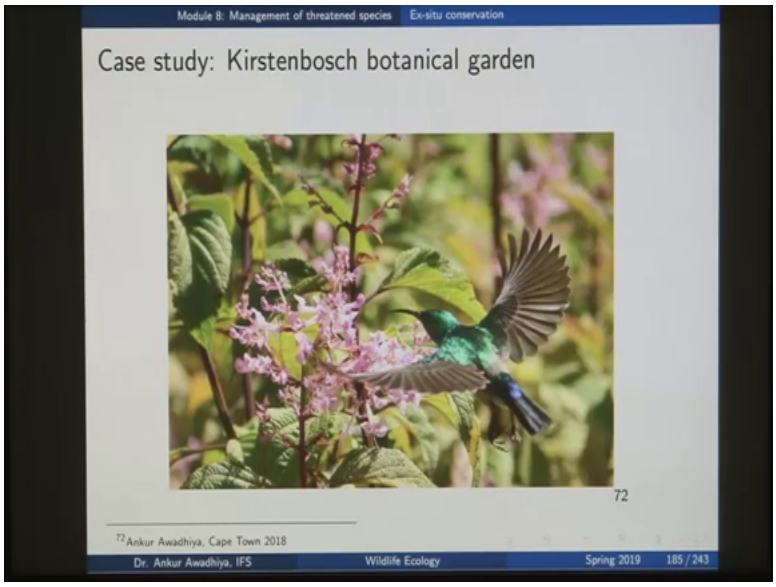
So, people visit these areas to look at plants.

(Refer Slide Time: 33:58)

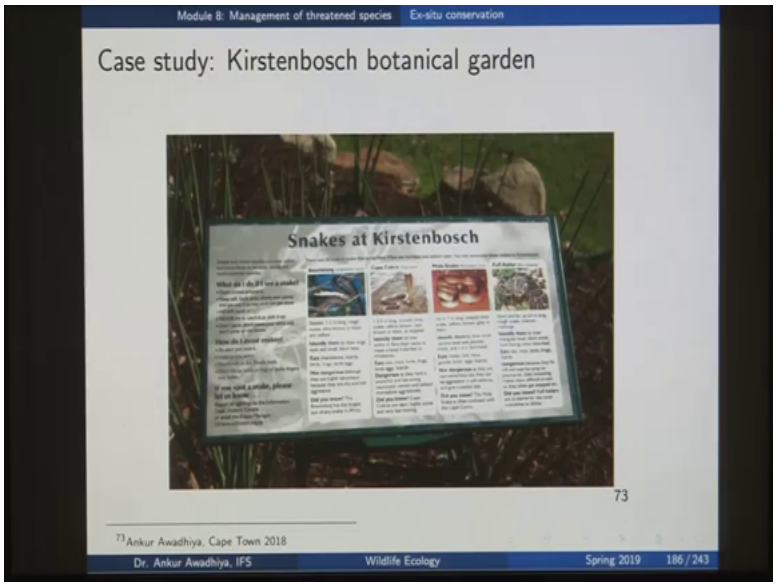


To even people who are interested in studying insects can come to this area to study different kinds of pollinators or different kinds of birds that are there in this area or even things like snakes that are found in these forests.

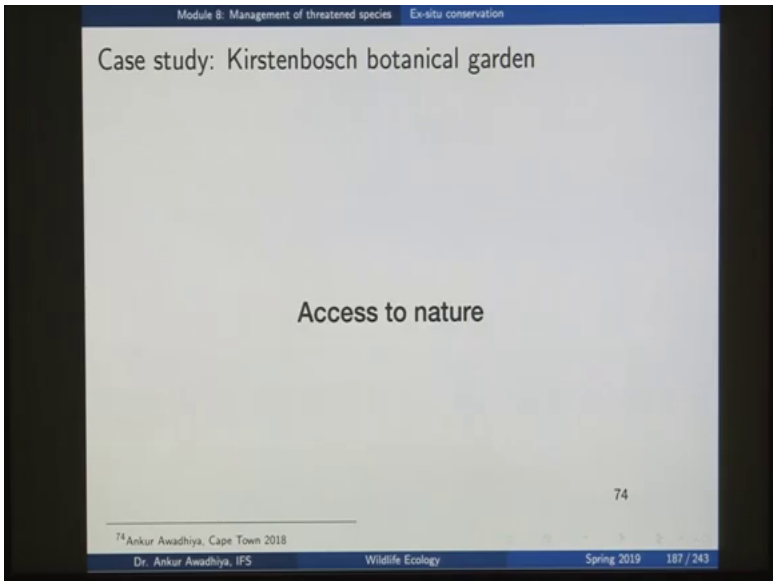
(Refer Slide Time: 34:04)



(Refer Slide Time: 34:08)

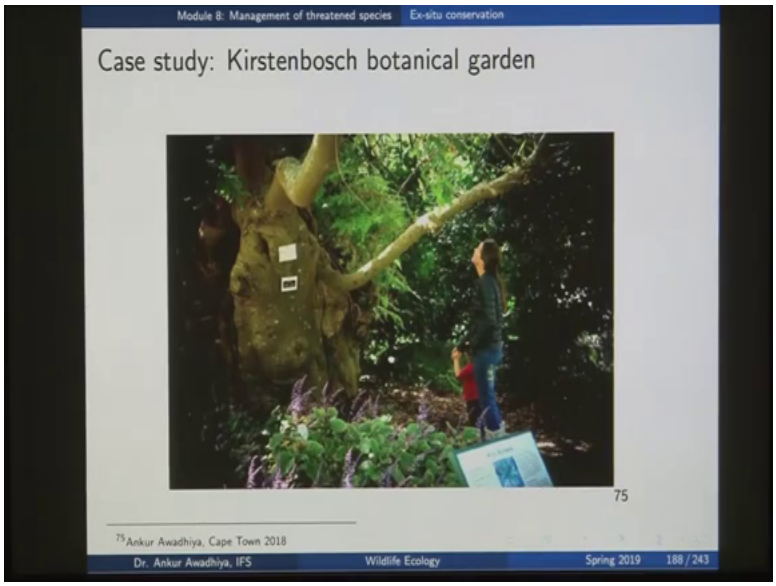


(Refer Slide Time: 34:13)



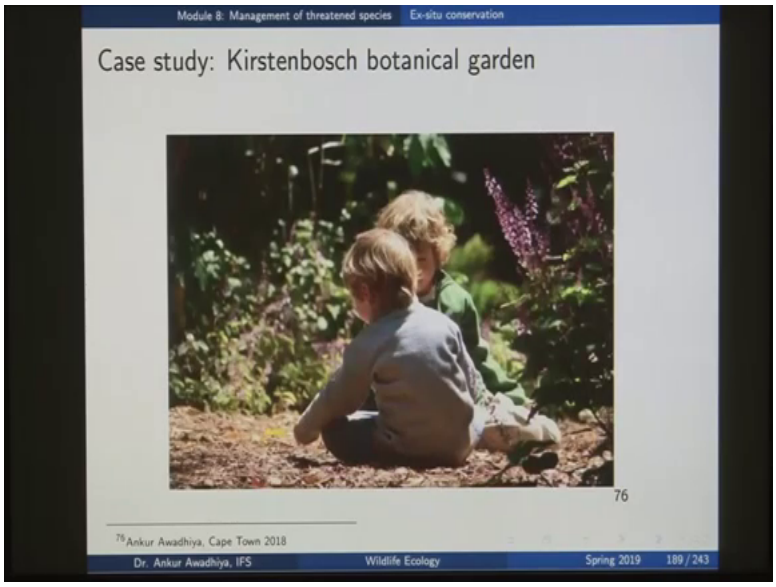
So, they provide an access to nature.

(Refer Slide Time: 34:14)



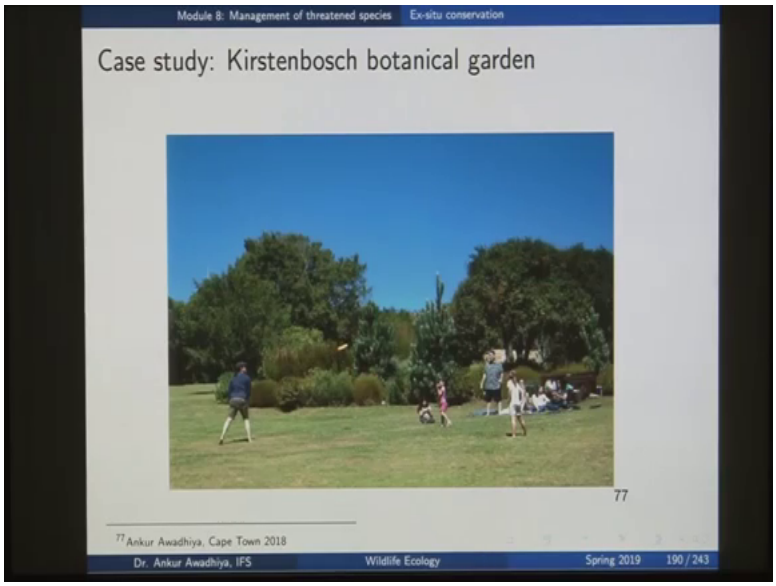
And play a very important role in educating people. So, you would observe that some parents would come to this area with their kids and they would be telling what are trees, what are leaves, how do they make food, what is photosynthesis and so on.

(Refer Slide Time: 34:30)



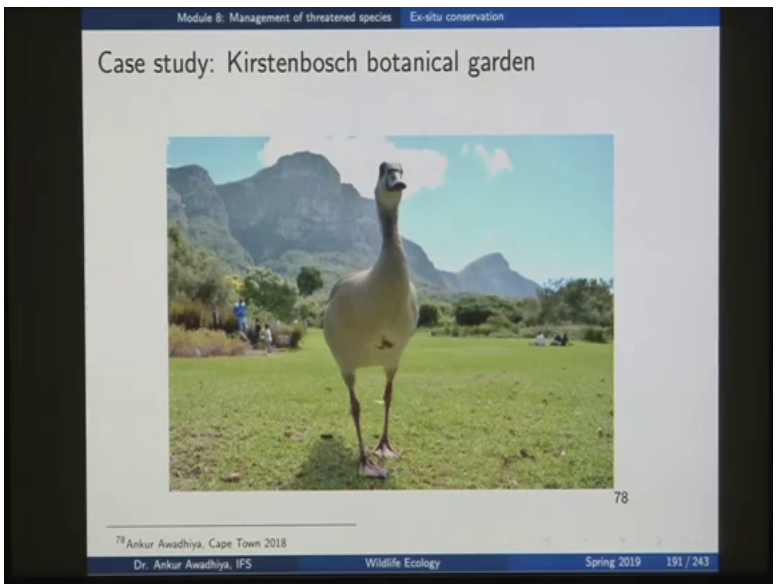
So, people can spend time here, they can even spend family time here between the nature.

(Refer Slide Time: 34:31)



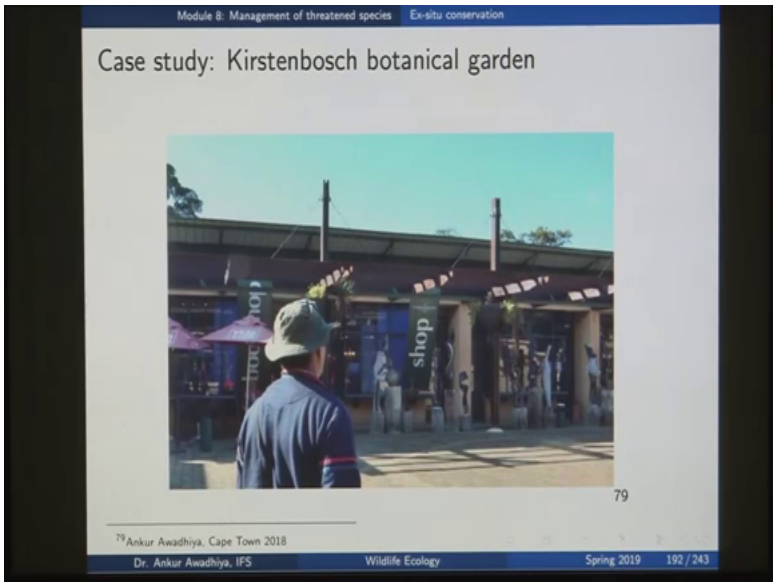
And the idea here is that the more time people spend with nature the more they can relate to the cause of conservation. And so, when people are coming to this area every day, if later on there is a proposal that this garden should be closed. So, in that case there will be so, many people who would very mentally oppose such a proposition. At the same time because these people know what different plants look like, if there is an area that is suffering from a decline in species, there would be a number of people who would write to policymakers who would who would write to lawmakers to conserve those species. So, this is the idea.

