Module 4: Professional Skills for Biodiversity Conservation

Forestry Training Institute

Tubmanburg, Liberia

Fundamentals of Biodiversity: Key Questions

1. What is scientific research and why is it important for conservation?
2. The scientific approach
3. Statistics Basics
4. Survey Design
5. Reading Scientific Literature

What is Scientific Research?

- Scientific research is the systematic investigation of scientific theories and hypotheses.
- A hypothesis is a proposed explanation of something yet to be explained, based on available knowledge. A hypothesis is an assertion that is subject to further experimentation.
- Monitoring is the observation of long-term trends.

What Scientists Do

1. Make observations.
2. Formulate hypotheses.
3. Test hypotheses using laboratory and field experiments and statistical tests of data.
4. Use theory to test hypotheses and make predictions.

The Scientific Method

PRACTICUM
“Making Observations”

The Scientific Approach

The scientific method entails the formulation and modification of hypotheses followed by testing of hypotheses through systematic observation, measurement, and experimentation.

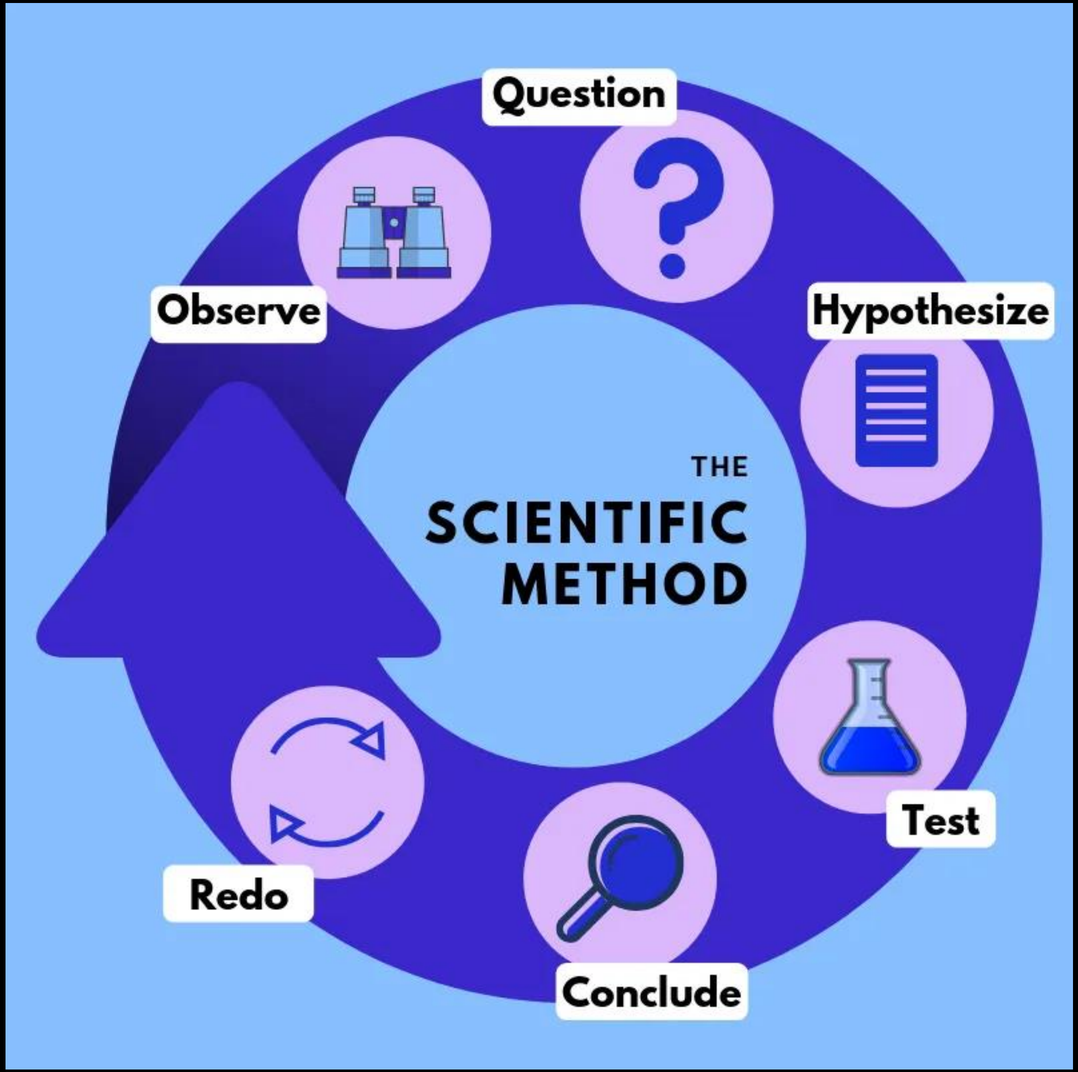
Type of Question	Type of Methodology	Type of data
What?	Qualitative	species lists, habitat lists, types of settlements, land uses, NTFPs
How many?	Quantitative	numbers, lengths, areas, weights, temperatures, “how many per unit - DENSITY”
Where?	Spatial	where is x in relation to y
When?	Temporal	phenology, sociological and geological history of a site, breeding periods, lunar cycles
What changes?	Can be all of the above	

Causality: Explaining Cause and Effect

Science seeks to discover the causes of observed phenomena. That is, why does something happen? For example, we might ask ….

- Why do some species of plant fruit at certain seasons?
- Why do some species of animal plant prefer certain habitats?
- Why do some species of tree no longer produce seedlings when the habitat is changed by humans?
- Why has there been a reduction in elephant numbers in Liberia?
- Why are some fruits red and some smelly?

The Scientific Method



The Scientific Method

The steps go something like this:

1. **Observe** → *Make an observation*
2. **Question** → *Ask questions about the observation, gather information*
3. **Hypothesize** → *Form a hypothesis — a statement that attempts to explain the observation, make some predictions based on this hypothesis*
4. **Test** → *Test the hypothesis (and predictions) using a reproducible experiment*
5. **Conclude** → *Analyse the results and draw conclusions, thereby accepting or rejecting the hypothesis*
6. **Redo** → *The experiment should be reproduced enough times to ensure no inconsistency between observations/results and theory.*

The Scientific Method

PRACTICUM
“Learning the Scientific Method”

Hypothesis formulation

- You have a set of observations. Now you want to understand the reasons for the patterns you observe in the data.
- Formulate possible explanations. Hypotheses are expressed as statements. They are explicative, offering possible cause-and effect statements about the observed phenomena.
- The pattern that you observe may be explained by one of several hypotheses.
- Hypotheses should be testable.

Hypothesis formulation

STEP 1: Formulate hypotheses

- Observation: The density of *XY Plant Species* differs between two sites studied. One of the sites is on flat ground and the other is on a slope.

- **Hypothesis (H_1):** Differences in soil moisture are responsible for differences in [species name] abundance.

- **Null Hypothesis (H_0):** Soil moisture does not affect the abundance of [species name].

Hypothesis formulation

STEP 2. Make predictions based on these hypotheses.

- You then have to make predictions as to what would happen if this hypothesis were true.

- **Prediction:** There is a significant relationship between soil moisture content and [species name] abundance.

Hypothesis formulation

STEP 3. Design a test of the predictions

- Design a way in which you collect new data – or use existing – relevant data which would test your hypotheses.

Hypothesis formulation

STEP 4. Make a preliminary summary of the data

- Use a graph or table to report the mean and a description of the variability of the data, as well as the distribution.
- It often helps to visualise the data in some graphic form; a table often gives less clarity than a graph.

Hypothesis formulation

STEP 5. Analyse the data using statistical tests.

