Practical Manual: Ecology (ZOO405)

Virtual University

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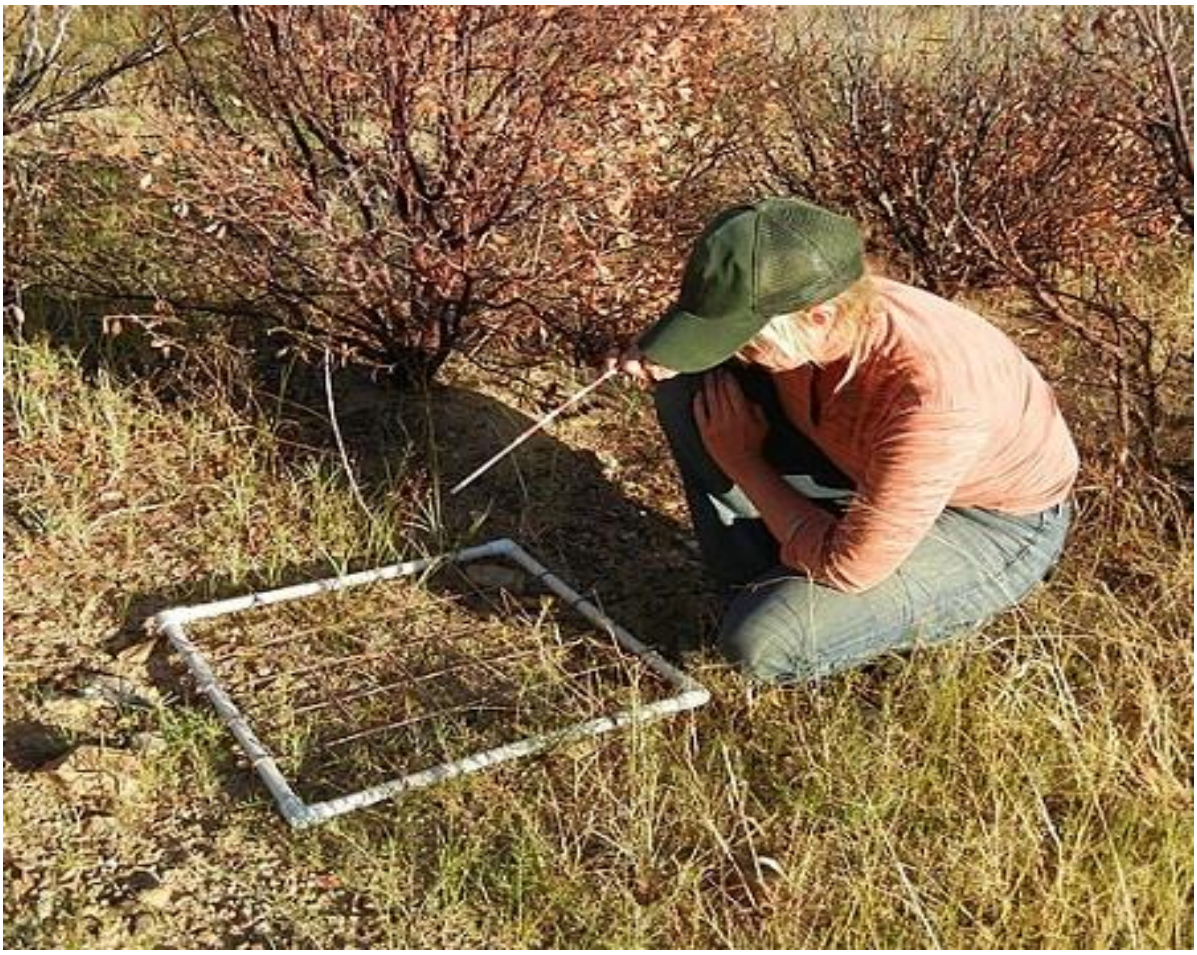
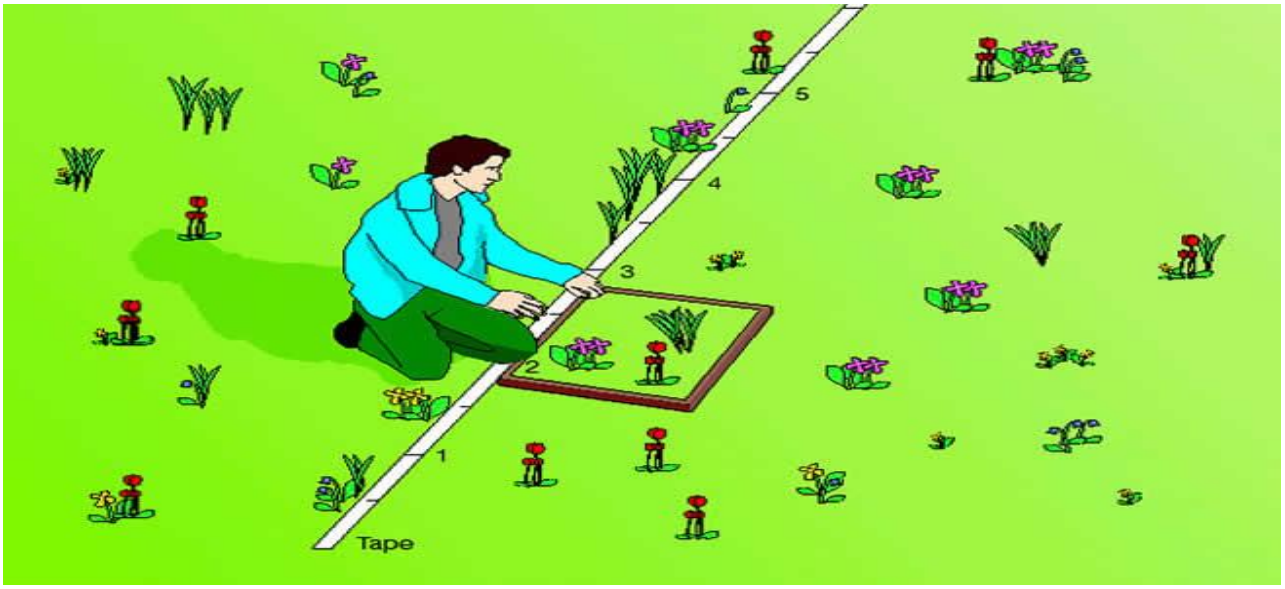
Contents