(Refer Slide Time: 35:18)



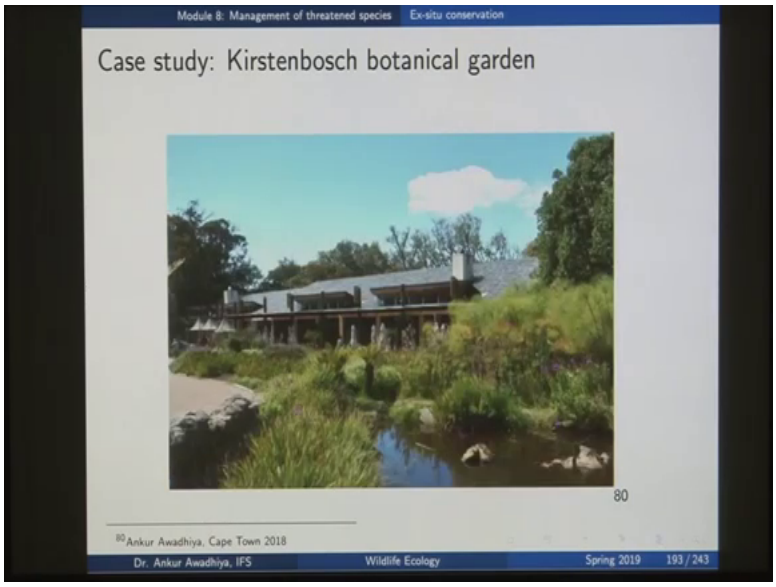
So, you can spend a lot of time here you can observe a different species.

(Refer Slide Time: 35:20)

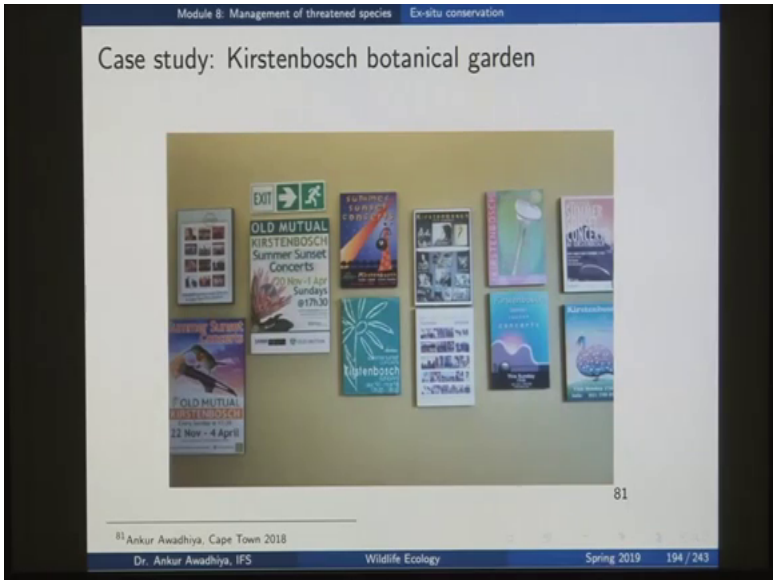


And just to ensure that people have a quality time you also have a number of shops you also have a cafeteria.

(Refer Slide Time: 35:28)

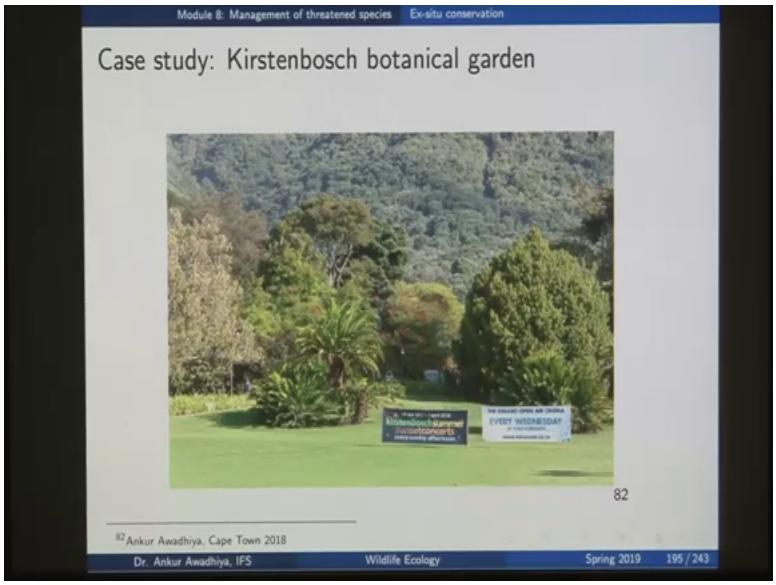


(Refer Slide Time: 35:29)



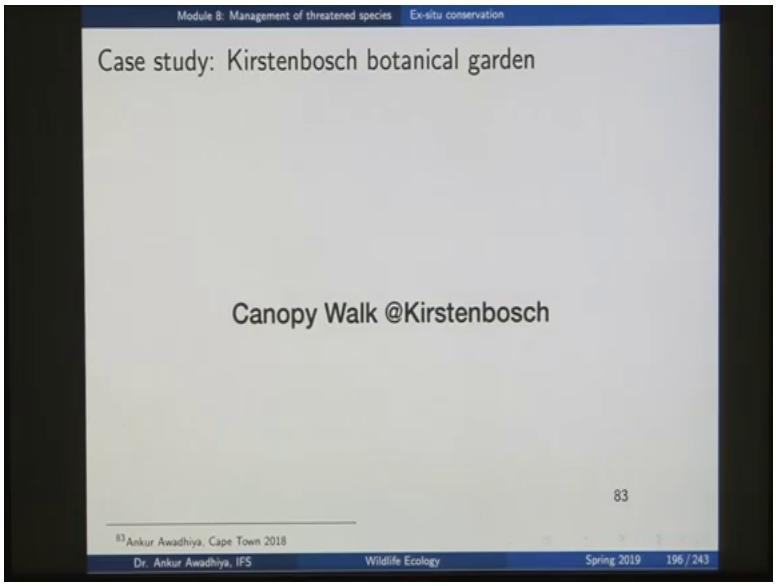
So, that people can just spend their time there.

(Refer Slide Time: 35:34)

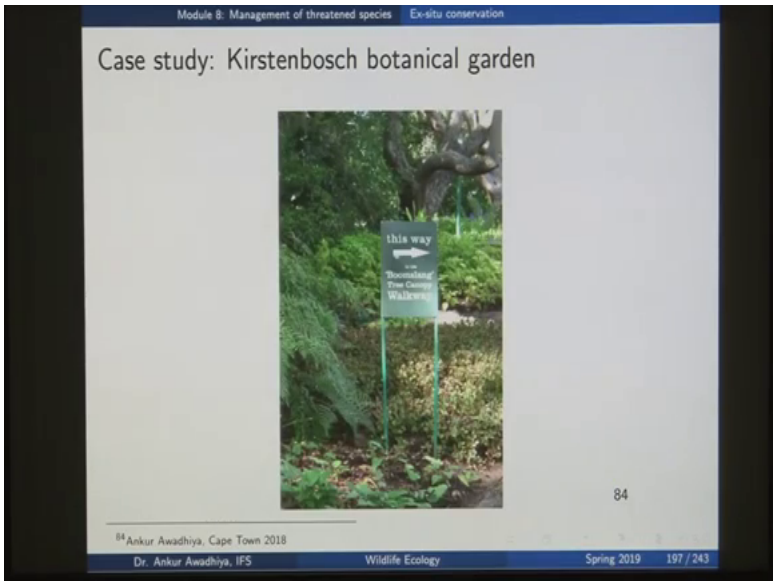


So, again in the case of an ex situ conservation facility, it is extremely important that people should be able to visit these facilities.

(Refer Slide Time: 35:40)

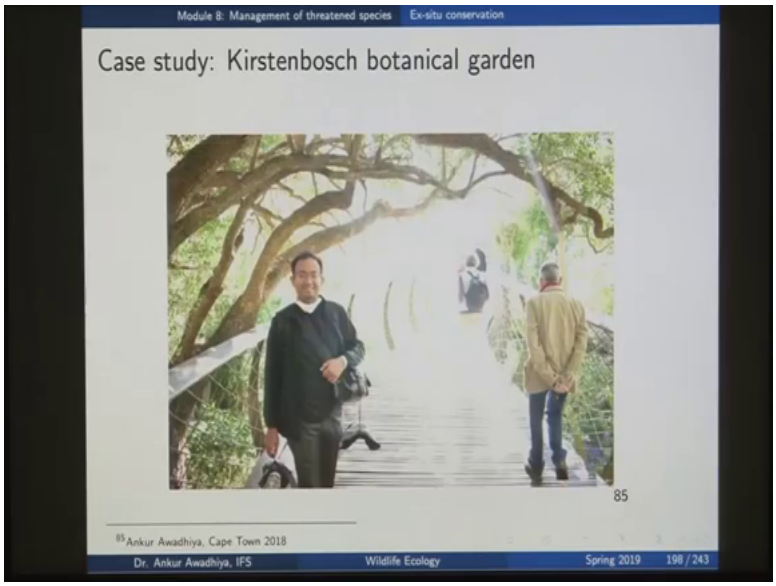


(Refer Slide Time: 35:41)



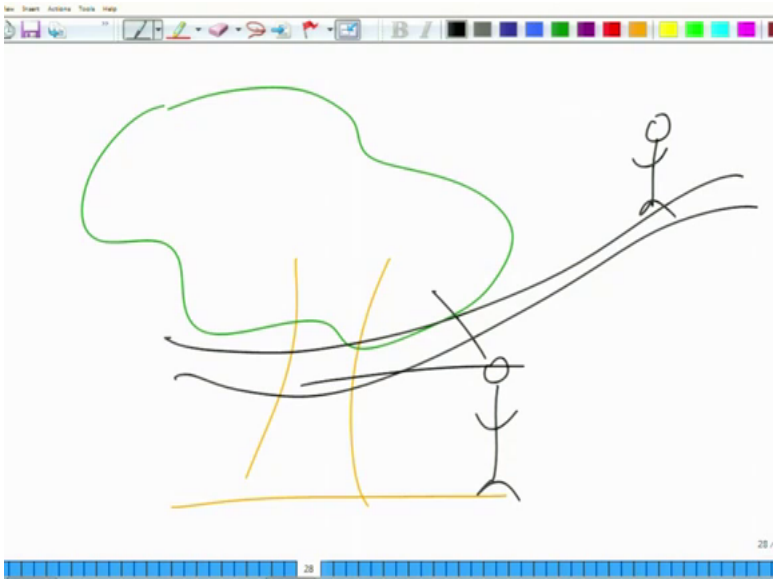
Now, there are also some attractions in the form of canopy walk.

(Refer Slide Time: 35:43)



So, now this is the canopy walk, what they have done here is that here you have the canopy of trees and there is this bridge. And this bridge moves through the canopy of trees and in certain locations and it moves above the canopy of the trees.

(Refer Slide Time: 36:02)



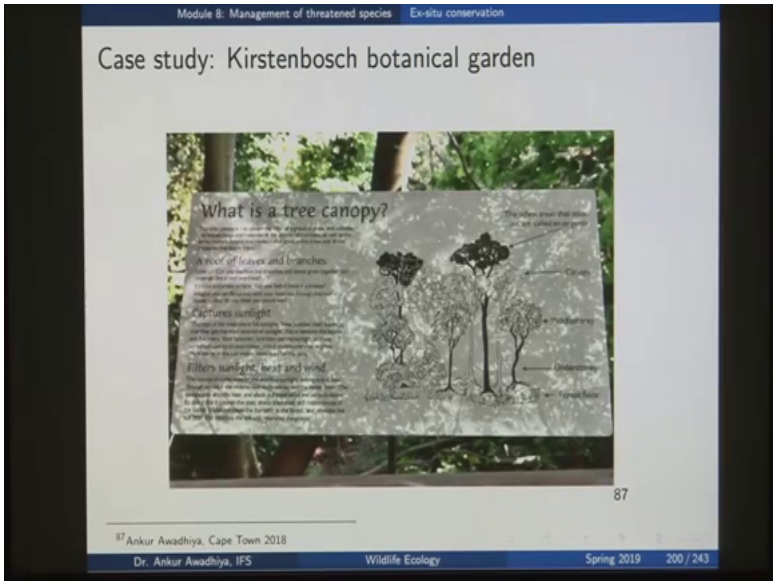
So, essentially if we look at any tree for any large sized tree, when we are observing the tree we are generally at this level. So, we are able to see the stem of the tree, but we and we can observe some, we can also observe the leaves of the tree, but we can never observe the canopy of the tree. Now, for observing the canopy you have to be at this

level. Now, the canopy walk is a large bridge in which you can while walking through this bridge you can get to the level of the canopy. So, the canopy is at your eye level and you can even go above the canopies.

(Refer Slide Time: 36:42)

So, this is how it looks like. So, you have different trees and this canopy walk is even above quite a number of stems.