- A research project is not finished until you have analyzed and interpreted the data**,** and made a report so that others can read it.
- Data interpretation is the process of giving biological meaning to the results.
  - What do the data tell me?
  - What do the data not tell me?
- Look at the data to see if there the observed differences between data in two (or more) situations are statistically significant**.** Or if observed variables are **correlated.**
- Data analysis is the process of taking the numbers collected in the field and summarizing them into a form that is easy to interpret (graphs or tables). This summary is called the **results.** Results should be put into their biological context.

Hypothesis formulation

STEP 6. Accept or reject the hypotheses.

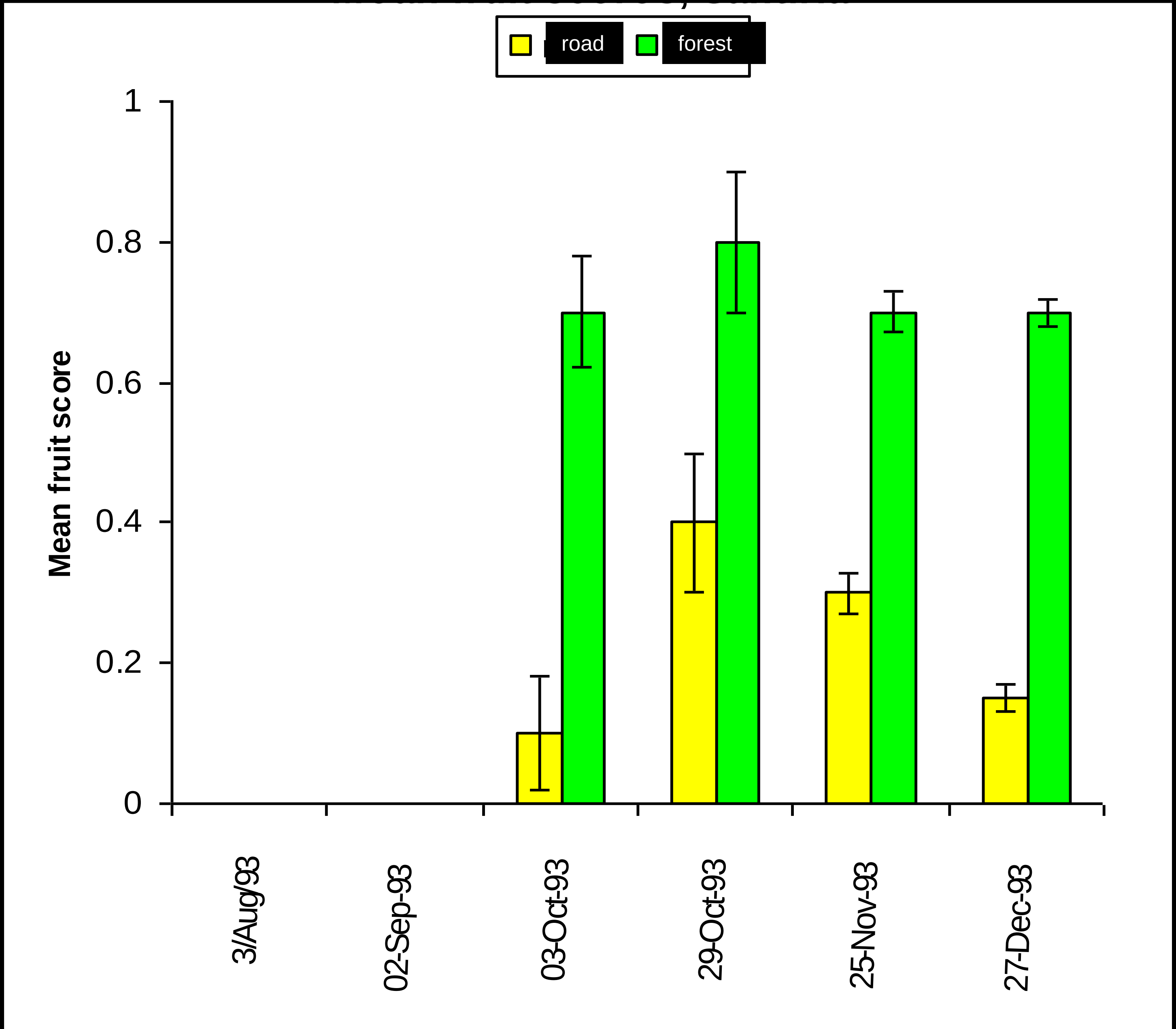
- The **null** hypothesis (no difference between 2 situations) is the opposite of the alternative hypothesis.
- If there is a significant difference between two situations, you can reject the null hypothesis.

The Scientific Approach: An Example

Observation

- A tree species, Santiria trimera, grows beside forest roads and in the forest.
- We know that Santiria produce important fruits for chimpanzees.
- At the edge of the forest road, Santiria trimera was fruiting more than the trees of the same species inside the forest, in the same area.

Santiria trimera: fruits in1993



How do we explain this observation?

- Identify possible variables that may affect fruiting
- Formulate hypotheses
- Make predictions
- Decide which data to collect
- Propose a study that can shed light on the reasons for the observed differences.

Formulating Hypotheses

Hypothesis

- H1: Physical damage reduces the fruiting of Santiria.
- H0: Physical damage does not affect the fruiting of Santiria.

Prediction

- Santiria produce less fruit if they suffer physical damage.

What data should be collected?

Damage to trees

- number of broken branches / tree
- % of bark area per tree removed
- Damage to roots (cut number / tree)

Fruiting rate

- Precipitation patterns

Propose the outline of a study

- Choose trees in the forest along the road.
- Measure the fruiting rate on an undamaged sample
- Measure the fruiting rate on a damaged sample.

The Scientific Method

PRACTICUM

"Collecting Data"

Survey Design

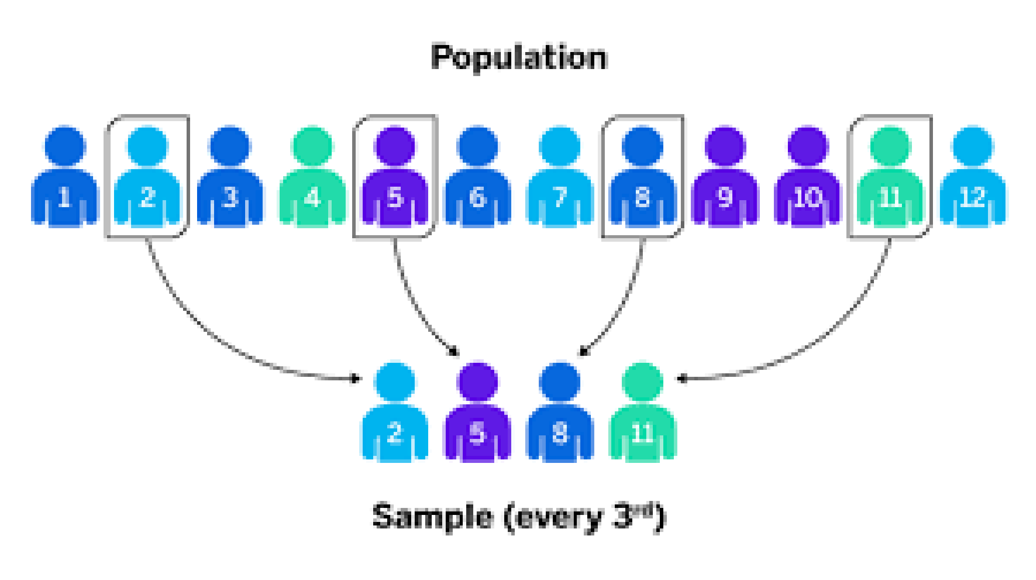
- Sampling helps you decide the amount of data you need to collect in order to track a resource. Because sampling always includes some uncertainty, estimation is also required of the precise number of samples needed to confidently conclude that management did or did not work.
- Undersampling (taking too few samples) prevents one from detecting a change even if a change has occurred.
- Oversampling will let one identify a change in response to management but results in an unnecessary waste of effort. Because monitoring in the field is often very expensive and time consuming, it is important to optimize sampling.