Practical No. 1
Population Sampling Techniques

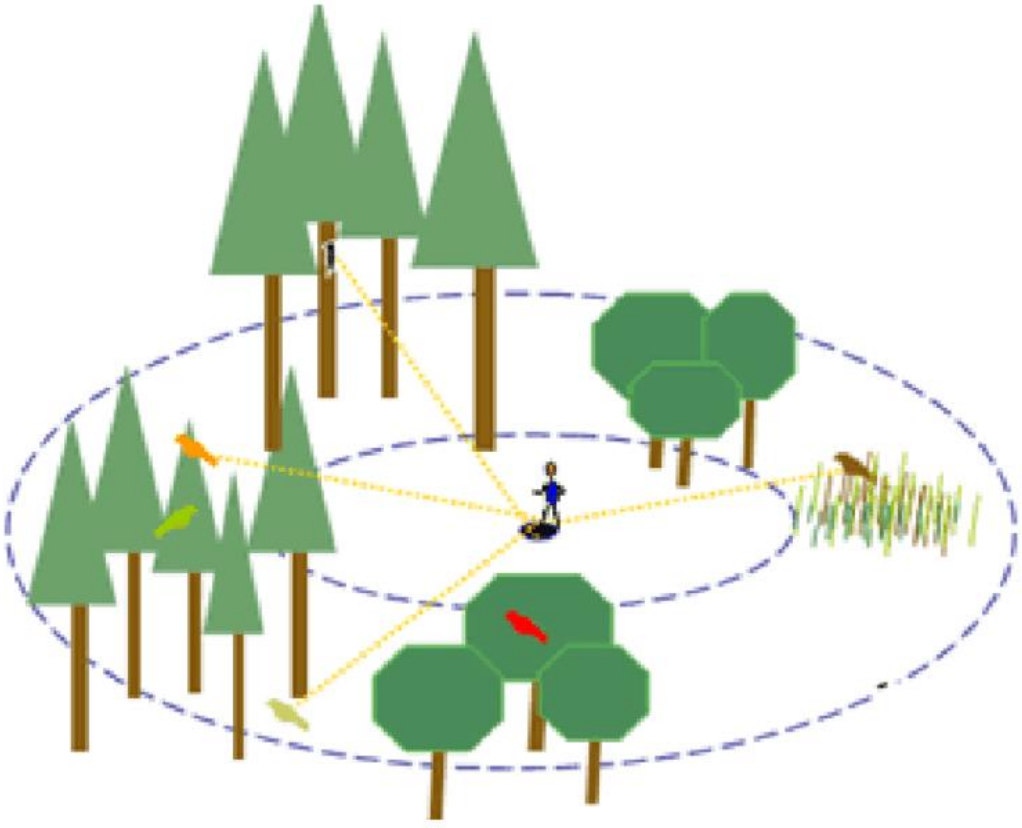
1. Quadrate Method: A quadrat is a small, designated portion of the entire area to be sampled that is marked off so that the population within it can be counted by hand or by a similar method, like by taking an aerial photograph. A quadrat is often rectangular-shaped, although any shape can be used as long as all of the quadrats marked off in the area whose population is to be estimated are the same size. To estimate the population of an entire large area, then, several quadrats of equal size are marked off within that total area.



2. **Line Transact method:** Transect sampling is conducted by using a transect line. A transect line is usually a rope or measuring tape that had been marked at a set measurements , such as every metre. The line is unrolled throughout the habitat. At every interval, the type and number of species along the line is recorded.

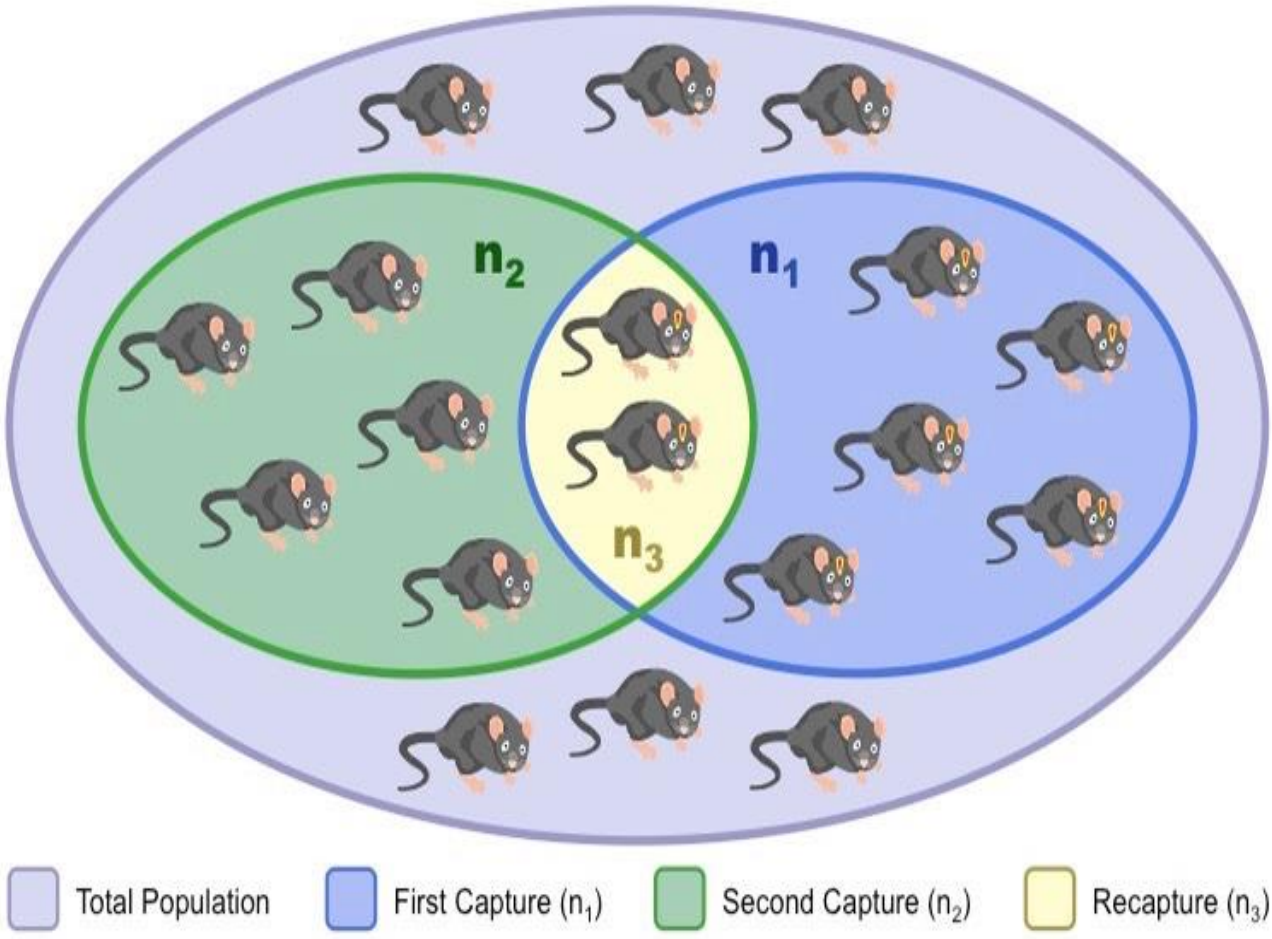


3. **Point count Method:** A point count is a survey method used to count birds, where an observer stands at a single location and records all of the birds seen and heard in a given amount of time.