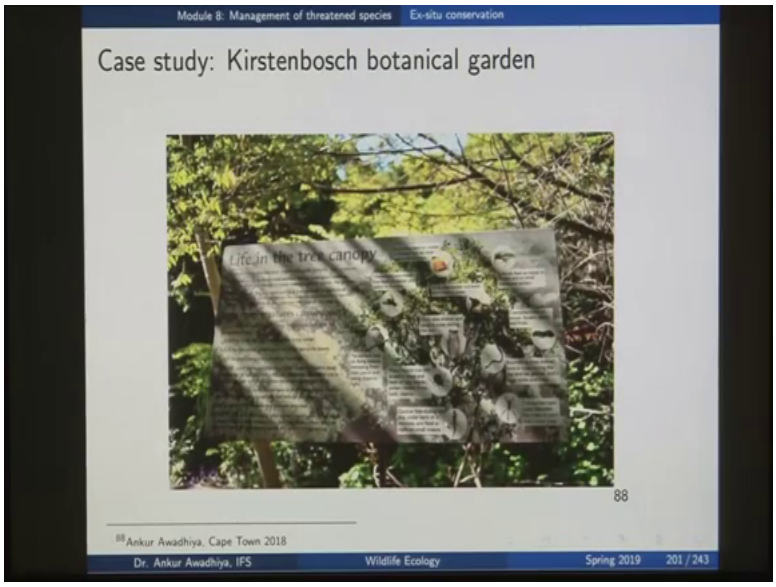
(Refer Slide Time: 36:52)



And here also you have a number of educational play cards. So, like this one is telling you what is the tree canopy, what are different kinds of canopies, this is the canopy, this

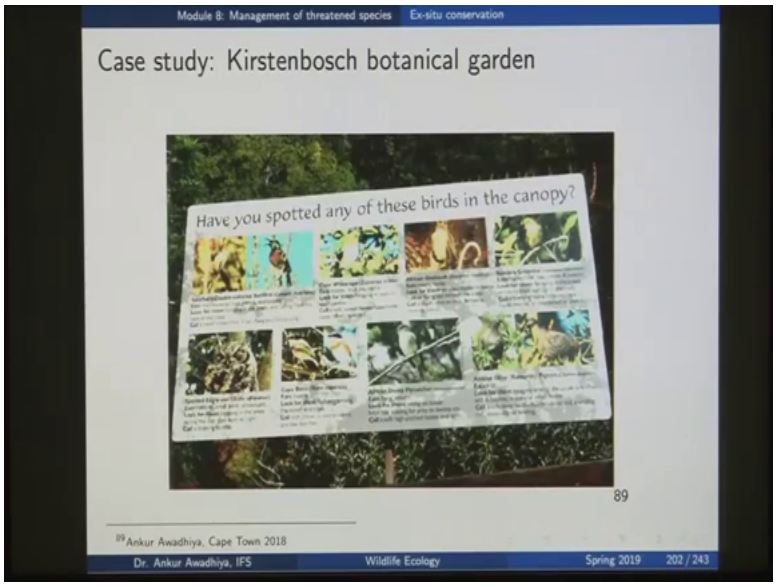
is middle story, this is understory, this is forest floor and so on. So, the ex situ conservation facilities play a very important role in giving an imparting education to the people who are visiting these areas.

(Refer Slide Time: 37:15)



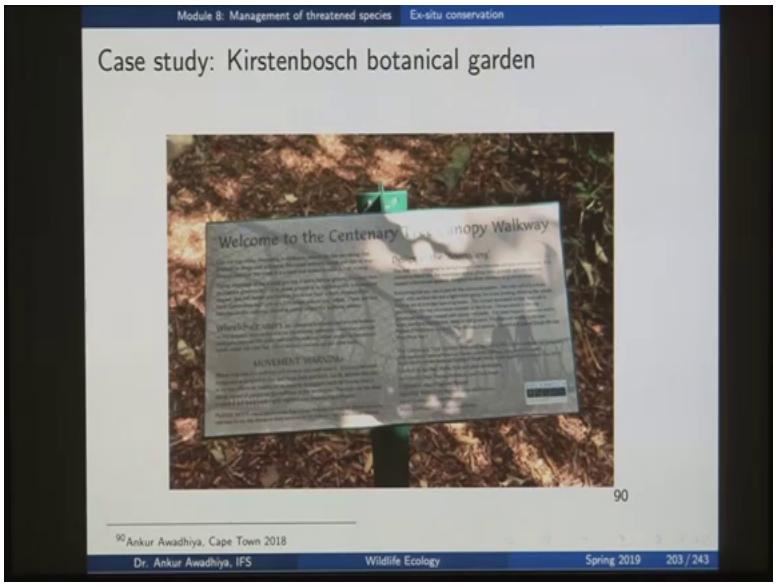
Then, this play car tells you about life in a tree canopy. So, what are different kinds of birds that live in this area, what are different kinds of organisms that live in this area, how they work together in a food chain or in a food web and so on.

(Refer Slide Time: 37:32)



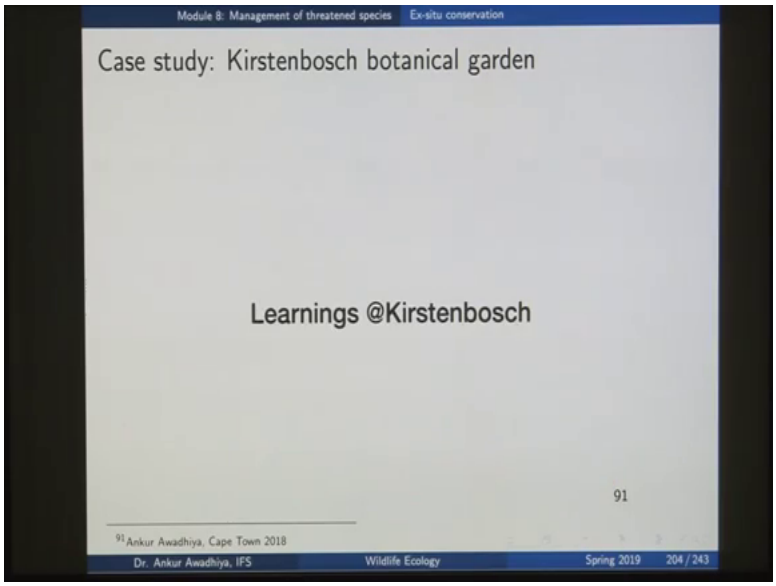
Then, it also tells you about the biodiversity that is there in the canopy. So, these are all birds that are found in the canopies. So, when you go to these areas you can get a sense of what is the level of biodiversity in different parts. So, when you are walking on the ground, you can see different biodiversity, when you are walking at the level of the branches you can see different biodiversity, when you are walking in the canopy you can see a different biodiversity.

(Refer Slide Time: 37:59)

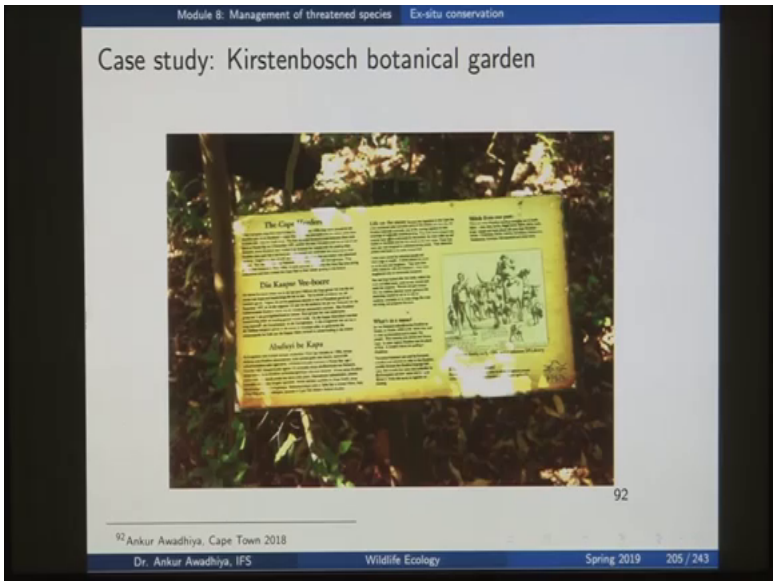


Or things such as how this canopy walk is constructed so, engineering learning's and so on.

(Refer Slide Time: 38:07)

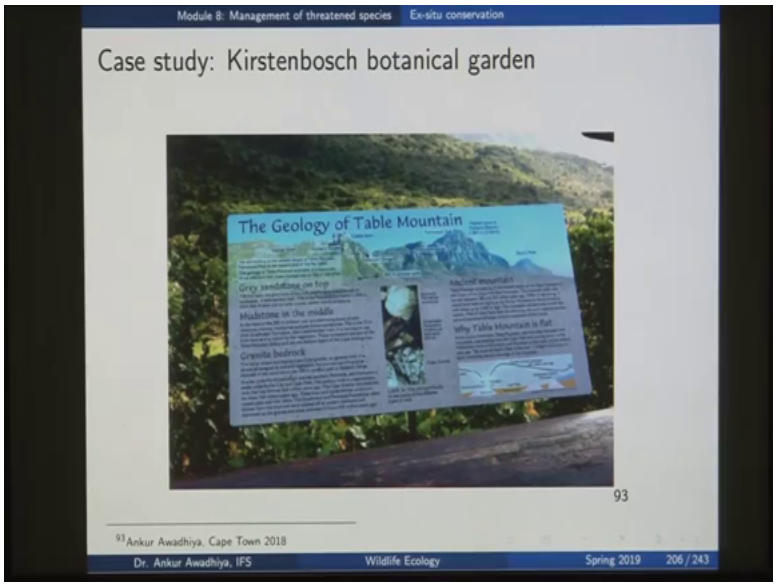


(Refer Slide Time: 38:07)

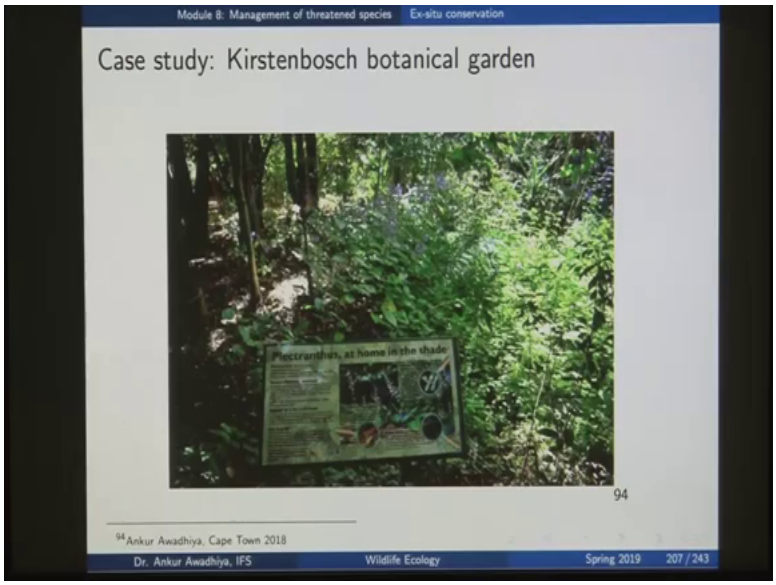


Then you have historical learning's, you have learning's about the geology of the place.

(Refer Slide Time: 38:10)



(Refer Slide Time: 38:13)

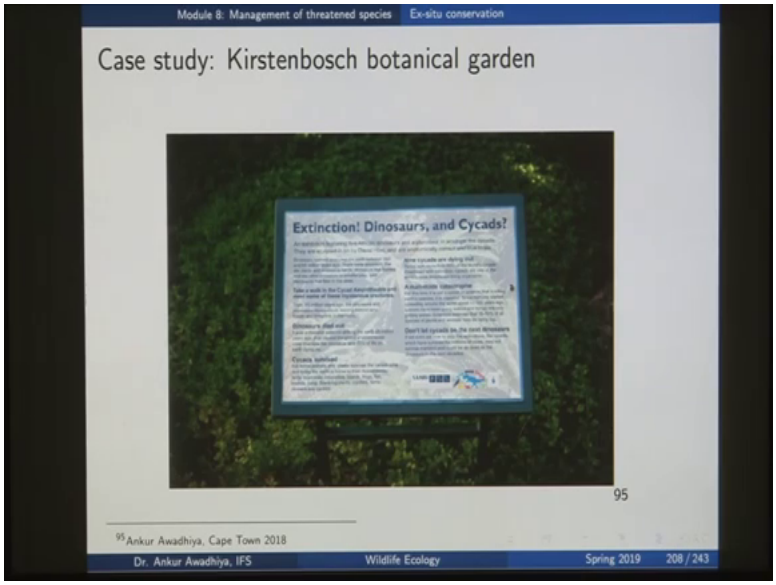


You have learning's about the habitat requirements of different species. So, for instance this particular play card tells, you that there is this is species that lives in the shade of the trees. So, here you can observe that you have tall trees and then you have this particular gosh like species that is living in this particular area.