Survey Design

- To sample, you repeatedly measure the environment to estimate a parameter in the population (the “what, where, when”) under management and to be able to compare this estimated value to the threshold value desired.
- Different minimum sample sizes are required to meet different survey objectives. Also, sample size varies depending on the techniques used to survey the targeted community. These must be carefully considered prior to fieldwork. In general, the greater the sample size the better the precision at estimating species or population trends.

Survey Design

- Random sampling means all the points in your study area have an equal probability of being chosen so that systematic bias will not affect the sample.
- Systematic sampling. Things are not usually systematic in space in nature, so a random start point can be the corner for a systematic design (plots or transects). If you deliberately choose plots transects for convenience, you BIAS your sample.



Survey Design

- Bias can result in the overestimation of human signs and under-estimation of animal signs.
  - For example, hunting and trapping is usually more intensive near roads so if a survey only takes place near roads, the sample will be biased.
- Surveys are also subject to bias if data collectors walking along existing roads and paths and if they avoid wetlands and other habitats difficult to traverse.
- Bias also happens when an intensive survey is conducted in small area and the results are extrapolated to a much larger area without knowledge of different habitats or hunting pressures in areas not surveyed.

Survey Design

- What kinds of bias should we consider?
  - Spatial: How might sampling near a village affect results from plots?
  - Temporal: How might season affect our results? Time of day?
  - Social: How might speaking only to men in a village affect a survey?

Survey Design

Random Error and Systematic Error (Bias)

- Each unit in the population should have an equal chance of being picked for the sample.
- Random error affects the precision **(variance)** but not the accuracy of a sample because there will be the same number of erroneous readings above and below the true value.
- Systematic error affects accuracy, because it pushes the numbers to one side or the other of the real value.

Survey Design

In order to determine causality, we need to test the effects of independent variables on dependent variables.

- INDEPENDENT: what might affect the thing you are measuring
- DEPENDENT: the thing you are measuring

Survey Design

Examples of independent variables:

- rainfall
- temperature
- soil type
- depth of the ocean
- patch size of a forest
- distance from a village

Examples of dependent variables:

- tree density
- number of species in a forest patch
- seasonality of fruiting
- gathering technique used

Survey Design

Some variables co-vary. For example, if we ask, “Why has there been a reduction in elephant numbers in Liberia?” there may be a number of possible, and nonexclusive, reasons:

- Demand for ivory continues
- Abundance of guns during and since the Civil War
- Lack of control over poaching
- Removal of necessary foods or shelter due to logging
- Others?

Data Collection, Entry, and Analysis

- Always carry a notebook with you to record interesting observations.
- List as many fauna (mammals, birds, reptiles) and flora (large tree species and flowering species) as possible.
- Also, record unusual observations.

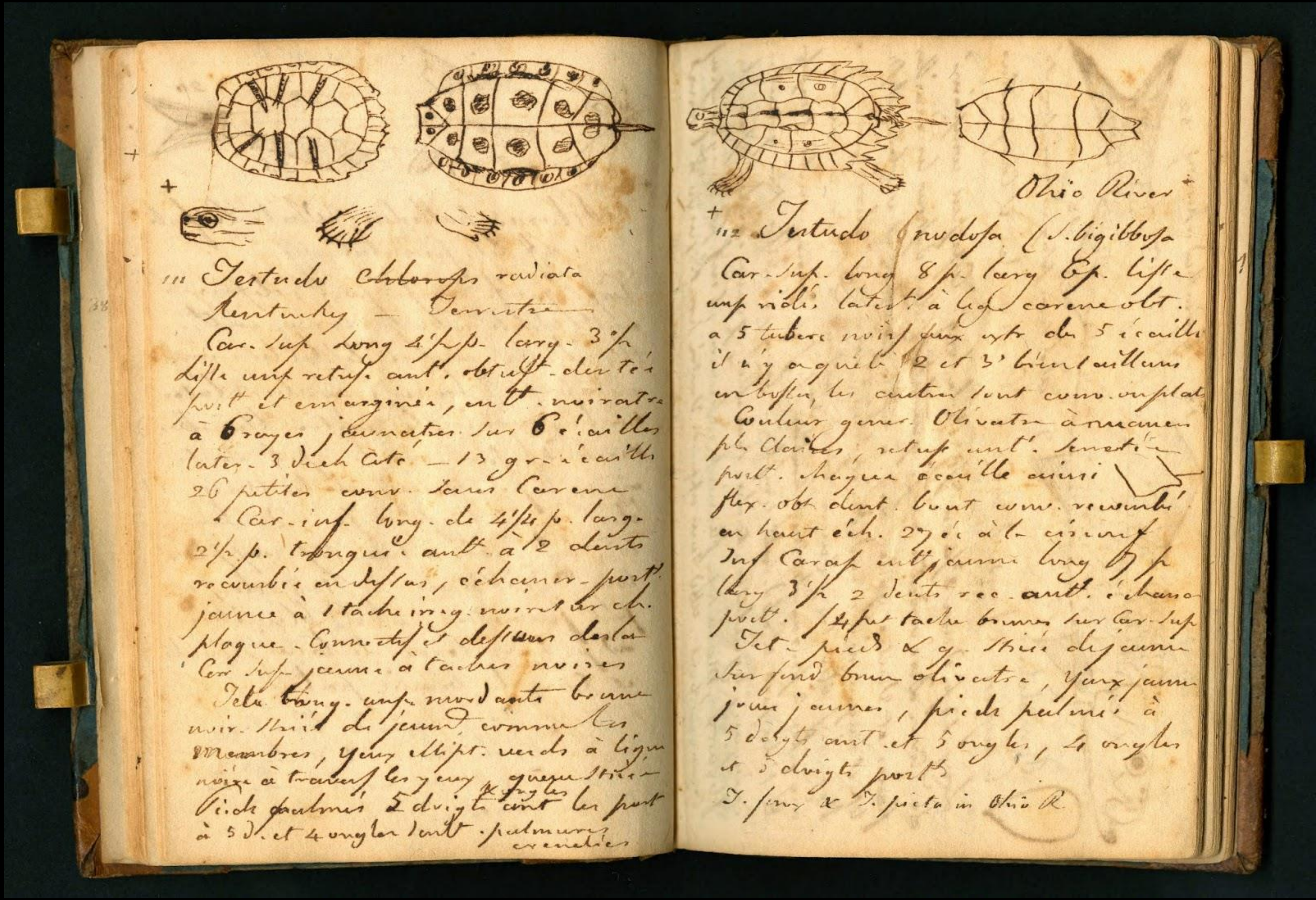
Data Collection, Entry, and Analysis

- Write down exactly what you observe. Good notes last forever, for example, we still refer to Charles Darwin’s notes from the 1840s.
- Your notes should be clear, legible, and ordered logically or even you will not be able to understand them later.
- The first step to taking good notes is to be a good observer. You must be clear about what it was you saw or heard, or just as importantly, what you didn't see or hear.

Data Collection, Entry, and Analysis

Field Books

- Field books are good for non-numeric data and you can draw sketches/maps etc. in them.
- Number and date all the pages.



Data Collection, Entry, and Analysis

Field notes

- Field notes contain Information collected during day to day activities. You should write down any observations of note.
- For example, in addition to observations in the forest, information on road kills, bushmeat for sale, etc. can be recorded for wildlife studies.