4. **Focal Scan method:** Focal animal sampling involves observing a single individual of a particular species, usually for a specified period of time. This technique is often used to study specific behavior patterns. The observer records all instances of the behavior under study within a given time interval.

5. **Capture and Recapture Method:** Capture-Recapture sampling methods are being used to estimate the population size of an unknown population. These methods are widely used for determining the population size of animals and birds. In this animals are trapped, eg using pitfall traps. they are marked in a harmless way and then released. traps are used again a few days later. the numbers of marked and unmarked animals caught in the traps are recorded.



Practical No. 2
Study of different Ecosystems

Freshwater Ecosystem: The freshwater ecosystem is one of the essential ecosystems for humans and other organisms living on land. This is because this ecosystem is a source of drinking water. Additionally, it also helps in providing the necessary energy and water for transportation, recreation, etc.Freshwater ecosystems mainly include lentic, lotic, and wetlands.The freshwater ecosystem is the smallest type of ecosystem among the major types of ecosystems. There is usually no salt content in the freshwater ecosystem. Besides, it consists of many insects, small fish, amphibians, and various plant species. Plants help provide oxygen through photosynthesis and also provide food for the organisms living in this ecosystem.

Marine Ecosystem: Marine ecosystems are usually characterized by the presence of salt content. These ecosystems have a higher salt content than the freshwater ecosystem. Moreover, they are known as the largest type of ecosystem on Earth. It usually includes all the oceans and their parts. Besides, marine ecosystems have a distinctive flora and fauna, which support greater biodiversity than freshwater ecosystems. This type of ecosystem is essential for both marine and terrestrial environments.

Terrestrial Ecosystem: Terrestrial ecosystem refers to all such ecosystems which are mainly located on land. Although the presence of water in these ecosystems is measured, they are entirely land-based and exist on land. More specifically, a low and sufficiently needed amount of water is located in terrestrial ecosystems. The low amount of water separates these ecosystems from aquatic ecosystems. Besides, terrestrial ecosystems typically have temperature fluctuations in both seasonal and diurnal climates. It is also a specific factor that makes these ecosystems different from aquatic ecosystems in similar environments.Terrestrial ecosystems are mainly classified into the following types:

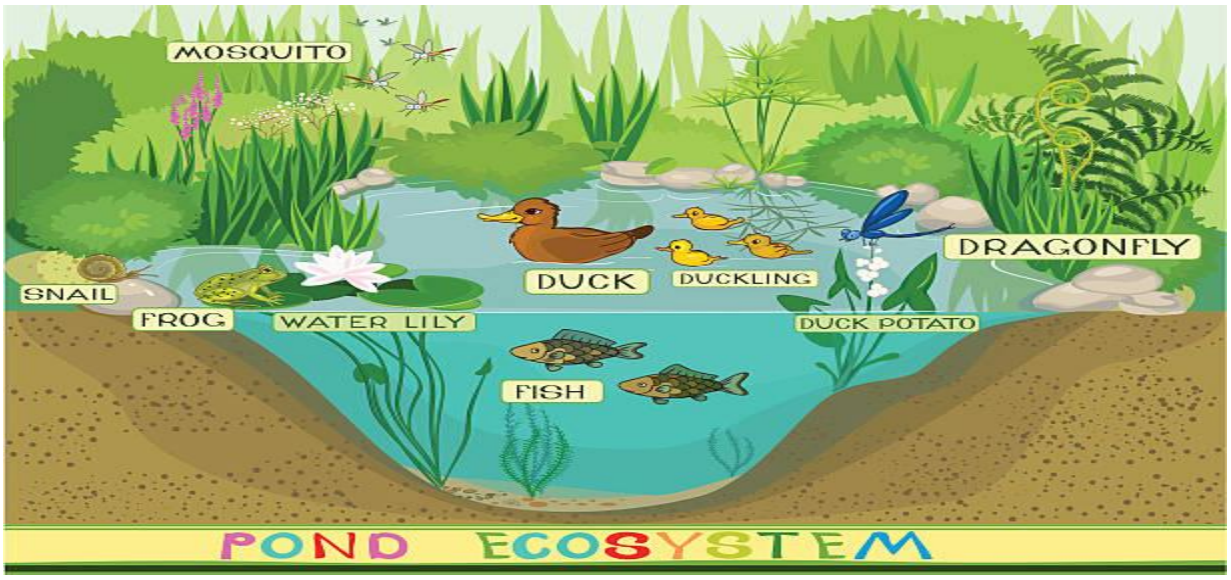
Forest Ecosystems: A forest ecosystem is an ecosystem where many organisms live together with the environment's abiotic components. There are much different flora and fauna in this ecosystem. This usually means that the forest ecosystem has a high density of living organisms that live with non-living abiotic elements. The forest ecosystem usually includes various plants, microorganisms, animals, and other species.