Now, this play card is telling you what are the adaptations, why this species prefers this particular area? And now when you go to these areas you get a very good idea of what is

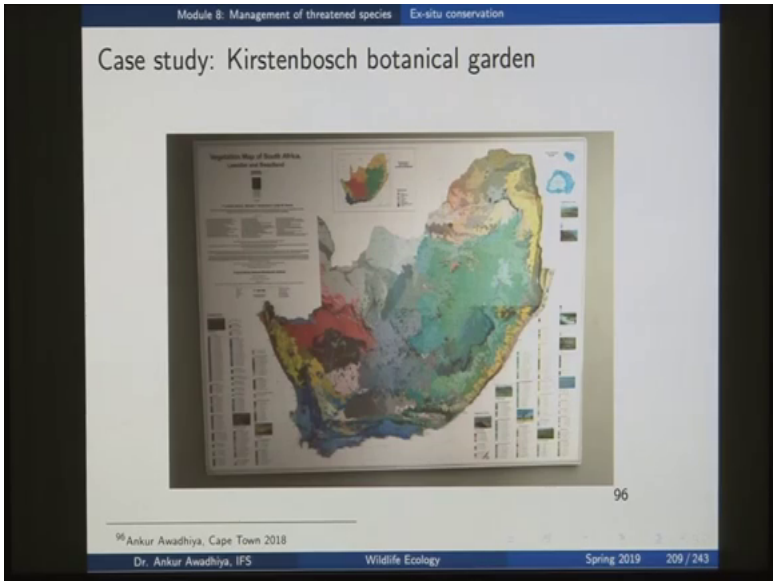
biodiversity and why different species live in different areas, what are what do you mean by niches that are used by different species?

(Refer Slide Time: 38:53)

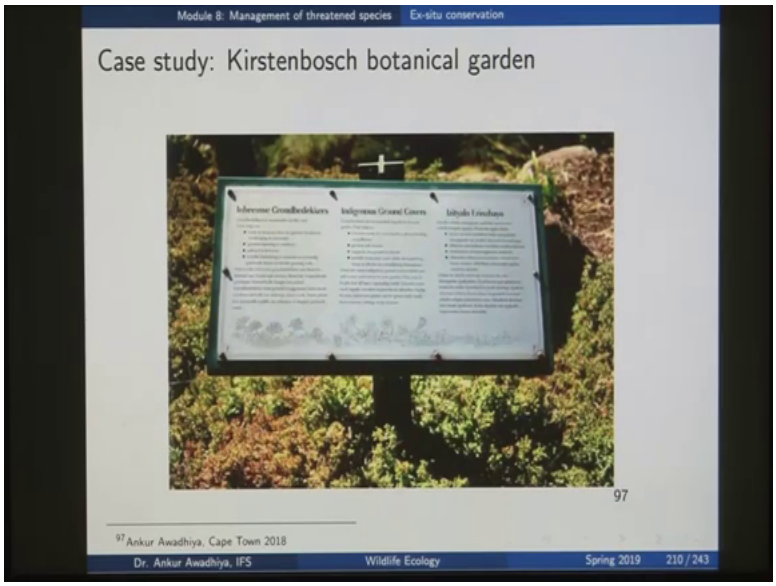


Then, it also gives you a message about conservation by talking about dinosaurs or, by talking about different areas which have different species.

(Refer Slide Time: 39:01)

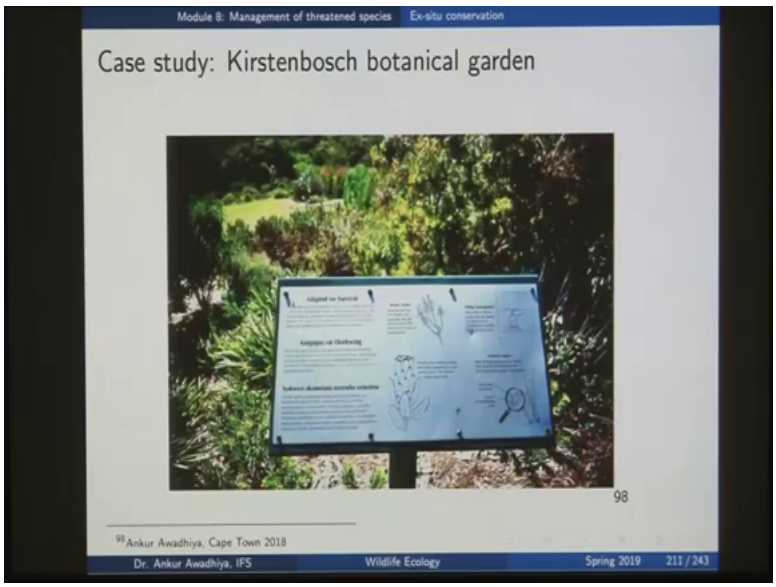


(Refer Slide Time: 39:04)



Or, by talking about the indigenous species, the ground covered species, the kinds of adaptations that are there in different species and so on.

(Refer Slide Time: 39:10)



So, essentially in a botanical garden what you have is you have an area which is an ex situ conservation area, because all of these species are not naturally found in this area, they have been planted in these areas. So, seeds were brought from different areas and planted here. Then, they are given a lot of care and attention.

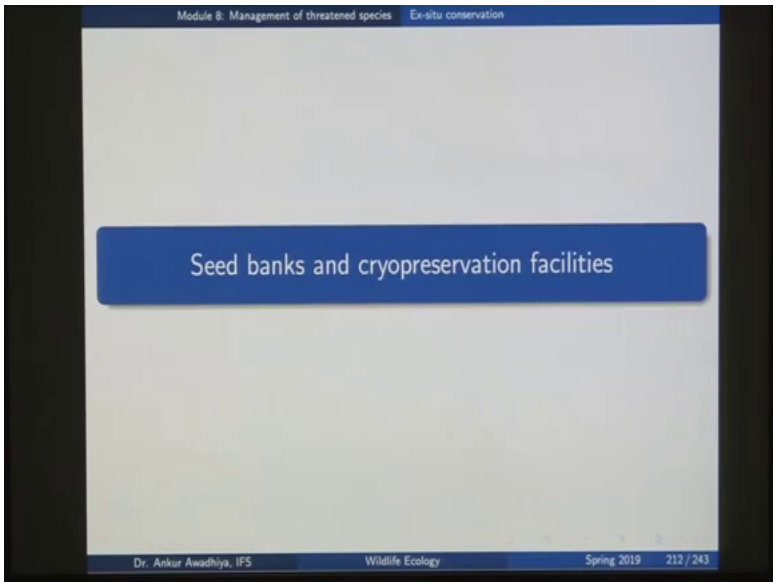
And once these species have come up into this area, then these species are used for conservation in a number of ways. One way is that by having these plants here, even if their natural habitat suffers a decline you still have these species here and you can always collect seeds and you can repopulate the original area. Or you can substantiate the population of the original area or by observing these different species, you can make a correlation about the require of these different species, when do these plants flower, when do these plants produce fruits, when are the seeds that are there in the fruits, when are they alive, when are they dead and so on.

So, all these information can be made use of in the in situ conservation facilities as well. Then they are very important for conservation, because they provide access of access to people to nature. So, in this case when people are coming to these areas, they can look at biodiversity, they can understand what our adaptation, they can understand why do we need so, many different kinds of species to exist on this planet.

Because, on a very superficial understanding some person might say that ok, you have trees in this area that is good enough because you are getting photosynthesis you are getting carbon dioxide that is getting sequestered and oxygen that is getting released. Why do you why should you have so, many different kinds of species, but then once you have been to such an area you get this idea of why these different species are important.

Then, you also get an idea of what are the adaptation that are there in these different species. You also get an idea of how these species are related to each other, how is the plant kingdom related to the animal kingdom, which particular trees provide nest nesting sites to different birds, which particular trees provide fruits to different birds and so on. And by allowing people to understand nature the idea of a botanical garden is that people would become aligned to the cause of conservation.

(Refer Slide Time: 41:47)



Now, the third ex situ conservation facility that will observe is a seed bank or a cryopreservation facility. Now, the idea of a seed bank or a cryopreservation facility is that.

(Refer Slide Time: 41:57)


PNAS

Regeneration of whole fertile plants from 30,000-y-old fruit tissue buried in Siberian permafrost

Svetlana Yashina[a,1], Stanislav Gubin[b], Stanislav Maksimovich[b], Alexandra Yashina[a], Edith Gakhova[a], and David Gilichinsky[b,2]

Institutes of [a]Cell Biophysics and [b]Physicochemical and Biological Problems in Soil Science, Russian Academy of Sciences, Pushchino 142290, Russia

Edited* by P. Buford Price, University of California, Berkeley, CA, and approved January 25, 2012 (received for review November 8, 2011)

Whole, fertile plants of *Silene stenophylla* Ledeb. (Caryophyllaceae) have been uniquely regenerated from maternal, immature fruit tissue of Late Pleistocene age using in vitro tissue culture and clonal micropropagation. The fruits were excavated in northeastern Siberia from fossil squirrel burrows buried at a depth of 38 m in undisturbed and never thawed Late Pleistocene permafrost sediments with a temperature of −7 °C. Accelerator mass spectrometry (AMS) radiocarbon dating showed fruits to be 31,800 ± 300 y old. The total γ-radiation dose accumulated by the fruits during this time was calculated as 0.07 kGy; this is the maximal reported dose after which tissues remain viable and seeds still germinate. Regenerated plants were brought to flowering and fruiting and they set viable seeds. At present, plants of *S. stenophylla* are the most ancient, viable, multicellular, living organisms. Morphophysiological studies comparing regenerated and extant plants obtained from modern seeds of the same species in the same region revealed that they were distinct phenotypes of *S. stenophylla*. The first generation cultivated from seeds obtained from regenerated plants progressed through all developmental stages and had the same morphological features as parent plants. The investigation showed high cryoresistance of plant placental tissue in permafrost. This natural cryopreservation of plant tissue over many thousands of years demonstrates a role for permafrost as a depository for an ancient gene pool, i.e., preexisting life, which hypothetically has long since vanished from the earth's surface, a potential source of ancient germplasm, and a laboratory for

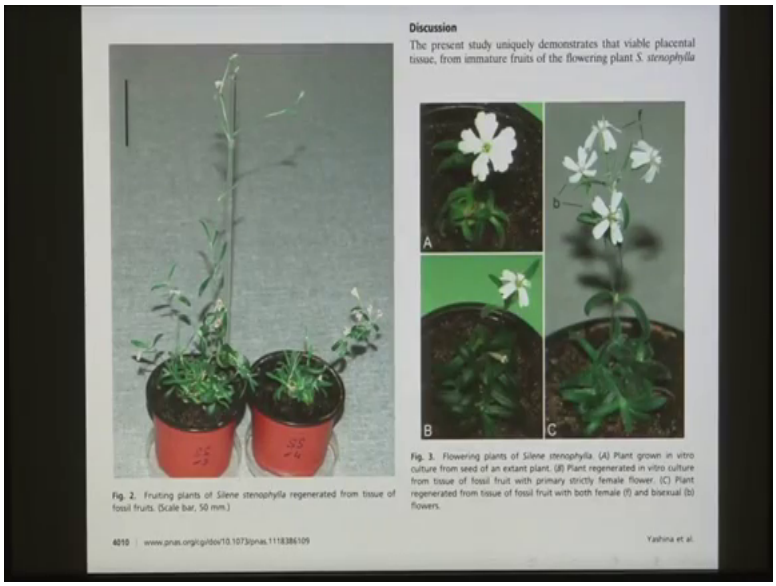
However, to date, no viable flowering plant remains have been discovered from these ancient permafrost sediments.

Outside the permafrost zone the longevity of seeds in soil has been studied during the last 45 y in many places, including archaeological sites (10, 11). At the moment, the oldest viable seeds with the ability to germinate were radiocarbon dated to the first and eighth centuries of the Common Era. These are, respectively, *Phoenix dactylifera* found near the Dead Sea (12) and *Nelumbo nucifera* found in northeastern China (13).