Data Collection, Entry, and Analysis

<u>Field notes</u>

- You must record each trip or forest walk whether or not you see animals.
- For example, if you are collecting data on animal abundance, you should, at the same time, collect data on human signs. This means that, even if your initial interest was animal abundance, you can later see if it related to the abundance of human signs.

Data Collection, Entry, and Analysis

Sketches

- Emphasize key distinguishing features, such as color and shape, and accurate measurements should be written next to the sketch. Even if you can't draw, it helps a lot.
- Sketch tracks together with measurements of their length and width. Also note the distance between individual tracks and the track arrangement.

Data Collection, Entry, and Analysis

Data Sheets

Data sheets allow for standardized data collection between observers or over time. They also summarize a lot of data quickly and inform eventual analysis.

Site name______________________ Plant descriptions (larval host plants, available nectar and types)____________________

Date____________ Time______ Personnel names and contact info______________________

Weather: %cloud cover______ wind______ humidity______ temp______ Other notes:____________________________

Species	ID#	Sex	Location description	Time	GPS	Photos?	Collector	Notes

Data sheets must always be stored properly!

Data Collection, Entry, and Analysis

Site name________________________ Plant descriptions (larval host plants, available nectar and types)____________________

Date_____________ Time_______ Personnel names and contact info________________________

Weather: %cloud cover______ wind______ humidity______ temp______ Other notes:______________________________

Species	ID#	Sex	Location description	Time	GPS	Photos?	Collector	Notes

Every data sheet should contain:

- type of data;
- names of observer(s);
- date, time, and location of observations
- weather
- habitat type(s)

Data Collection, Entry, and Analysis

- If the data were carelessly collected or if the research design was poor, the results are meaningless, i.e., "Garbage in, garbage out." You should always ask yourself the following questions:
  - Accuracy: *Were the data collected carefully?*
  - Training: *Were data collectors adequately trained?*
  - Appropriate methods: *Is this the right method to accurately capture observations?*
  - Assumptions of the methods: *Do the methods employed fit the research question?*

Data Management

Data cleaning

Data Management

Ensure that a master copy exists before starting the analysis, in several locations (hard drives and memory sticks, preferably stored in different locations)

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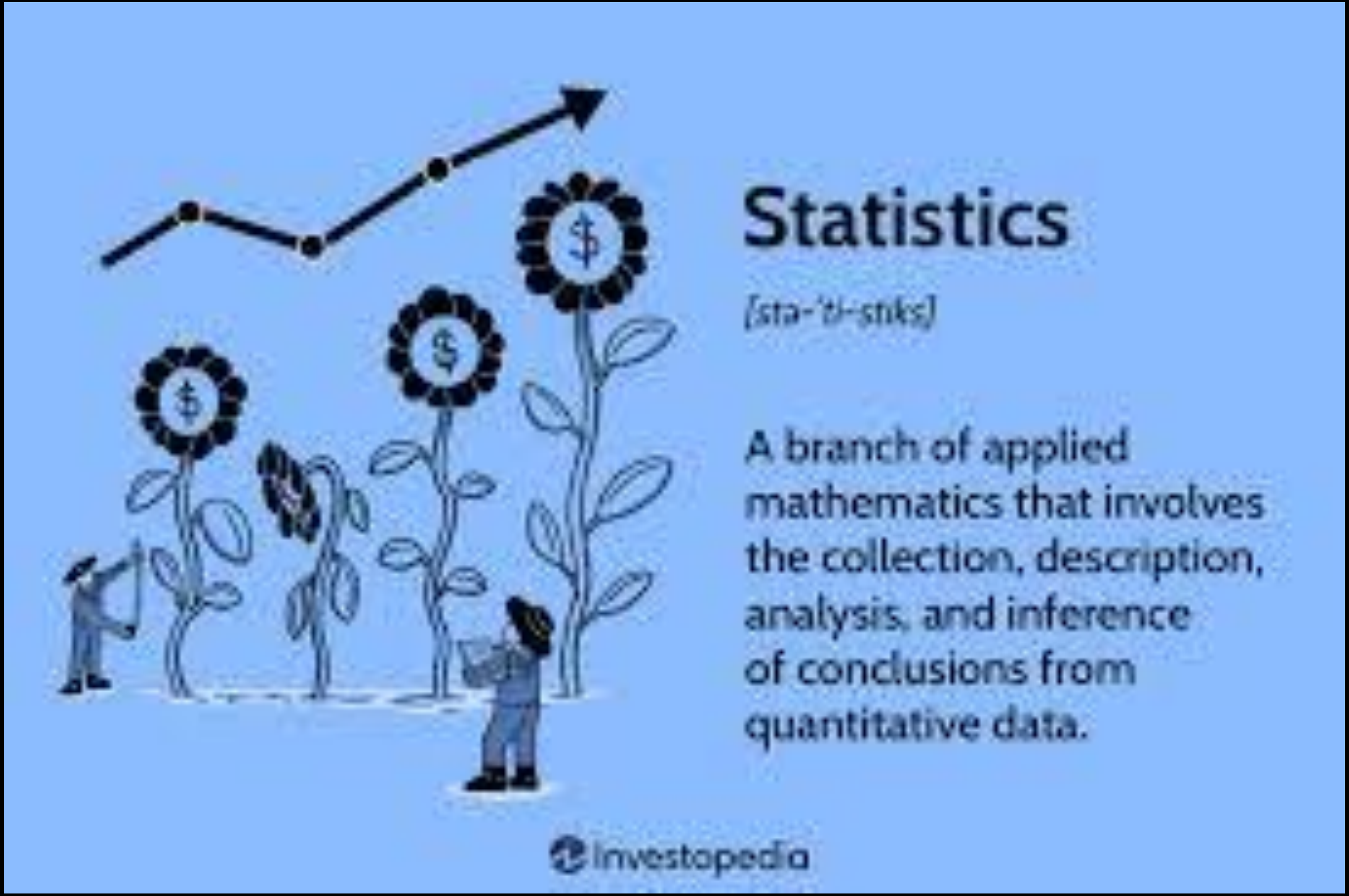
Basics of Statistics



Basics of Statistics: What is Data?