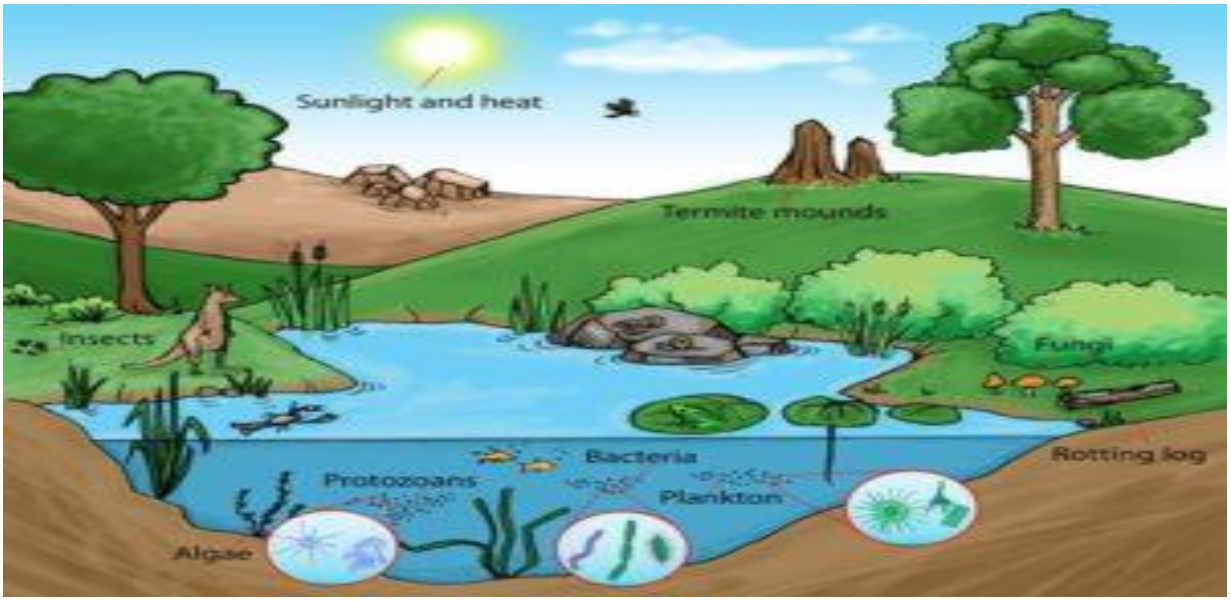
Grassland Ecosystems: Grassland ecosystems are referred to as those ecosystems where the number of trees is low. These ecosystems mainly consist of grasses, shrubs, and herbs. That means grasses are the primary vegetation in these ecosystems, along with legumes that typically belong to the composite family.

Mountain Ecosystems: As the name suggests, the mountain ecosystem is characterized by mountainous regions where the climate is usually cold, and rainfall is low. Due to these climate changes, these ecosystems have a wide variety of habitats where various animal and plant species are found. The high altitude areas of mountainous regions have a cold and harsh climate. This is the reason why only treeless alpine vegetation is found in these ecosystems. Animals found in these ecosystems usually have tick fur coats to protect them from cold climates. Besides, mainly coniferous trees exist on the lower slopes of the mountains. Examples of mountain ecosystems include mountain tops in Arctic regions. They are covered with snow for most of the year.

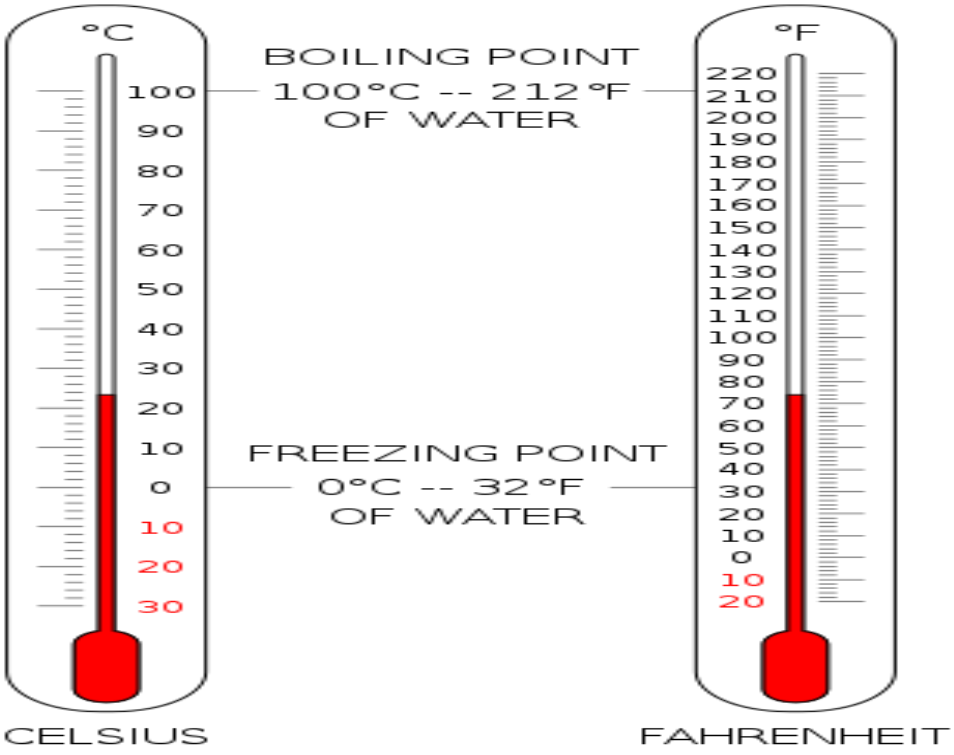
Desert Ecosystems: Desert ecosystems exist worldwide and cover about 17 percent of desert areas. These are areas where annual rainfall is usually measured less than 25 mm. Due to fewer trees and land of sand, sunlight intensifies in these ecosystems. This is why these ecosystems have incredibly high temperatures and low availability of water. However, the nights are quite cold.The Desert ecosystem has unique flora and fauna. Plants grow with small amounts of water and conserve water's possible amount in their leaves and stems. For example, the spiny-leafed cactus is a type of desert plant that has the characteristic of storing water using a stem. Similarly, animals are also adopted to the condition of desert

ecosystems. Some common animals are camels, reptiles, a diverse range of insects and birds.





Practical No. 3
Measurements of physical Factors of different Ecosystems

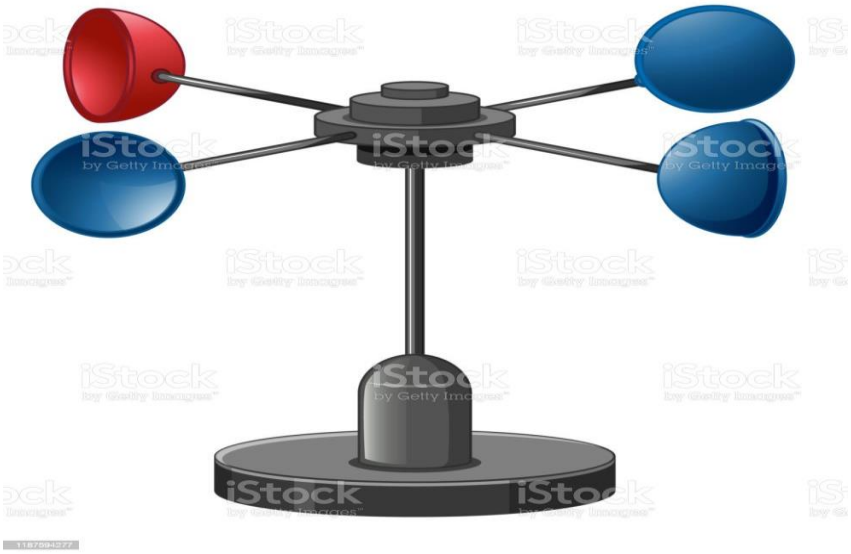
1. **Temperature**: This is measured using a mercury thermometer read in degree celcius (°c). At least two readings are taken in a particular area of the habitat being studied to ensure accuracy. A soil thermometer is used for soil temperature, a maximum-minimum thermometer for recording the highest and lowest temperature of the day, and a waxed bulb thermometer for temperature of water at different depths in a pond, stream, etc. The waxed bulb thermometer is usually tied to a string knotted at regular intervals to indicate depth.
2. 