The burrows from which our study material derived were buried in permanently frozen loess-ice deposits on the right bank of lower Kolyma River, northeastern Siberia (14). These deposits (Fig. 1*A*) are representative of a widely distributed, so-called Late Pleistocene ice complex found throughout the eastern Arctic, which has continuously accumulated during the last 60 ky. This complex comprises icy silts with a network of large syngenetic polygonal ice wedges and is richly fossil bearing (pollen, insects, plants, macrofossil, and mammal fossils). The studied burrows (Fig. 1*B*) were found in three exposures: Zelyony Mys, Stanchikovsky Yar, and Duvanny Yar. The last represents a key cross-section of Late Quaternary environmental history in the eastern Arctic studied by many scientists. All burrows were found at depths of 20–40 m from the present day surface and located in layers containing bones of large mammals such as mammoth, wooly rhinoceros, bison, horse, deer, and other representatives of fauna from the age of Mam-

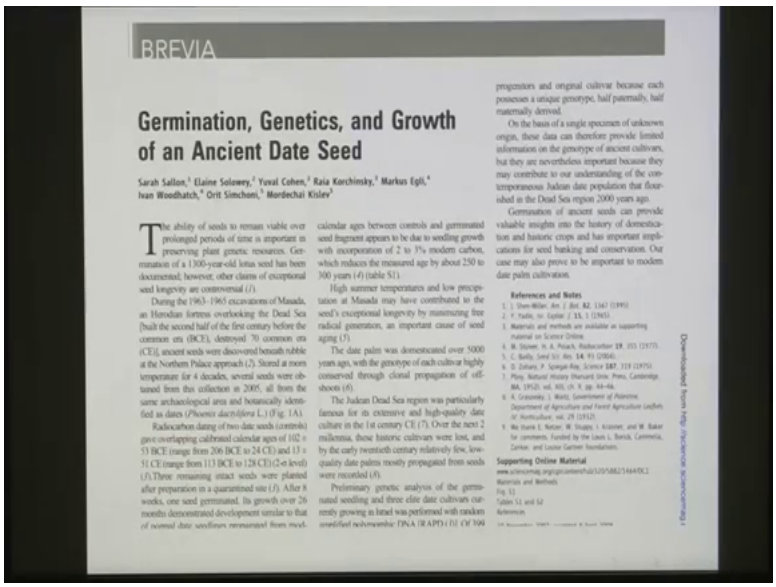
Even, if you have seeds that are very old say, even 30,000 year old seeds and if they have been kept in a very cold area, then they continue to survive and then even if you take those heats today.

(Refer Slide Time: 42:08)



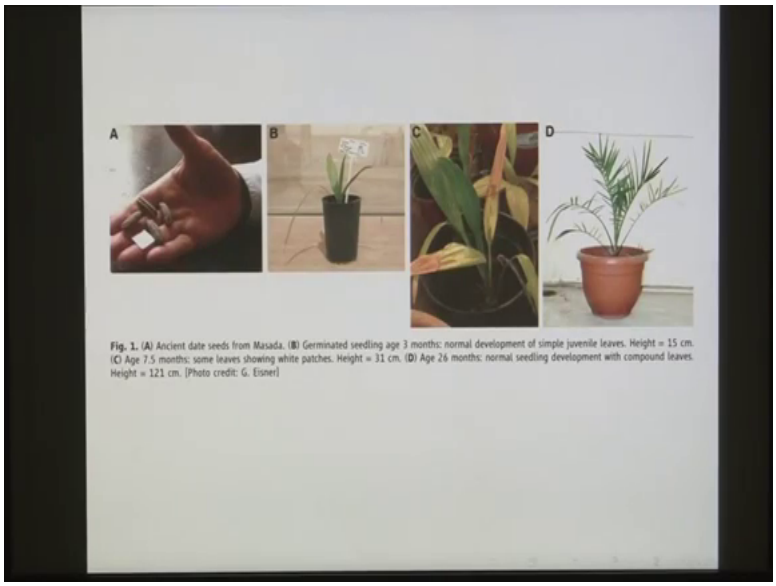
So, even after 30000 years you can plant them and they will give out the plants and the flowers.

(Refer Slide Time: 42:23)



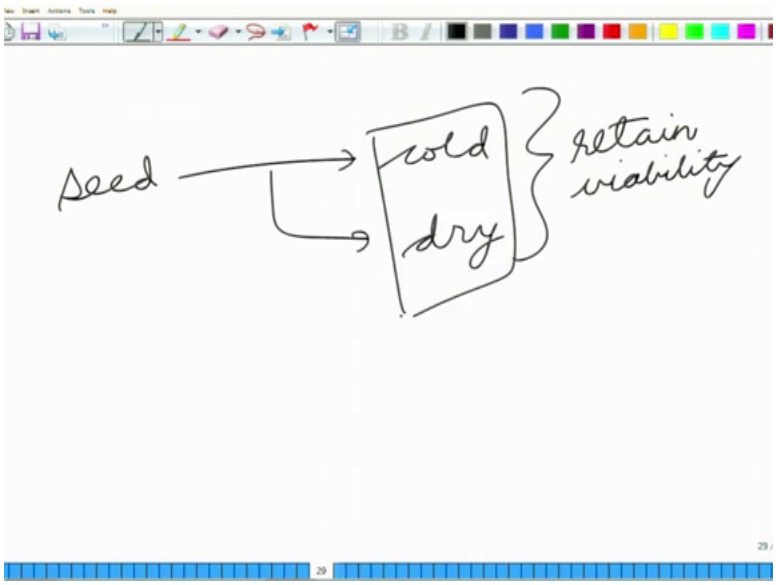
Or those species that are; those seeds that are kept in very dry atmospheres. So, even after 1000s of years you can take those seeds and you can grow plants out of them.

(Refer Slide Time: 42:27)



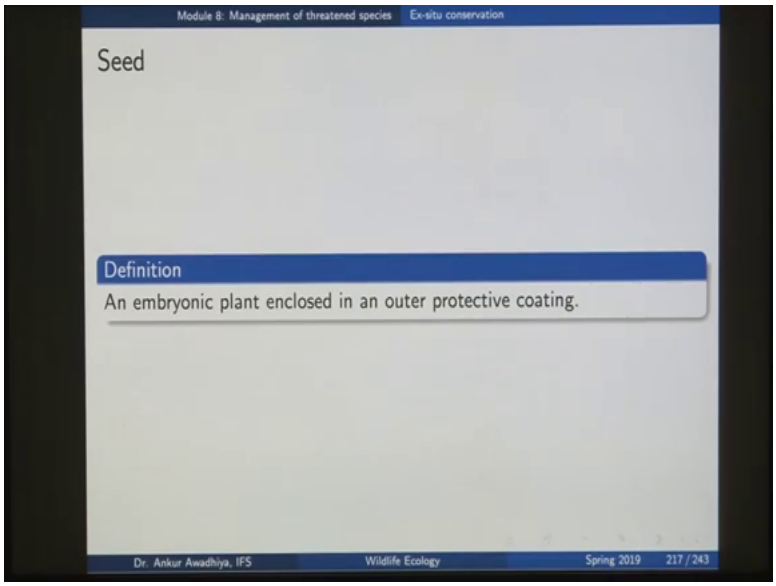
So, essentially if you take a seed and you keep it in an environment that is cold and in an environment that is dry, you are able to retain the viability.

(Refer Slide Time: 42:37)



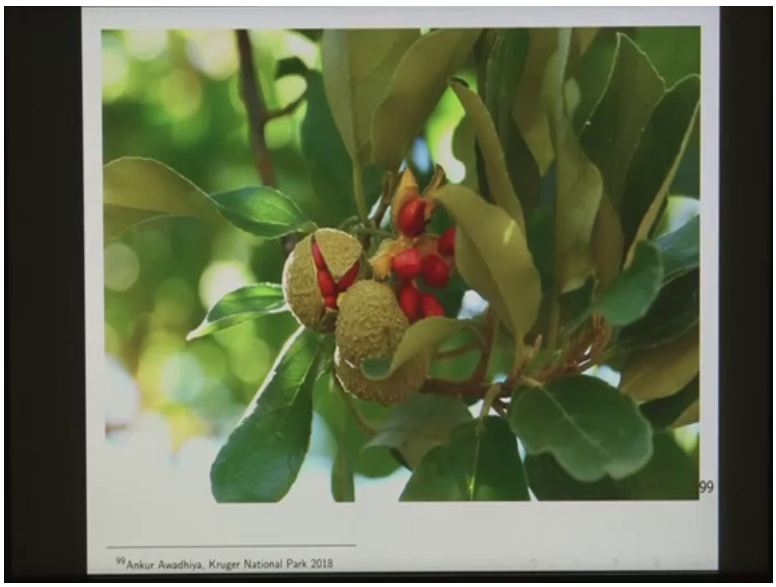
And if you are able to retain the viability so, in if you want to conserve a number of species you can do a very simple thing that you can collect the seeds from all these different species and then you can keep them in cold and dry conditions and that becomes a very good repository of all these different species. So, that is the idea behind a seed bank or a cryopreservation facility.

(Refer Slide Time: 43:17)



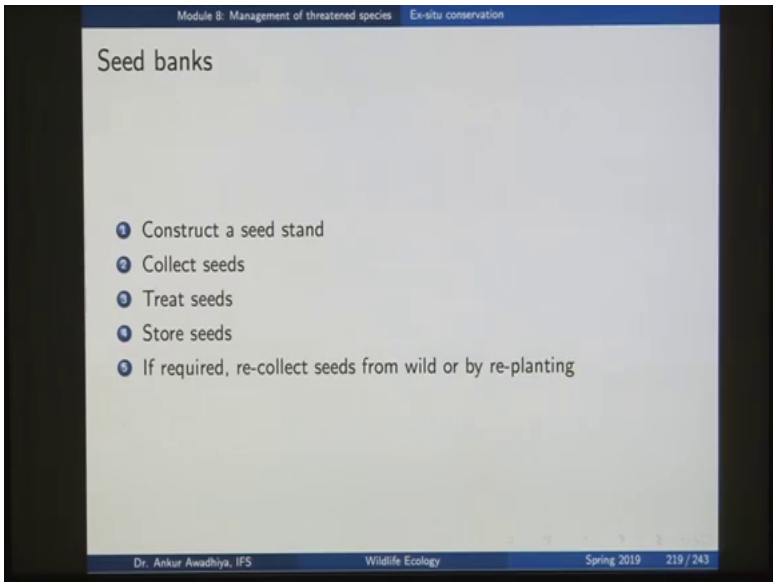
So, let us begin by looking at what a seed is? A seed is an embryonic plant that is enclosed in an outer protective coating. So, essentially this is an embryonic plant. So, given suitable conditions it will give rise to the plant, that is the most important thing and it is covered in a protective coating.

(Refer Slide Time: 43:33)



And seeds are found in fruits. So, here we see some fruits of a tree and these fruits have so, many seeds inside. So, you can collect these seeds.

(Refer Slide Time: 43:45)

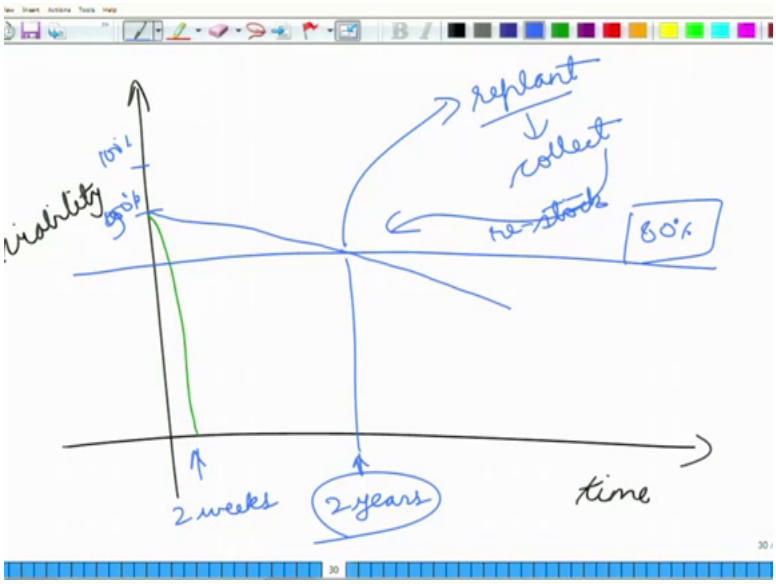


Now, if you want to construct a seed bank where these seeds can be stored, what are the steps that you will do? The first is to construct a seed stand; a seed stand is an area in which you have trees that give out a lot of seeds. So, that you can collect these seeds from there or else if you are not constructing a seed stand, you can directly go into the forest area and collect the seeds of different trees, but then seed stand helps because you can have access to a massive amount of seeds.

Once, you have collected these seeds you treat these seeds. Now, treatment consists of things such as deep pulping. So, seeds are there inside the fruit, if you have the pulp along with the seeds. So, pulp has a lot of moisture it also has a lot of feeding materials, it has sugars, it has carbohydrates and so on. So, you will have animals that will come and eat up these seeds or you will have some amount of fungal infestation in these seeds.

So, to remove that possibility you treat these seeds. So, you remove the pulp and then you dry these seeds. After, drying or after this treatment you store the seeds under proper conditions. And those conditions are cold climate. And dry climate and if required you recollect seeds from the wild or by replanting, because even when you are putting these seeds into these cold and dry conditions, you can retain the viability for some time, but this viability is not an infinite viability. So, if you have seeds with time and here you have the viability.