Data are the raw information from which statistics are created

Statistics provide an interpretation and summary of data

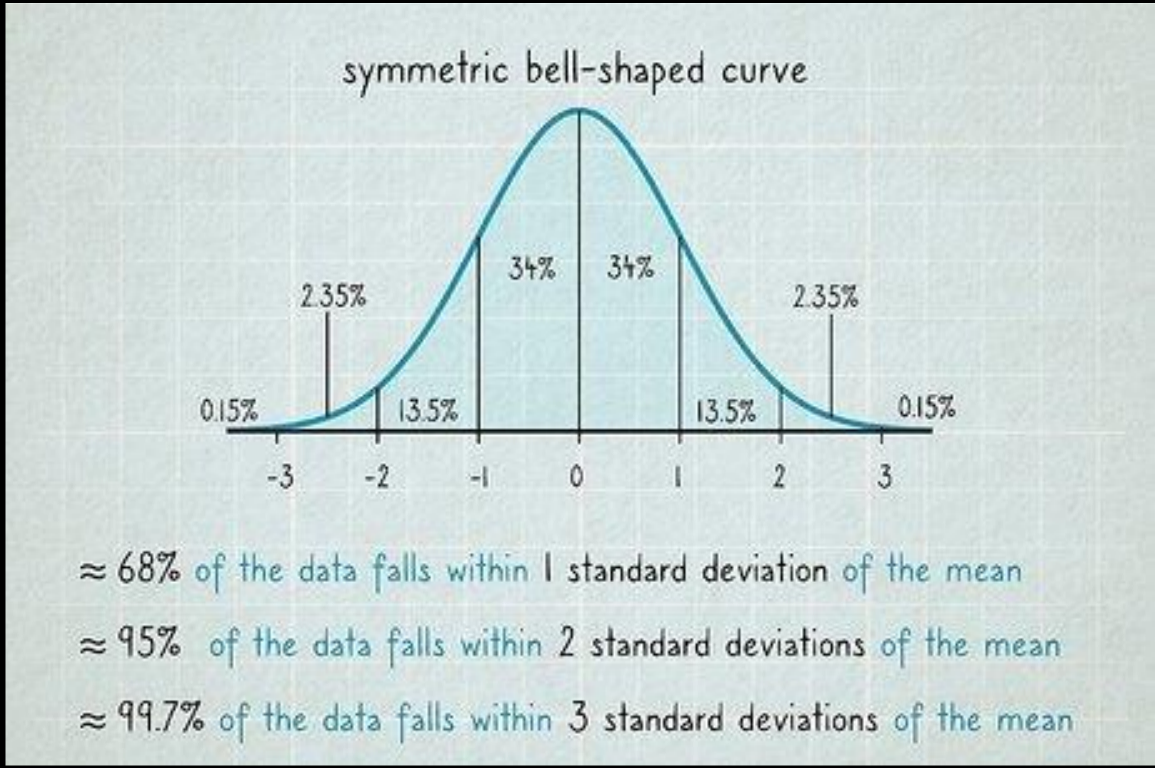
- If you want to understand a phenomenon, you need data
- Raw data is collected as a part of research, observations, and surveys .

Basics of Statistics

- Sampling means to count the number of things or events using a pre-determined sampling methodology. This can provide an accurate estimate of the "number of things" you want to measure in the study area.
- Sampling can help answer questions like …
  - How many pygmy hippos are in Sapo National Park?
  - How often do zebra duiker come to this area?
  - How many Azobé (Lophira alata) trees are there per hectare in a typical wetland in SE Liberia?
  - How old is the average Famira tree?
- In order to produce an accurate estimate, you have to develop a robust sampling design, which may be unique for each new study.

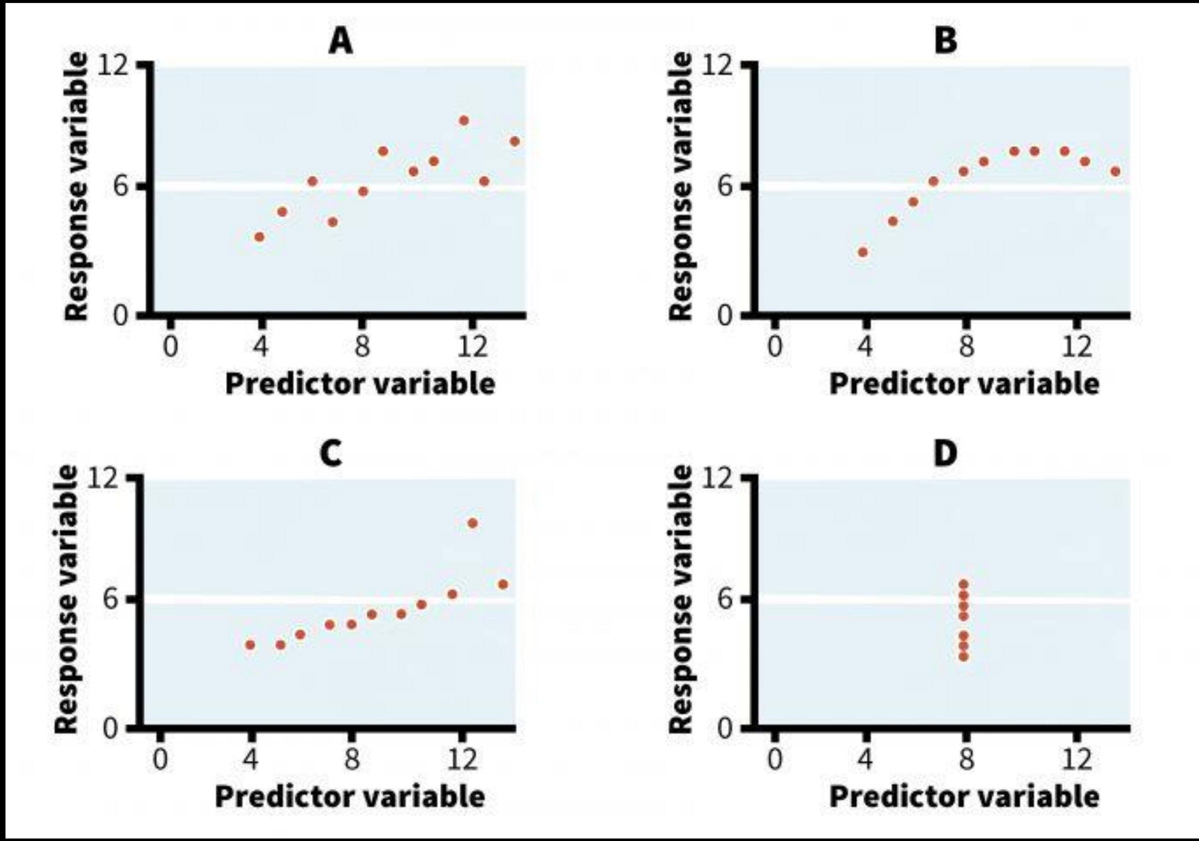
Basics of Statistics

Statistically significant results in biology are those where the probability is less than 1 chance in 20 that your observed difference in the sample is due to random chance.



Uses of Statistics

- Detect differences between two periods of time at the same place
- Detect differences between two places in the same period.
- Detect correlation between a set of observations and a potential explanatory factor