3. **Rainfall**: This is measured with a rain gauge. This can be made from a tin can, a plastic funnel and a 50ml measuring cylinder. The amount of rainfall is calculated in millimeters, with the formuladD2×h= rainfall for a period where;d = diameter of mouth of funnelh = height of rainwater in the cylinderD = diameter of collecting cylinderUsually, the height of the water

in the cylinder indicates the amount of rainfall after every storm.

4. **Relative Humidity:** This is measured using a wet and dry bulb hygrometer, or a pocket hygrometer. The pocket hygrometer is exposed to air and the reading taken after the lever arm has stabilized. The wet and dry bulb hygrometer is swung in air for 30seconds and the reading on the thermometers taken and converted to relative humidity units using a table of conversion. The hygrometer may also be kept in a Stevenson's screen.

5. **Wind:**Wind has both speed and direction. Wind direction is measured / indicated by a wind vane while wind speed is measured with an anemometer (recorded in ms^{-1}).



6. **Light Intensity**: Is measured by a light meter or photometer. The readings on the meter are expressed in lux units. The greater the intensity of light, the higher the readings on the meter and vice-versa.

7. **Pressure**: Atmospheric pressure is measured with a barometer. It is measured in millibars (or millimeters of mercury, mmHg). The readings are taken directly from a scale.

Picture: Modern Aneroid barometer

8. **Water Depth**: Is measured with a meter rule or a marked and weighted line knotted at one meter intervals. The meter rule is attached to a weighted line to ensure that it is vertical in water.
9. **Water Flow**: To measure the speed of flow of a water body, the distance (m) covered per unit times by a float is taken. The float may be a weight tube and the distance covered has to be pre-determined. Speed of the current is calculated in meters per second. A simple water-speed meter can be used to compare the speed of water flow at different positions in a stream
10. **Turbidity**: Is measured by slowly sinking a weighted white disc called a secchi disc into the water, noting the depth at which it just cannot be seen anymore. This is not a real measurement of turbidity but a useful method of comparing the turbidity of different aquatic habitats, different sites of the same habitats, or at different times.
11. **Slope**: Is measured with a simple slope gauge constructed with a meter rule to which a protractor is attached. The angle readings on the protractor are read and recorded. Small angles indicate a steep slope.
12. **Height**: The height of objects like tall trees is measured using the principle of similar triangles.

Practical No. 4
Adaptive features of animals in relation to food and environment

Adaptations are any behavioral or physical characteristics of an animal that help it to survive in its environment. Adaptations can be either physical or behavioral. A physical adaptation is some type of structural modification made to a part of the body. A behavioral adaptation is something an animal does - how it acts - usually in response to some type of external stimulus. When you look at an animal, you usually can see some of its adaptations -- like what it is able to eat, how it moves, or how it may protect itself. Different animals have many different ways of trying to stay alive. Their adaptations are matched to their way of surviving. Each group of animals has its own general adaptations. These groups are: fish, amphibians, reptiles, birds, and mammals.

Body Parts Many animals have developed specific parts of the body adapted to survival in a certain environment. Among them are webbed feet, sharp claws, whiskers, sharp teeth, large beaks, wings, and hooves.

Webbed Feet: In most aquatic animals, swimming is a must. To aid swimming, many animals have adapted and evolved with webbed feet. Webbed feet help animals propel themselves through the water with ease. This can help the animal swim faster to catch prey or escape a predator. Also, if an animal has to swim long distances, webbed feet can help it save energy so it can swim farther. One animal that can be observed at the Zoo with webbed feet is the rockhopper penguin. Other animals with slightly webbed feet: the polar bear and otter.

Sharp Claws: Many land and sea animals alike have developed sharp claws. Sharp claws can be used for many different purposes. For instance, many herbivores use their sharp claws for digging for berries, roots, and herbs or burrowing for shelter. Animals that eat meat may use their claws for killing their prey or tearing meat from their kills. Also, claws can be used to increase traction to run faster, as in the case of the cheetah. Other times, sharp claws have evolved for use in defense. For some animals, showing of claws is enough warning for their predators or competitors to back off. There are many animals at the Milwaukee County Zoo with sharp claws, including many of the bears and felines, as well as aquatic animals like the California sea lion.

Whiskers: Although not usually thought of as an adaptation, whiskers serve an important purpose for many animals. In most cases, whiskers around the face, specifically the mouth area, help the animal feel its way through tight spots. In a way, they serve as "feelers," telling the

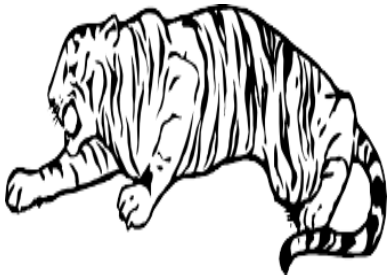
animal whether or not it can fit into a specific area. One example is that of the North American river otter, which can use its whiskers both on land and in water. On land, they are used to feel their way through narrow channels, with a similar purpose for the whiskers under water. They are also useful to sense prey.

Sharp Teeth: One of the most visible adaptations on many animals, sharp teeth help an animal eat meat.Found primarily on meat-eating animals, or carnivores, sharp teeth are used mainly for the tearing and chewing of an animal's prey. Rather than developing the dull teeth of plant-eaters, or herbivores, carnivores rely on their sharp teeth to allow them to eat and survive. Sharp teeth can serve another purpose: defense. In some animals, bearing a large set of sharp teeth can show power or fear. The Milwaukee County Zoo features many animals with sharp teeth. Unfortunately, it is often difficult to see this distinctive feature. Some animals that we suggest you watch are the snow leopard, cheetah, African lion, mandrill and lowland gorilla.