(Refer Slide Time: 45:14)

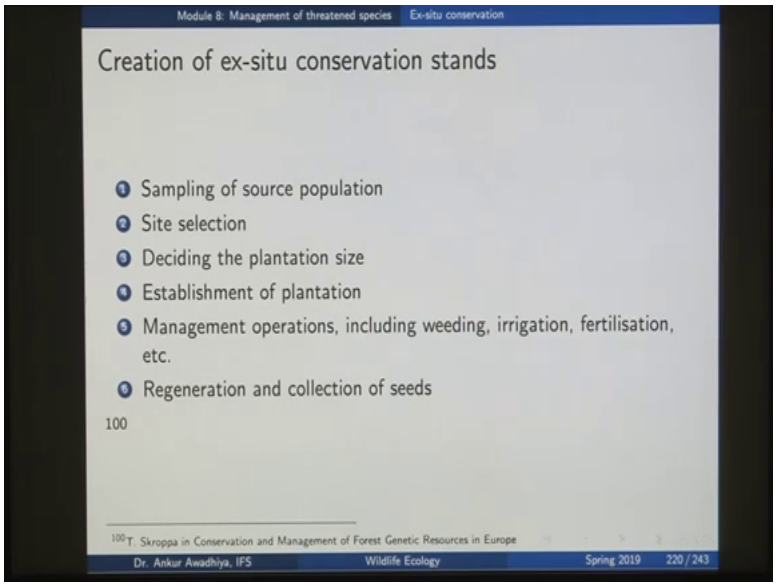


Now, if you have a seed that is there in the wild then you might have a viability that goes down very fast, but then in the proper conditions you will have a viability that goes down in a slow manner. But, then suppose you so, this is your 100 percent viability and let us say; let us say that this is your 100 percent viability, because even seeds that you correct from the wild will not have 100 percent viability, this is 90 percent viability. And suppose you have a condition that you want to have you maintain that you should maintain at least 80 percent of the viability.

Now, if you just kept seeds as such. So, probably they will lose their viability in say 2 weeks, but once you kept them in your facility, they are able to retain at least 80 percent viability up to say 2 years. Now, at the end of 2 years you have seeds that have 80 percent viability, but then if you wait further then the viability will go down below 80 percent.

Now to reduce that possibility, what you do is that you recollect seeds from the wild to restock your seed bank or else what you can do is you take these seeds and then you replant them. And once you have replanted these seeds and especially for those species that are very vigorous in their growth and are very fast in their growth. So, you can replant those seeds and then you can collect the seeds again and then you can restock. So, this is the process in which you maintain a seed bank.

(Refer Slide Time: 47:06)



Now, the first stage what we had see was construction of a seed stand? Now, a seed stand is in area where you are keeping the trees themselves. So, that they make the seeds available again and again in a large quantity. Now, if you want to construct a seed stand, how would you do that? The first step would be sampling of the source population, because you will again you will have a very great amount of diversity a great amount of variety that is available in nature. And through the sampling you will come to a conclusion about what different varieties you should collect. So, that your seed stand is a representative of the natural population.

Next, you go for a site selection. Now, site selection will make use of the ecological principles, if there is a plant that grows in the desert. So, the site where you should set up your seed stand should also be a desert area or if there is a plant that grows in a very colder area. So, your site should also be there in a very cold area and so on.

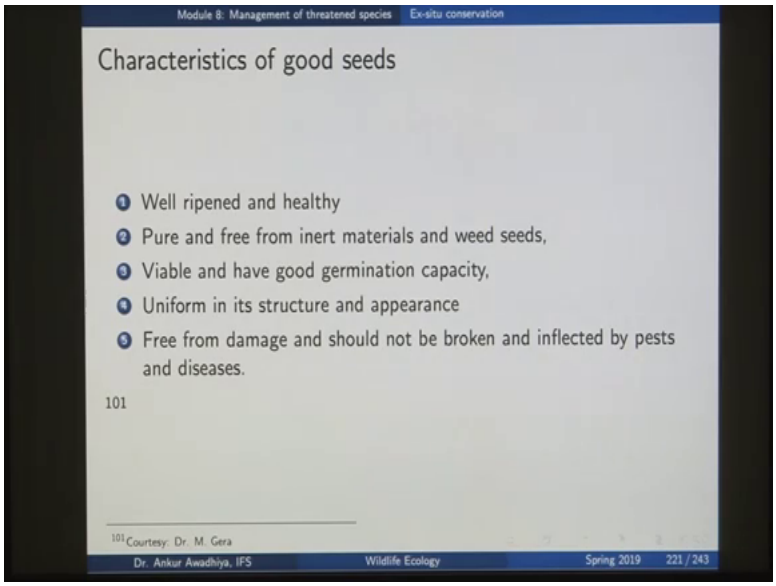
Once, you have selected the site and you have sampled next you decide on the plantation size. How many trees should you have in your area? So, that you are able to map the diversity that is there in the nature. So, you should have a very large number of trees, but not so, large that you are not able to manage that. So, you decide on a plantation size.

Once, you have done that now you establish the plantation. So, establishment of the plantation would mean that in this side for this mining size you bring the seeds or you bring the plants from the while and you plant them. So, that is establishment of a

plantation. Next, you manage that plantation, you do breeding operations, irrigation, fertilization and so on. And then once all these plants have become mature and they are giving out fruits and seeds. So, you regenerate this stand, you collect the seeds probably, you replant some of these seeds and so on. So, that is the process of construction of an ex situ conservation stand.

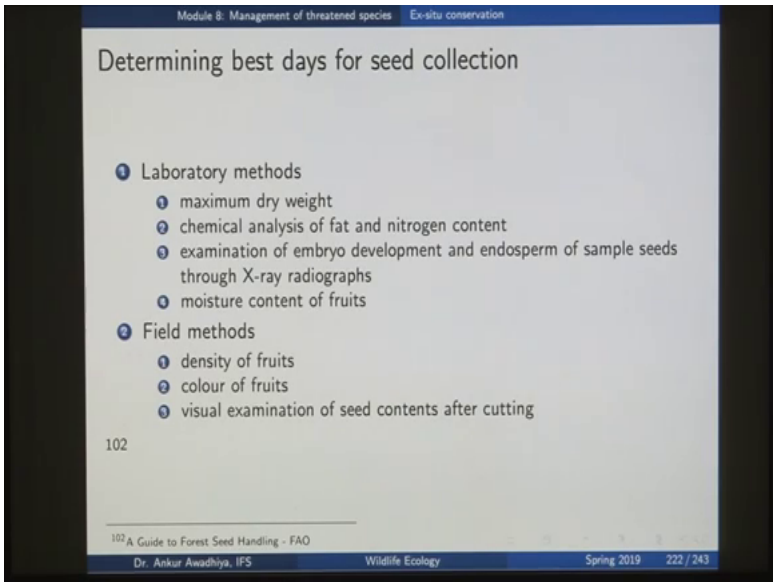
Whereas, if you are not constructing a stand if you are directly wanting to protect into a seed storage facility. So, in that case you need to know about, what are the characteristics of good seeds, what are the characteristics of a good seed bank and then bring 2 n 2 together. So, that you get a very good amount of viability of these seeds.

(Refer Slide Time: 49:33)



So, next we look at the characteristics of good seeds. Good seeds are well ripened and healthy pure and free from inert materials and weed seeds. So, inert materials include things such as dirt or hay or some other husk portion of the fruit or of the seed and so on. And it should be free of weed seeds so, when you are planting them again into the wild you should not be having any weeds. They should be viable and have good germination capacity; uniform in it is structure and appearance free from damage and should not be broken and infested by pests and diseases.

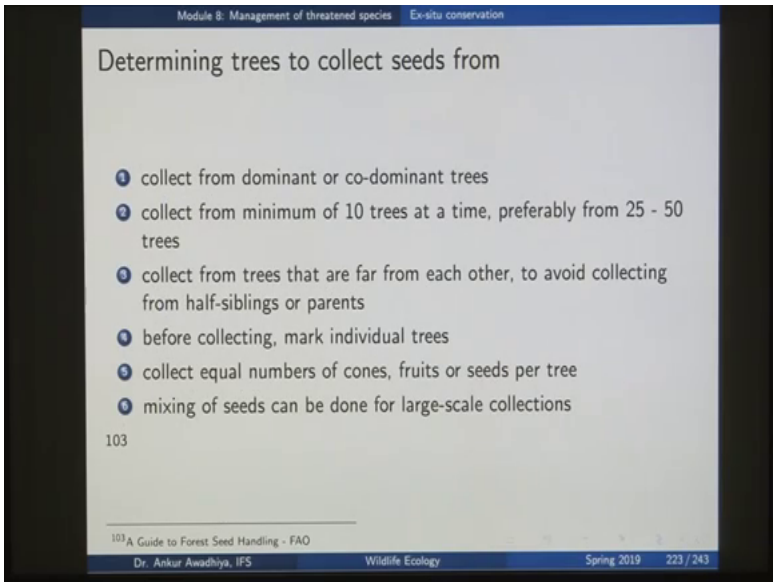
(Refer Slide Time: 50:13)



Now, you can determine the best days for seed collection using laboratory methods and field methods. So, essentially when you are collecting the seeds the fruits should be completely mature. And their maturity can be assessed by looking at their density looking at their colors or visual examination of the seed contains after cutting, or by looking at laboratory methods, such as maximum weight that can be attained by the fruit has that been attained.

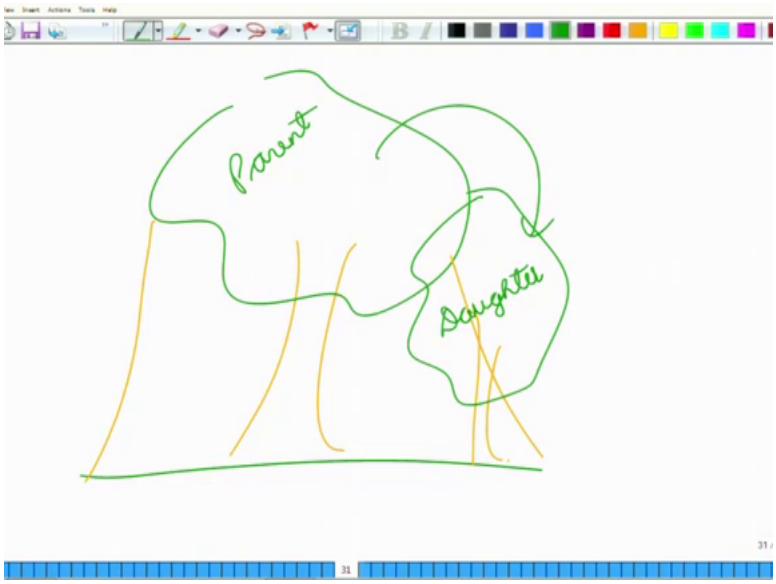
So, that would tell us that the fruit is now completely mature or we can have a chemical analysis of fat and nitrogen content or we can look at embryo at embryonic development and endosperm of sample seeds using X-rays or we can look at moisture content of fruits and so on. So, there are a number of ways through which we can understand, what is the best time to collect these seeds?

(Refer Slide Time: 51:01)



Then we also determined, what are the best trees to collect these seeds from? So, we normally collect from a dominant or codomain increase, because these trees get ample amount of sunlight and they are generally very vigorous and very healthy and their seeds also have a very good germination capability. And we collect from a number of trees, because we want to have variety in the seeds, we collect from trees that are far apart from each other to avoid collecting from half siblings or parents because if you have a tree.

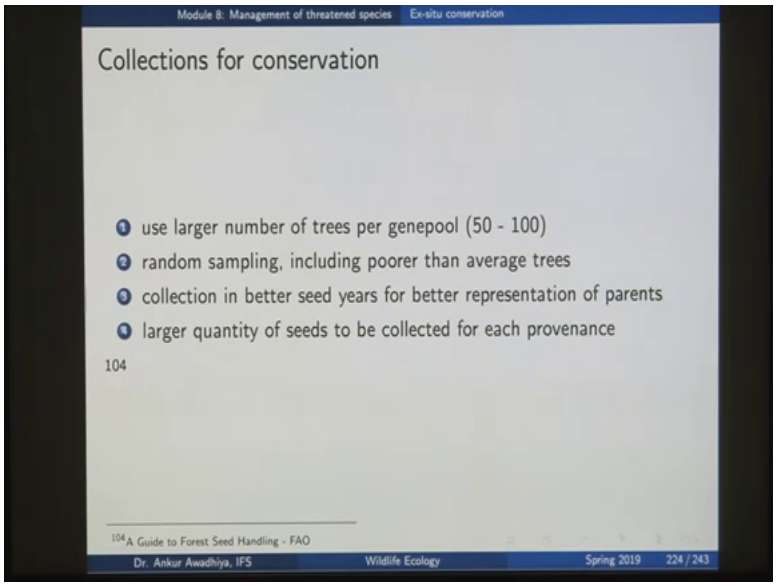
(Refer Slide Time: 51:36)



So, if you have a tree here and it is giving out fruits and it is giving out seeds. So, those seeds might fall in this particular area. And so, if you have another see, another tree, that is so, close to each other to the first tree, then it is possible that this tree is the so, this is the parent tree and this is the daughter tree. In which case because these, because both of these trees are so, closely related, so, we might be losing out on the diversity.