Uses of Statistics

PRACTICUM

Database exercises 1-5

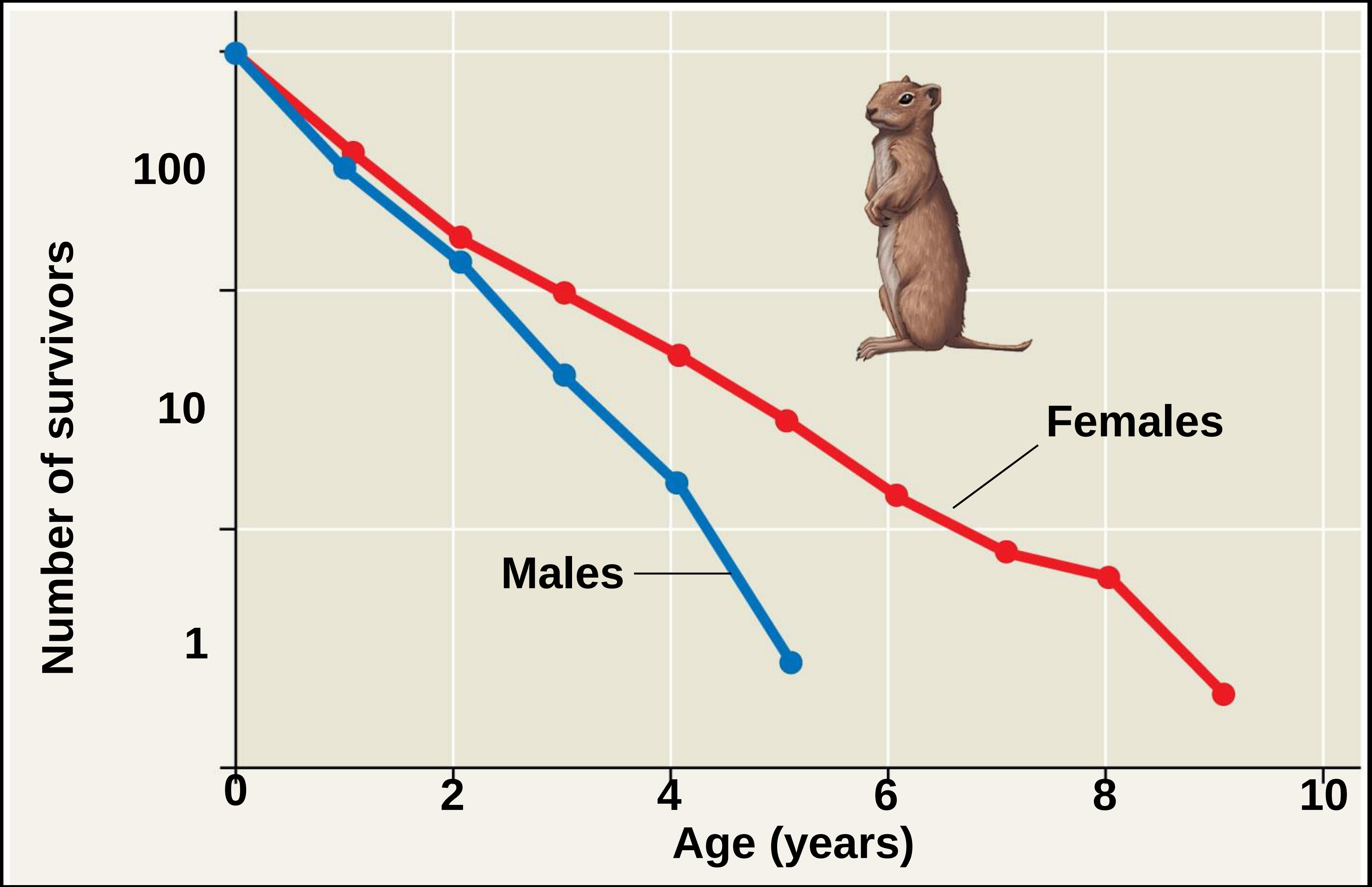
Statistics: Populations

Table 53.1 Life Table for Belding's Ground Squirrels

Age (years)	FEMALES				
	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate†	Average Additional Life Expectancy (years)
0–1	337	1.000	207	0.61	1.33
1–2	252‡	0.386	125	0.50	1.56
2–3	127	0.197	60	0.47	1.60
3–4	67	0.106	32	0.48	1.59
4–5	35	0.054	16	0.46	1.59
5–6	19	0.029	10	0.53	1.50
6–7	9	0.014	4	0.44	1.61
7–8	5	0.008	1	0.20	1.50
8–9	4	0.006	3	0.75	0.75
9–10	1	0.002	1	1.00	0.50

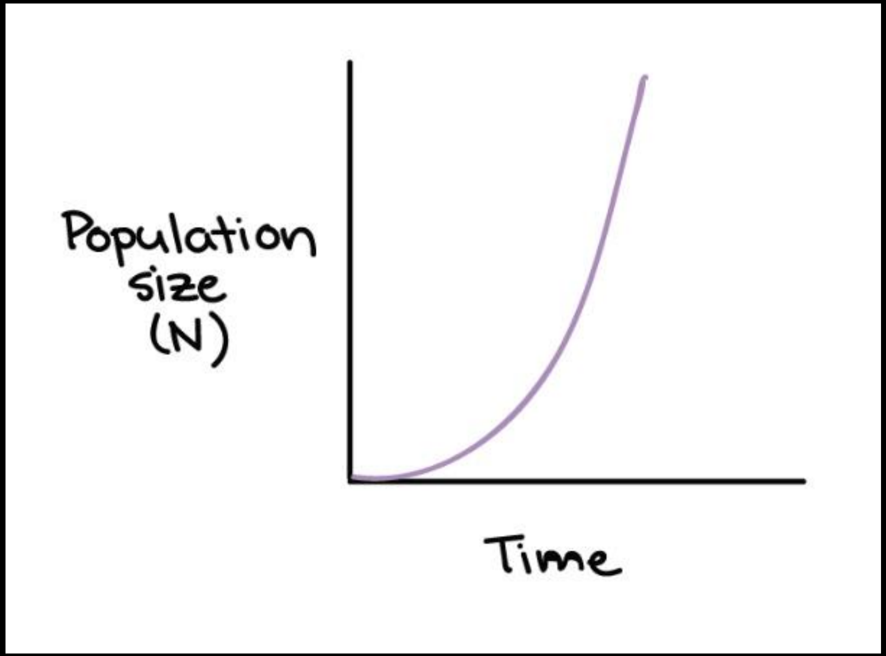
- A life table is an age-specific summary of the survival pattern of a population.
- It is best made by following the fate of a cohort, a group of individuals of the same age.
- Life tables reveal important aspects about wildlife populations.
    - e.g., life tables provide data on the proportions of males and females alive at each age