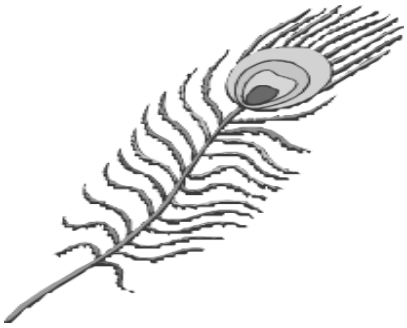
Large Beaks: Just as in the case of sharp teeth, large beaks are often an adaptation used to help an animal eat. However, large (and often sharp) beaks can be a feature of both carnivores and herbivores. For instance, the large beak of the macaw has been adapted to help it crack open large nuts to reach the sweet fruit and pulp inside. On other birds however, the large beak is used to tear meat, as in the case of the rhinoceros hornbill. The rhinoceros hornbill uses its large beak to tear meat off of an animal it scavenges -- usually the result of another animal's kill.

Body Coverings: An animal's body covering is one clearly visible adaptation. Body coverings help to protect animals in diverse environments -- from the land to water, from the arctic to the desert. Mammals have hair, or fur, that helps insulate their bodies. It keeps them warm in winter and can protect specific areas of the body, like eyelashes protecting the eyes.

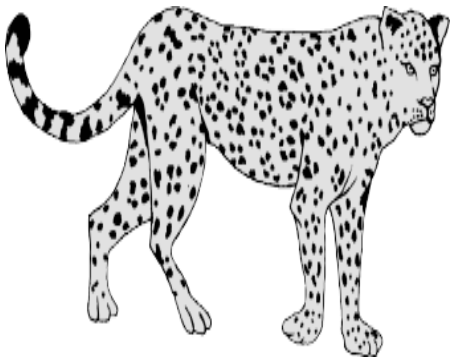
Striped Fur: Striped fur is one variation of a special adaptation called camouflage. Striped fur, in most cases, helps animals blend into their environment. This helps the animal in one of several ways, including hiding from predators and sneaking up on prey. Striped fur, as in the case of a tiger's vertical stripes, serves the animal by helping it match the surrounding vegetation, thus making it nearly invisible to other animals. In other animals, like the skunk, the stripes serve as a warning to predators. In this way, the stripes serve as a defense mechanism.



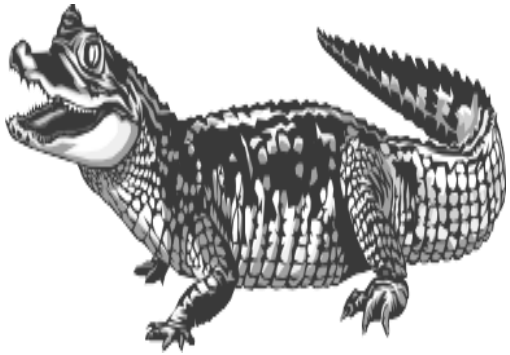
Brightly Colored Feathers: Found mostly in tropical rain forests, birds with brightly colored feathers are another example of an animal with an adaptive body covering. Brightly colored feathers can serve several purposes, including camouflage, defense, and mating. In some parts of the rain forest, the macaw and its brightly colored feathers can hide amid similarly brightly colored plants and flowers. The male peacock uses its bright feathers for another purpose: attracting a mate. In contrast to the male, the female peafowl has very dull colored feathers. This feature, common among female birds of most species, helps females hide while guarding their nest and protecting their young.



Spotted Fur: Another adaptive type of body coloring is spotted fur. Spotted fur is similar to striped fur in the fact that it serves as camouflage. Many animals with spotted fur live in heavily wooded forest areas. One example is the jaguar, which lives in the rain forest. The jaguar's spotted fur helps it blend in with the small patches of sun that reach the rain-forest floor. These patches,mixed in with the shade, produce an effect that highly resembles a jaguar's coat. Another animal with spotted fur is the snow leopard. The snow leopard, with a white coat and black spots, lives in wooded areas as well, using its coat to hide amid the trees and snow.



Scales: One final type of body covering is scales. Scales serve a purpose different than that of fur and feathers. Scales are mainly a protectant from the environment for most animals. For instance, anacondas and other snakes at the Milwaukee County Zoo have scales to protect their bodies from the variety of terrain they encounter. In the case of the anaconda, its habitat is largely made up of water. In the case of other snakes, the climate may be dry and the land sandy and rocky; so they cannot afford to lose water from their body. Scales help protect the body of the animal in an instance where skin, fur, or feathers would become damaged or destroyed.



Practical No. 5
Food chain studies through analysis of gut contents

Studying Food and Feeding of Fishes: Gut content analysis helps understand the problematics of fish species natural history, nutritional requirements, trophic, material and energy dynamics, food webs, food chains, material and energy transfers between and within ecosystems.

The study of the feeding habits of fish and other animals based upon analysis of stomach content has become a standard practice. Stomach content analysis provides important insight into fish feeding patterns and quantitative assessment of food habits is an important aspect of fisheries management. Accurate description of fish diets and feeding habits also provides the basis for understanding trophic interactions in aquatic food webs. Diets of fishes represent an integration of many important ecological components that included behavior, condition, habitat use, energy intake and inter/intra specific interactions.

A food habit study might be conducted to determine the most. frequently consumed prey or to determine the relative importance of different food types to fish nutrition and to quantify the consumption rate of individual prey types. Each of these questions requires information on fish diets and necessitates different approaches in how one collects and analyzes data. Here, we outline qualitative and quantitative techniques used to describe food habits and feeding patterns of fishes.

For a better understanding of diet data and for accurate interpretation of fish feeding patterns, time of day, sampling location, prey availability and even the type of collecting gear used need to be considered before initiating a diet study or analyzing existing diet data.

Stomach contents can be collected either from the live or fresh died fish. Regardless of the method, investigators should ensure that the removal technique effectively samples all items in the gut. Otherwise data will be skewed toward items that are more easily displaced from the stomach. Alternatively, live fish can be sacrificed and stomach contents removed for analysis. If fish are to be sacrificed, they should be preserved immediately either by freezing or by fixing in formalin. Stomach contents will continue to digest, rendering rapid preservation of the fish or removed contents necessary to prevent loss of resolution. As in most fish groups feeding behavior of juveniles and adults vary distinctly attention should be taken to encounter more samples which will include all size groups of the particular fish.