So, we try to collect from seed from trees that are far from each other. Before correcting we mark the individual trees and collect equal number of cones, fruits or seeds per tree. So, that we are able to get ample amount of diversity and then mixing of seeds can be done for large scale collection. So, that would depend on your management objectives.

(Refer Slide Time: 52:31)

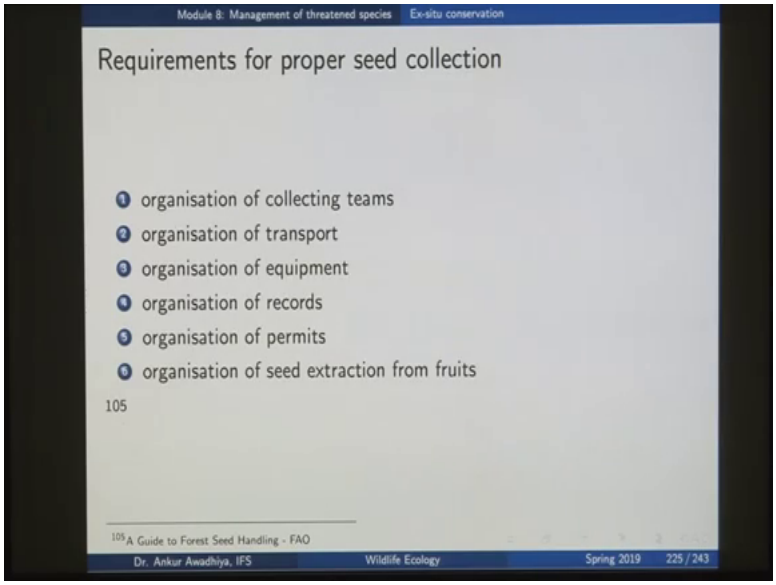


Then, we use large number of trees per gene pool, random sampling including poorer than average trees, because again when we say poorer than average trees there could be a tree that is not that tall that is not that healthy looking, but then probably that has some amount of disease resistance genes, that is not present in the taller trees. So, we even need to collect for from those trees that are not that good looking or poorer than average trees, because we want to maintain as much amount of diversity as is available in nature.

Then, collection in better seed years for better representation of parents so, seed years are those years where trees give out a very huge copious amount of seeds. So, we collect in good seed year. So, that there is more amount of seeds and a better representation of the

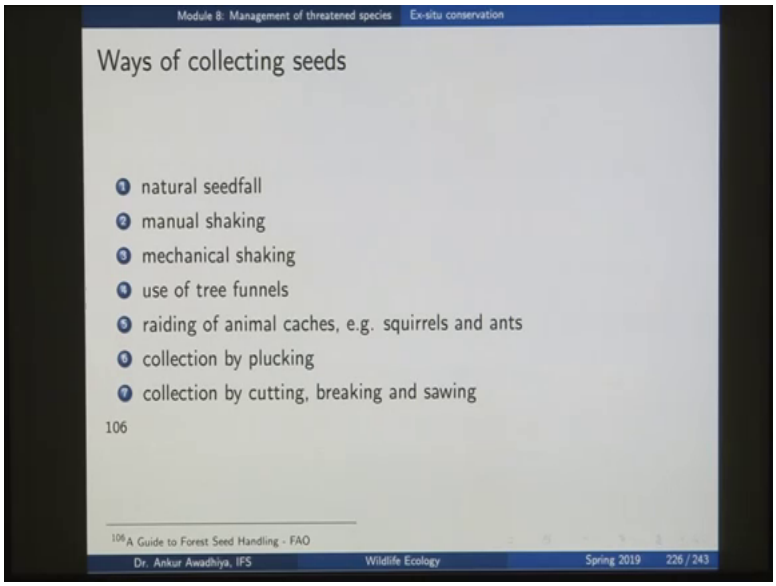
parents. And large quantity of seeds to be collected for each provenance of our each different geographical region.

(Refer Slide Time: 53:28)



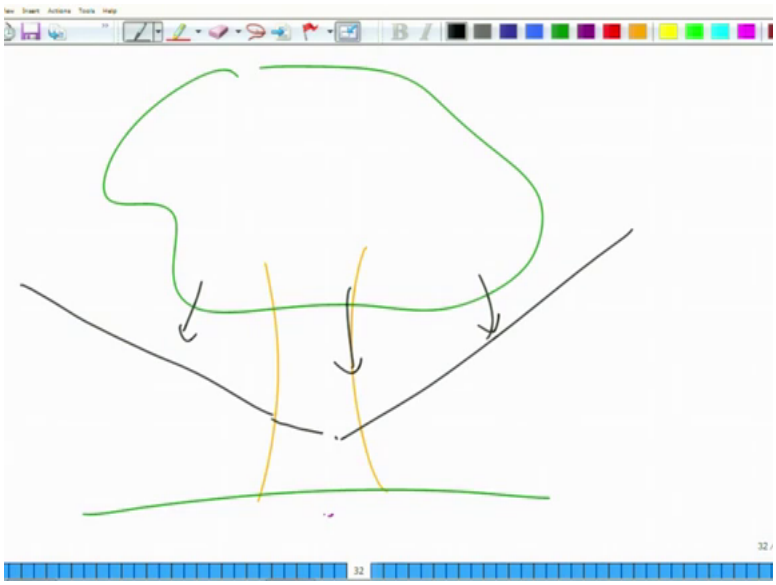
Next, for a proper seed collection we need to go for an organization of good collecting teams, we need to make arrangements for transportation equipment, records, permits, seed extraction from fruits and so on. Because, all of these things are time bound if you have collected the fruits and if you have not removed the seeds fast enough. So, it is possible that your fruits might get infested and the seeds might also get infested. So, all of these need to be properly managed.

(Refer Slide Time: 54:02)



Now, the ways of collecting seeds include natural seed fall in which you can make use of certain cones.

(Refer Slide Time: 54:15)

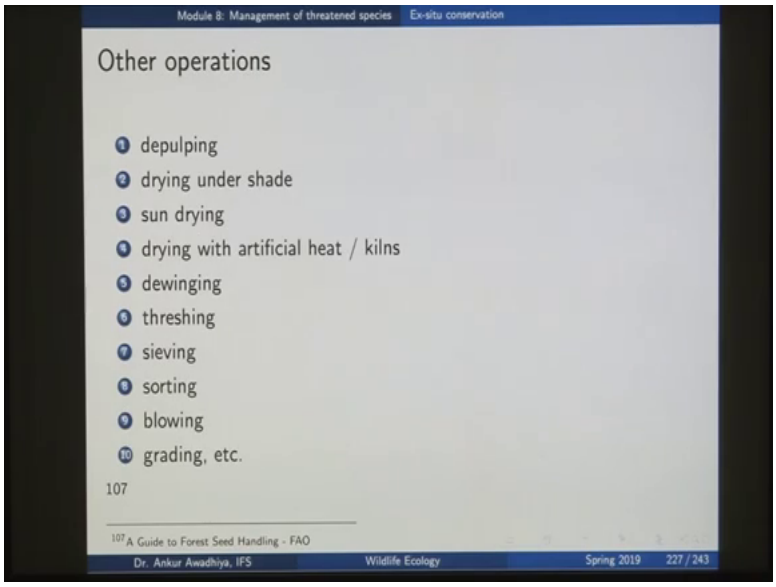


So, you have this tree and in the seeding season this tree would naturally release the seeds outside. So, probably you could set up a cone like arrangement of cloth. So, all these seeds when they fall from the tree they get collected in this cone and from there you can collect them for your storage facility.

So, you can make use of seed fall or you can shake the trees manually or mechanically or you can make use of tree funnels as we have seen or you can make use of raiding of animal caches like squirrels and ants. So, squirrels generally tend to store a large number of nuts seeds into their caches and we can read those caches and get all those seeds or we can collect by plucking or we can collect by cutting breaking and sowing of the trees.

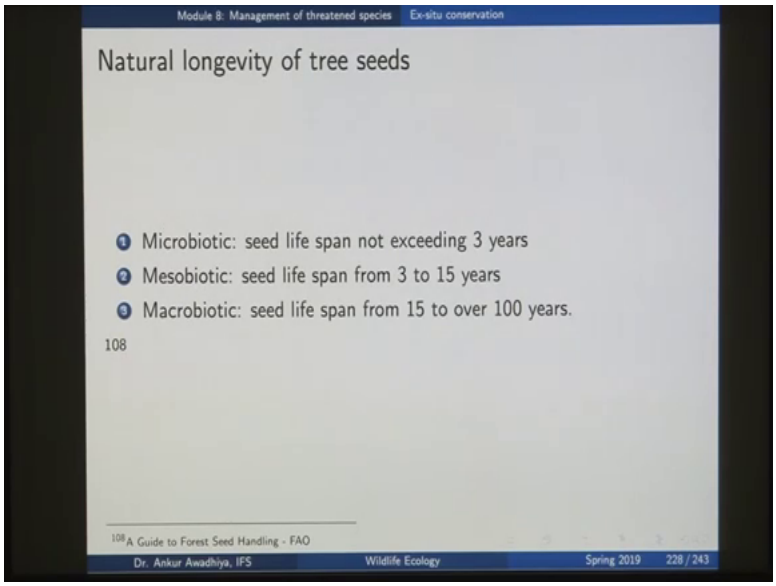
Now, in a number of cases natural seed fall is not used if not together with this tree, fennel because if there is a seed that is fallen to the ground, then there is a good possibility that, some insects or maybe some fungi or some microbes have already come into contact with that seed. Similarly, raiding of animal caches is not a very preferred option, because here again the cache of a squirrel might have a damp situation in which you might have fungi fungal infection on the seeds.

(Refer Slide Time: 55:41)



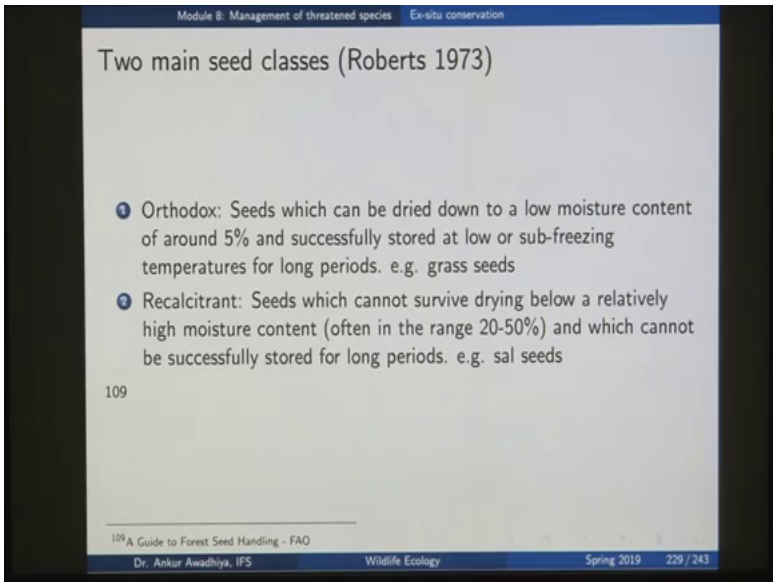
Then, the other operations include depulping removing of the pulp drying, under the shade sun drying, artificial drying, dewinging, threshing, sieving, sorting, blowing, grading and so on. So, essentially by all these methods what we are trying to do is that we are trying to get to the best possible seeds in the best possible state, which is a seed that is devoid of any other fruit contents, it should not be having any amount of pulp or any amount of husk with it and it should be in a dry state. And we also perform grading to get the best quality seeds, so, they are mostly last sized seeds.

(Refer Slide Time: 56:20)



Now, if you look at natural longevity of seeds we can divide seeds into 3 categories microbiotic in which the seed lifespan does not exceed 3 years, mesobiotic where the seed lifespan is from 3 to 15 years.