A survivorship curve is a graphic way of representing the data in a life table

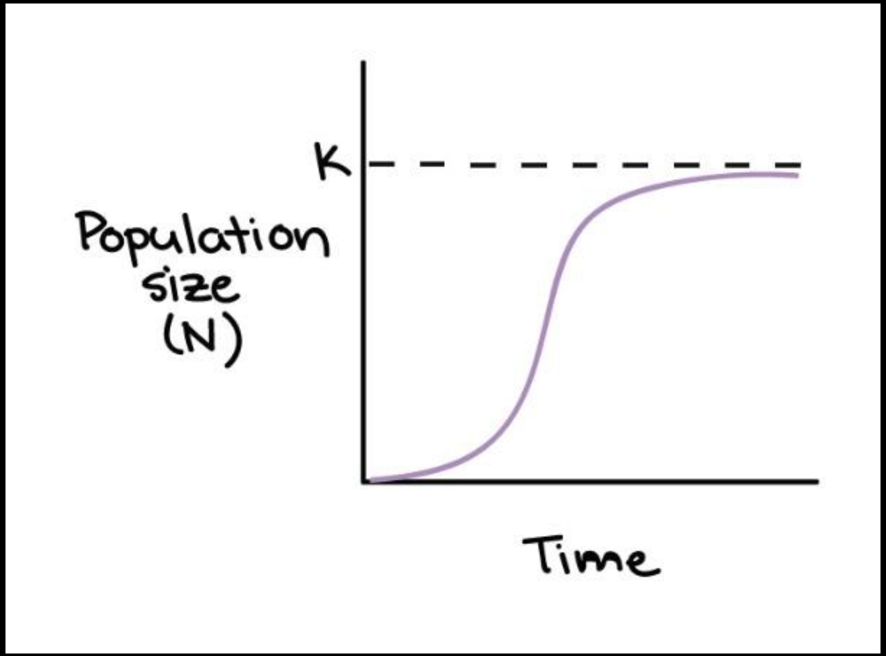


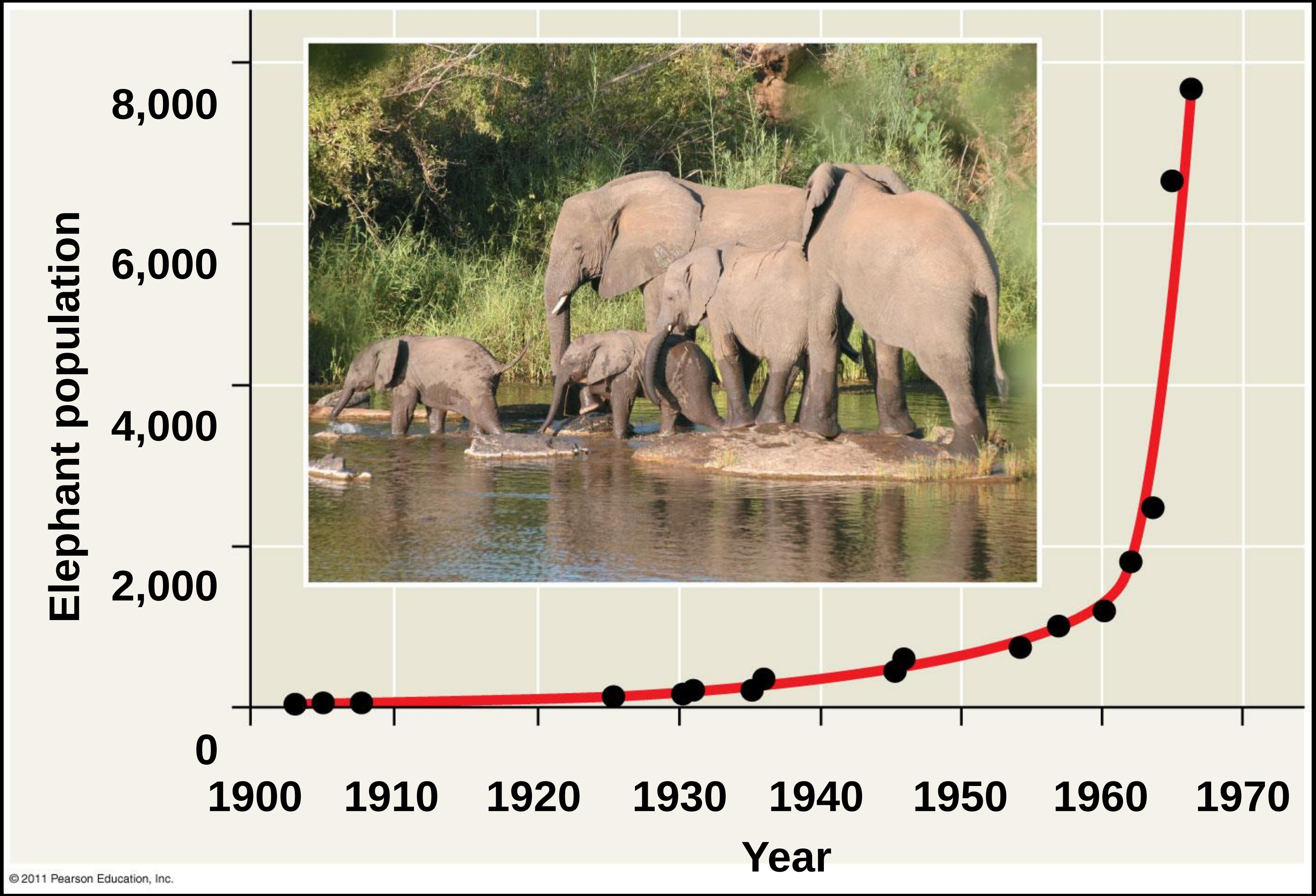
Statistics: Population Growth

Exponential growth cannot be sustained for long in any population



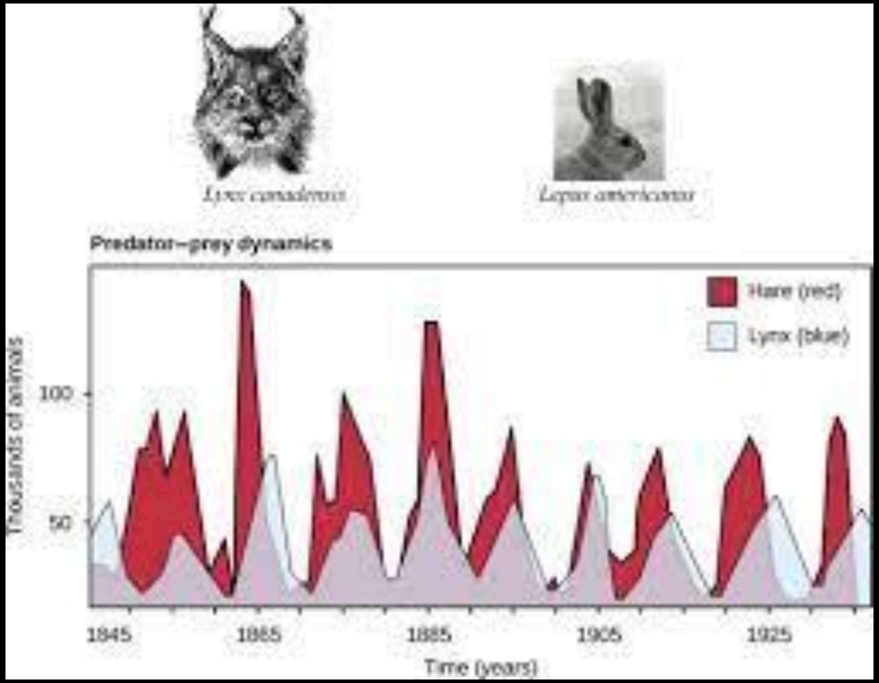
Logistic growth describes how a population grows more slowly as it nears its carrying capacity





Exponential growth in the African elephant population of Kruger National Park, S Africa.

Population Cycles



Case Study: Lynx (predator) and hare (prey) populations

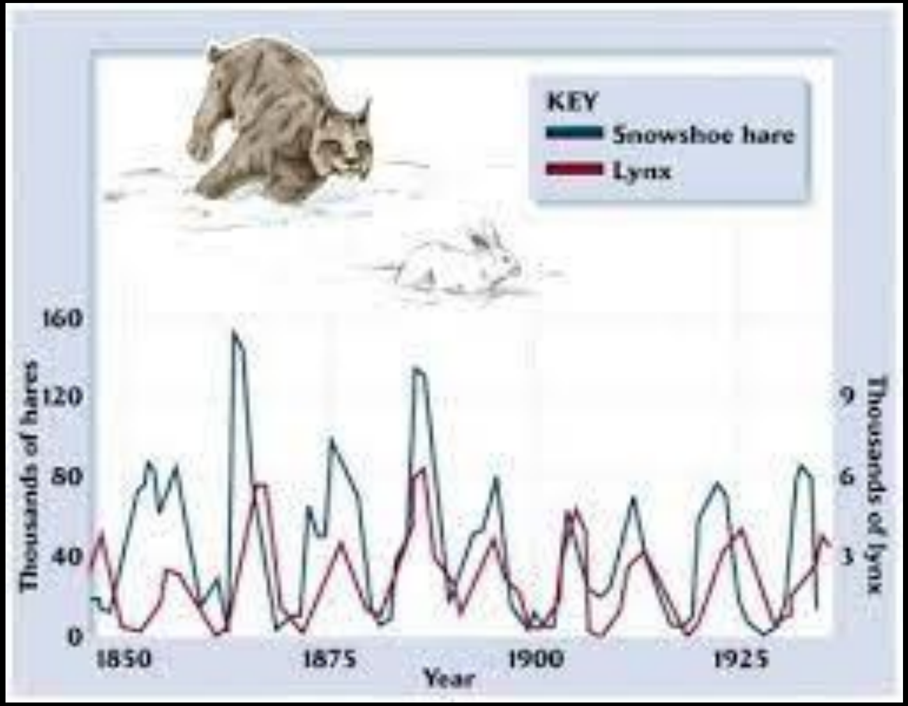
- Some populations undergo regular boom-and-bust cycles.
- Lynx populations follow the 10-year boom-and-bust cycle of hare populations.
- Three hypotheses have been proposed to explain the hare's 10-year interval.

What Explains Population Patterns among Hares?

Hypothesis 1: The hare's population cycle follows a cycle of winter food supply.