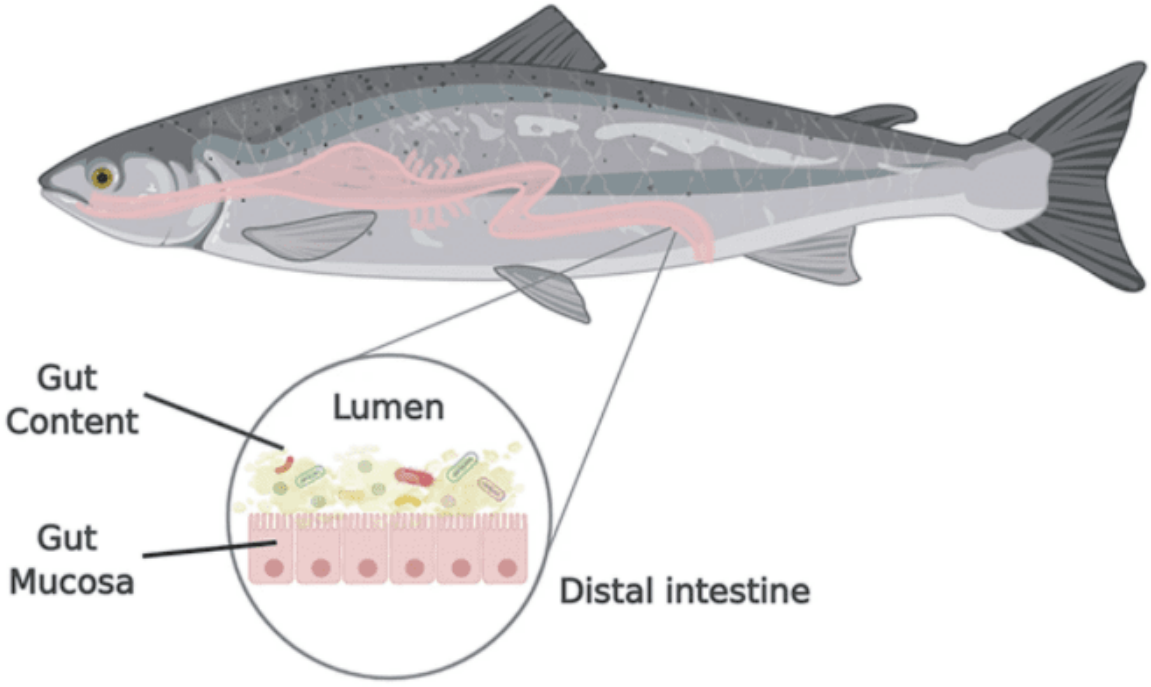
Method:

The specimens either from live or preserved should be measured to its total length to the nearest 1mm and weight to the nearest 0.1 g. Cut open the fish and record the sex and maturity stage of the fish. Remove the stomach and preserve them in 5% neutralized formalin for further analysis. For the analysis, a longitudinal cut must be made across the stomach and the contents are

transferred into a petri dish. The contents then keep for five minutes to remove excess formalin and then examine under binocular microscope. Identify the gut content up to the genus and if possible up to species level depending up on the state of digestion. Various taxa digest at different rates. As such, all recently consumed taxa may be present in the foregut but only resistant items remain in the hindgut.

To avoid bias when both easily digested prey and resistant prey are present, only the immediate foregut (e.g., stomach) should be sampled. Prey items in fish stomachs are often not intact. Hard parts such as otoliths, scales, cleithra or backbones have diagnostic, species specific characteristics useful for identifying prey. Alternatively, partially digested prey may be identified using unique biochemical methods such as allozyme electrophoresis, or immunoassays.

Fish diets can be measured in a variety of ways. Methods of gut contents analysis are broadly divisible into two, viz., qualitative and quantitative. The **qualitative analysis** consists of a complete identification of the organisms in the gut contents. Only with extensive experience and with the aid of good references it is possible to identify them from digested, broken and finely comminuted Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management 281 Trophic levels and methods for stomach content analysis of fishes materials. **Quantitative methods** of analysis are three types, viz., numerical, gravimetric and volumetric. All these types of analysis are widely employed by different workers.



Practical No. 6
Analysis of polluted and fresh water for biotic and abiotic variations

Plants and animals can't live without freshwater, because all organisms are made up mostly by water. Only a tiny fraction of the planet's abundant water is available to us as freshwater. About 97.4% by volume is found in the oceans and is too salty for drinking, irrigation, or industry. Most of the remaining 2.6% water is freshwater and locked up in ice layers or glaciers or it's too deep underground to be reached or too salty to be used. Thus, only about 0.014% of the earth's total volume of water is easily available to us as soil moisture, usable groundwater, water vapor, and lakes and streams.

Freshwater ecosystems and pollution

The concentration of dissolved O2 highly depends also on the amount of pollutants, because most water pollutants cause low oxygen levels in freshwater. These pollutants make it difficult for species to live, and many aquatic organisms, especially fish, die when dissolved oxygen levels fall below 5 ppm. There are a few natural sources of pollutants present in aquatic ecosystems. But mostly, freshwater ecosystems may become unbalanced by factors due to human activities. Human activities affect the bioavailability of chemicals to organisms, cause temperature fluctuations, and modify rainfall, pH and salinity. Water plays a key role in diluting pollutants and because of that superiority as a solvent, it also means that water-soluble wastes pollute water easily.

Freshwater species

The types of species that could become affected by water pollution in freshwater ecosystems are:

-insects
-crustaceans
-fish
-amphibians
-arthropods
-plants
-fungi
-bacteria
-algae
-viruses

Insects are usually the most sensitive group, followed by crustaceans, fish and amphibians. Any changes could have harmful or disastrous effects for them. Adverse effects, such as the presence of toxic substances in industrial effluents, may affect many components of the aquatic ecosystem. The extent of which will depend on both biotic and abiotic site-specific characteristics

Effects on aquatic life

Most freshwater lakes, streams, and ponds have a natural pH in the range of 6 to 8. Acid deposition has many harmful ecological effects when the pH of most aquatic systems falls below 6 and especially below 5. Extreme pH can kill adult fish and invertebrate life directly and can also damage developing juvenile fish. It will strip a fish of its slime coat and high pH level 'chaps' the skin of fish because of its alkalinity. When the pH of freshwater becomes highly alkaline (e.g. 9.6), the effects on fish may include: death, damage to outer surfaces like gills, eyes, and skin and an inability to dispose of metabolic wastes. High pH may also increase the toxicity of other substances. For example, the toxicity of ammonia is ten times more severe at a pH of 8 than it is at pH 7. It is directly toxic to aquatic life when it appears in alkaline conditions. Low concentrations of ammonia are generally permitted for discharge.