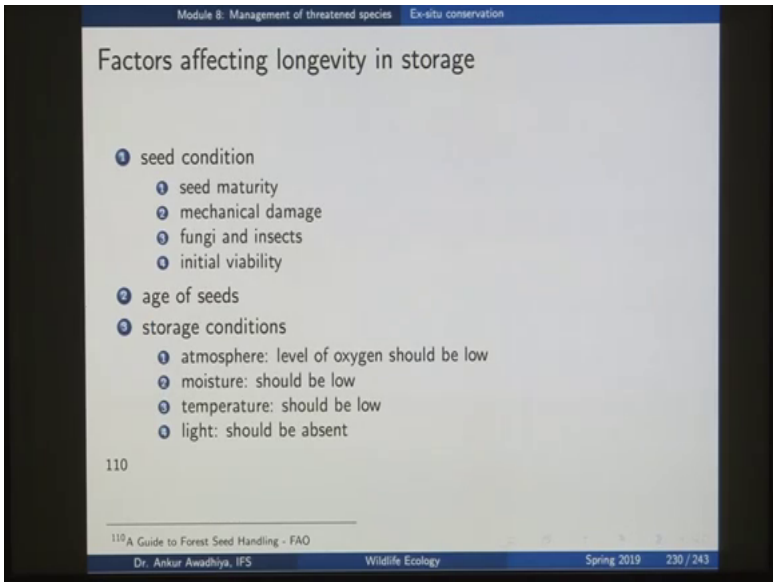
(Refer Slide Time: 56:43)



And macrobiotic where there is the lifespan is greater than 15 years. And whether or not we can dry a seed by this process we divide seeds into 2 main classes; one is orthodox seeds, where the seeds can be dried down to a low moisture content of around 5 percent. And the second one is recalcitrant seeds they often have very high oil content and they

cannot survive drying below a relatively high moisture content are now greater than 20 percent. And so, they cannot be successfully stored for long periods. Whereas, orthodox seeds can be stored for very long periods and good examples are grass bamboo or grain seeds.

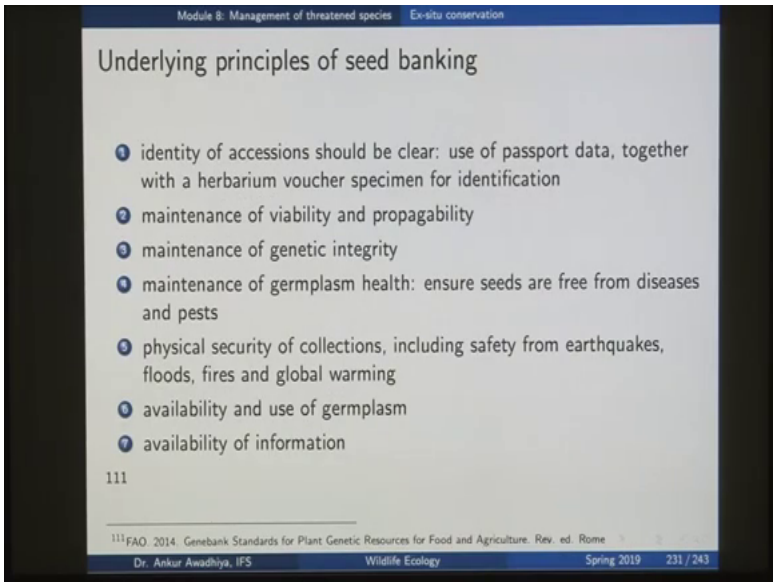
(Refer Slide Time: 57:17)



And in the case of our seed banks it is important to note the factors that affect the longevity of the seeds the seeds need to be in good condition. So, seeds should be matured free of mechanical damage should not have any infestation, the initial viability should be high, the age of the seeds has to be good. So, you cannot have seeds that are very young or that are very old, because in that case they will not have ample amount of viability in long term storage.

Then the storage conditions have to be optimum the atmosphere should have low level of oxygen. So, we generally seal these seeds, the moisture level should be low, the temperature should be low and the light should also be low or absent.

(Refer Slide Time: 58:01)

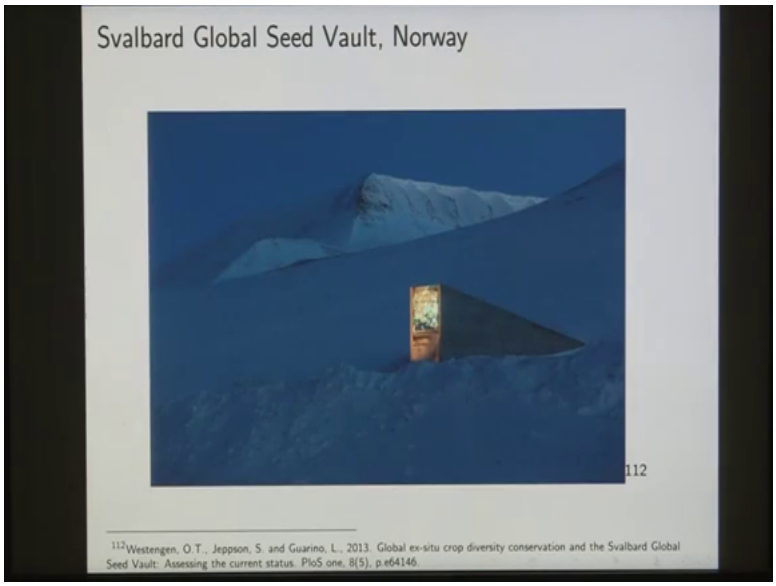


And in this case the underlying principles are that when you are collecting these seeds, when you are storing these seeds, then these seeds need to have clear cut accession numbers you need to have passport data which tells you, where this seed was collected, who collected it, when was it collected and which species does it belong to if there is any particular variety or any subspecies that it belongs to that also needs to be maintained.

And then the seeds have to be maintained in conditions of good viability and propagability, genetic integrity needs to be maintained, when you are doing a long term storage, maintenance of germplasm health. So, that the seeds are free from diseases and pests. So, they should be able to germinate when a we are putting them back into the soil.

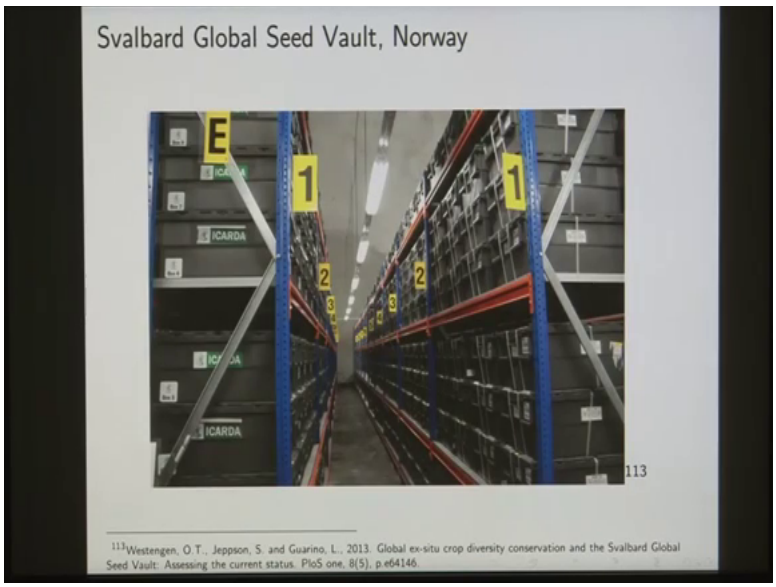
Then, your facility has to have a good amount of physical security, including safety from earthquakes floods fires and global warming, availability and use of germplasm. So, you need to decide on the policies, when and how do you make this germplasm available to different people. If, people wanted for research, if people wanted for restocking are you going to give it to them what are the processes involved are there any costs involved. And the availability of the information regarding what are seeds are available what all seeds are needed and so on.

(Refer Slide Time: 59:20)



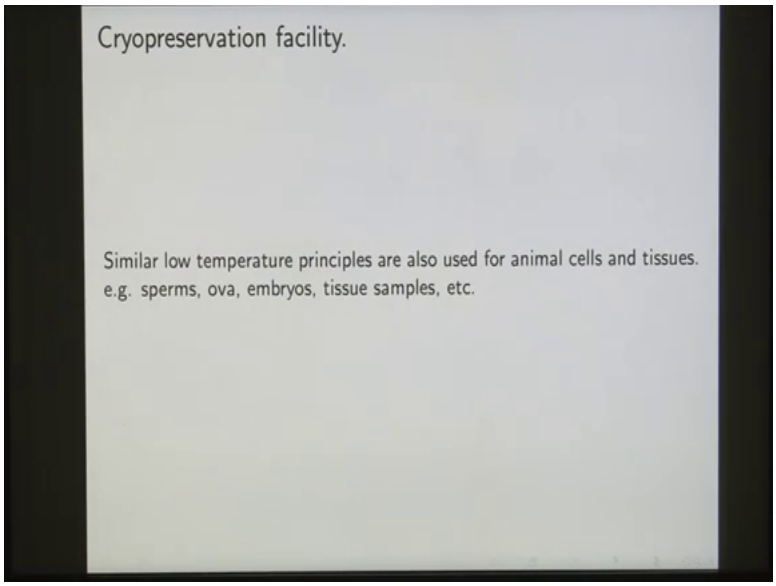
And a good example of such a storage facility is the Svalbard global seed vault in Norway. So, this is the seed vault is located in a location, where there is a permafrost. So, all down the year this area is well below the freezing temperatures and this is also at a very great height. So, that if there is global warming and if there is flooding, if the ocean levels rise even then this facility is saved.

(Refer Slide Time: 59:47)



And we keep the seeds in these different containers in these rocks, after properly naming all of these different germplasm.

(Refer Slide Time: 59:59)

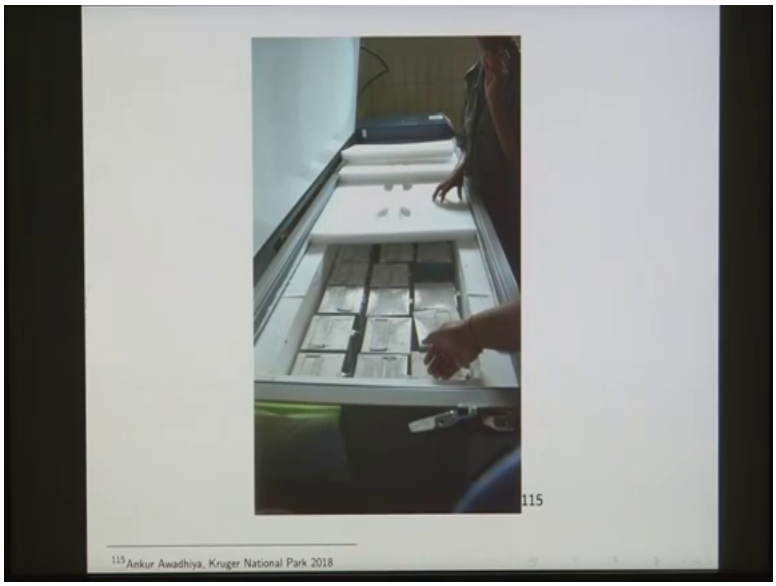


And similar to the case of the plant seeds, we can even have a cryopreservation facility for animal cells and tissues including sperm cells, ova sells, embryos, tissue samples and so on.

(Refer Slide Time: 60:09)

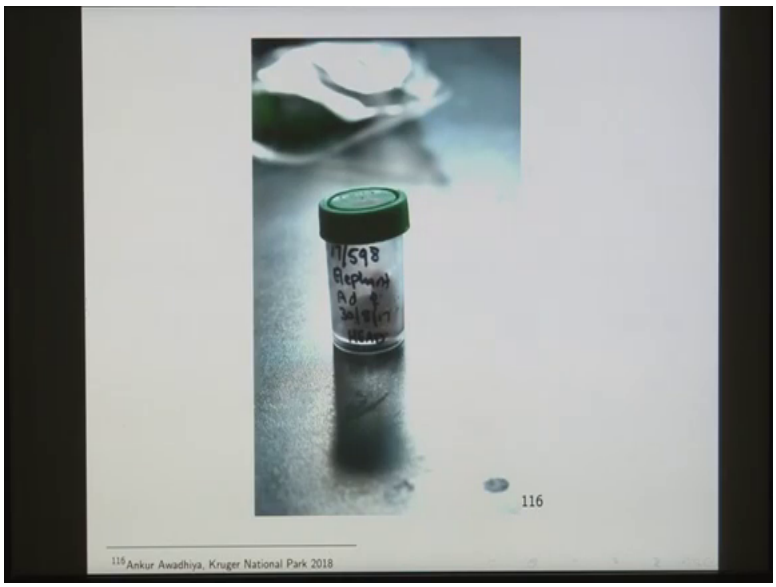
And in this case you can have it even in a laboratory, where you can have these chest freezers, which are maintained at a very low temperature say minus 18 degrees.

(Refer Slide Time: 60:18)



And in these chest freezers you can have these different boxes in which the different samples are kept.

(Refer Slide Time: 60:21)



So, that is this is another example of a cryopreservation facility. So, in this lecture we looked at ex situ conservation, what does it mean, why is it required, when do we do ex situ conservation, when do we go for any in situ conservation method? And then we looked at 3 different case studies of ex situ conservation facilities, we looked at the Mysore zoo to understand what zoos are how do they work, we looked at Kirstenbosch

botanical garden to understand, what are botanical gardens, what do people do in botanical gardens, why are they important, how do they work and so on. And we looked at the cryopreservation facilities in terms of small bird and in terms of the animal cryopreservation facilities.

So, ex situ conservation facilities are extremely important for conservation, they not only support the in situ conservation methods, but at the same time for certain species that are extremely critical, they are probably the only choices that we are left with. So, that is all for today.

Thank you for your attention [FL].