Thermal pollution can have a great influence on the aquatic ecosystem. Species that are restricted to heated waters, can build up large populations in the receiving waters. Respiration and growth rates may be changed and these may alter the feeding rates of organisms. The reproduction period may be brought forward and development may be speeded up. Parasites and diseases may also be affected. An increase of temperature also means a decrease in oxygen solubility. Any reduction in the oxygen concentration of the water, particularly when organic pollution is also present, may result in the loss of sensitive species.

Aquatic plants (like any other plants) need two essential nutrients to grow: **nitrogen (N) and phosphorus (P).** In a healthy lake the nutrients occur in small amounts. But in large quantities, they can cause a major water pollution problem. Too many nutrients stimulate the rapid growth of plants and algae, clogging waterways and sometimes creating blooms of toxic blue-green algae. This process is called eutrophication. The result of this is that when the plants and algae

die and decompose, they use up large amounts of oxygen (O2). So the amount of oxygen that is available for fish and other aquatic species will be reduced. In extreme cases it can lead to a completely oxygenl ess environment that can support nothing except a few species of anaerobic bacteria. It also can kill fish and other aquatic life and reduce the aesthetic and recreational value of the lake.

The nutrients include nitrates found in sewage and fertilizers, and phosphates found in detergents and fertilizers. Human inputs of nutrients from the atmosphere and from nearby urban and agricultural areas can accelerate the natural eutrophication of lakes, a process called cultural eutrophication.

Nutrients from urban sources may be derived from domestic sewage, industrial wastes and storm drainage. The contribution of nitrogen and phosphorus per person per day averages 10.8 g N and 2.2 g P, though there is a considerable range. In the 1940s detergents were developed containing sodium tripolyphosphate, which softens water by neutralizing calcium and keeps dirt in suspension once it has washed off clothes.These are the principal sources of nutrient overload causing cultural eutrophication in lakes. The amount of each source varies according to the types and amounts of human activities occurring in each airshed and watershed.

Nutrients irrigation water

A pathogen is an organism that produces a disease. It is an organic pollution (biological hazard) and occurs from fecal contaminations. Fecal contaminations of water can introduce a variety of pathogens into waterways, including bacteria, viruses, protozoa and parasitic worms.A very well known pathogenic bacteria is Salmonella. There are some 200 immunologically distinguishable types of Salmonella known to be pathogenic to humans. But there are many more that infect animals, including livestock. Cross-infection between people can occur via water pollution. The spreading of untreated sewage wastewater on land and its use for the irrigation of crops can also be a source of infection. Currently there appears to be an increase in the spread of Salmonella and this has been related to modern living conditions, such as mass food production (e.g. of poultry) and communal feeding.

Practical No. 7
Field visits for study of selected terrestrial habitat and writing notes

Students have to visit selected terrestrial habitat and write notes.

Practical No. 8
Experimental design and approaches in ecological research; writing a research project

Experimental design and approaches in ecological research are very important. Following are the proposed guidelines for ensuring proper experimental design in ecology. In a sequential fashion, it is important to begin with stating a hypothesis, followed by clearly defining terms and choosing appropriate samples and parameters. Following the tips and guidelines in order will help guide the researchers thought process when designing an ecological experiment. Consult the listed citations for in-depth explanations when required. The rules may be generalized to other fields of science.

1. Begin by identifying a hypothesis for the topic you are interested in. Testable predictions generated will allow you to formulate a hypothesis. The hypothesis is an explanation of how you think a system works based on observation. The hypothesis will be either accepted or rejected based on the data collected.

2. Define parameters for the experiment by being clear and concise in your wording. By clearly defining terms, you can focus in on experimental methods and avoid ambiguity. This ensures that the results will be more accurate and there will be less flexibility in the experimental design, again increasing accuracy.

3. Decide if you would like to perform a mensurative or manipulative experiment. A mensurative experiment involves making measurements at different times or in different areas. A manipulative experiment involves physically altering a treatment group, and thus always has two or more treatments.

4. Choose an appropriate sample size that is fitting for the results you wish to obtain. Generally, a smaller sample size produces results that are inaccurate for generalization. A smaller sample size will also produce a smaller effect size measure, which is the efficacy of the treatment, and thus should be avoided.

5. Introduce a control group. In biology, systems tend to exhibit temporal change, which could be an influencing third variable. In order to isolate any changes to the experimental treatment alone, a control is necessary.

6. Randomize assignment. By randomizing sample units to different treatment groups, experimenter bias is avoided. Randomization is a critical facet of the experimental design as it intersperses the samples being tested.

7. Replicate! The number of replicates necessary will vary with design, however it ensures precision in experiments.

8. Ensure samples are dispersed in space or time to avoid pseudo replication. This ensures replicates are statistically independent. Often, experimenters will make inferences based on the data collected and quantify samples from the same unit as independent, however in reality the samples come from the same unit, thus it is not a genuine replication.

9. Use linear regression based analysis first, before introducing analysis of variance (ANOVA). Linear regression is more powerful to analyze obtained data, and indicates how dependent variables change with the independent variable.

10. Refrain from deducing results based on P value alone. The p value is indicative of confidence interval in statistics, however it fails to indicate how a system actually changes. Effect size measures are more meaningful in ecology, and thus should be given more weight in findings.

Writing a Research Project in Ecology:

A research proposal/Project doesn't have a predetermined structure – different disciplines, universities, departments and even faculty members have their own regulations and preferences. Sometimes you receive a detailed template to follow, sometimes your supervisor gives you a general structure, sometimes it can even be relatively freeform. Anyway, the structure we show here is just an example of what you usually have to include in an ecology research proposal.

1. Title: The title summarizes the main idea or ideas of your study.

2. Abstract: A short and to the point statement of the nature of your proposed research, usually about 100 words or 3-4 sentences. Identify the problem or an issue you want to address in as few words and as straightforwardly as possible.

3. Introduction: Series of paragraphs that carefully layout your argument leading to your aims! • How to turn interrelated topics into to a single line of argument.

4. Review literature: A literature review is a comprehensive summary of previous research on a topic. The literature review surveys scholarly articles, books, and other sources relevant to a particular area of research.

5. Methods: Sections: context, study site, social sciences, field or lab work, data analysis • Methods appear easy to write but actually requires work to make sure it's clear.

6. Results: Tables and figures: They are a lot of work but it's worth getting them right from the start. • Structure of the text: what goes in and what stays out and how to present the results clearly.

7. Discussion: • How to relate your work back to the literature highlighting its importance. Conclusions and Acknowledgements • Conclusions is the main result(s) and why they are important – e.g. the implications

8. Bibliography/Works Cited: This is simply the list of all the sources of information you have used so far or intend to use in your research. Don't try to create a comprehensive list of everything written on the topic – your current bibliography does not limit what you can later use in your work.