- If this hypothesis is correct, then the cycles should stop if the food supply is increased.
- Additional food was provided experimentally to a hare population, and the whole population increased in size but continued to cycle.
- These data do not support the first hypothesis.

What Explains Population Patterns among Hares?

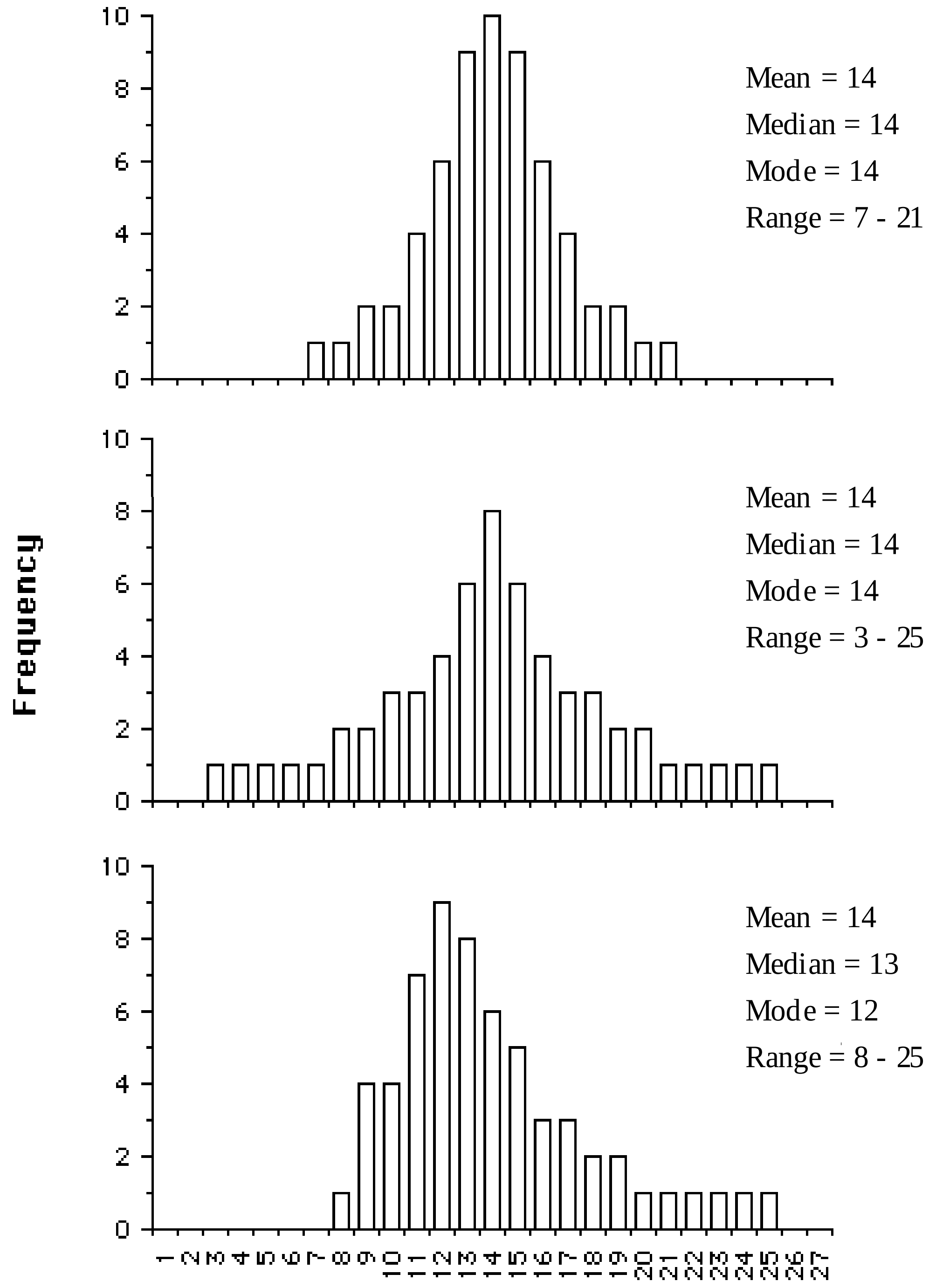


Hypothesis 2: The hare’s population cycle is driven by pressure from other predators.

- In a study conducted by field ecologists, 90% of the hares were killed by predators.
- These data support the second hypothesis.

Statistical Terms

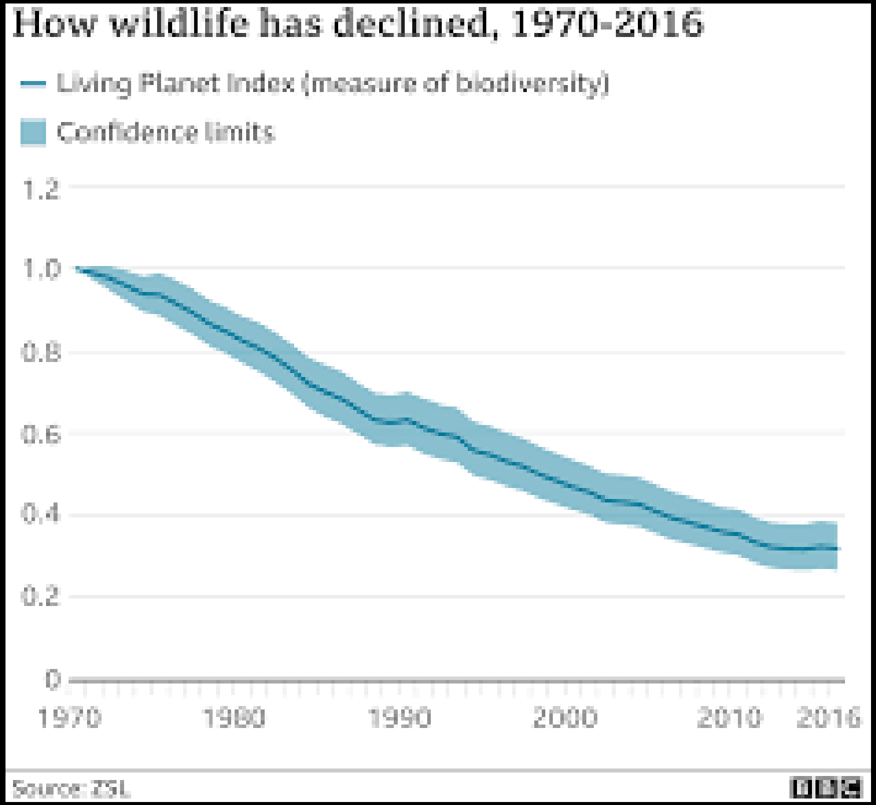
- Average: sum of observations / n
- Median: the value in the middle
- Mode: most frequent value
- Amplitude: difference between the smallest and largest



- The average is the same in each graph
- The median and the mode are the same in the first two graphs
- The amplitudes are different.

Statistics: Uses for Conservation

Statistics are used to understand the mechanisms behind the patterns we see in nature. Statistics help us account for uncertainty in the environment, which provides a range of possibilities for conservation decision making.



Statistics: Uses for Conservation

Statistics plays an important role in environmental science as it allows scientists to analyze and interpret data related to the environment. This includes data on air and water quality, biodiversity, and climate change.

By using statistical methods, scientists can identify patterns and trends in the data, which can help them understand the state of the environment and make informed decisions about how to protect it.

Additionally, statistics also plays a critical role in the design of experiments and the analysis of the results, particularly in terms of determining the significance of results and assessing the reliability of findings.

Reading Scientific Literature

- Primary literature is the first, formal publication of new scientific data or ideas based on the results of original research. Scientists publish their findings in the form of a scientific paper to share their data with others and advance their field.
- A scientific paper outlines research methods so that readers understand how the study was conducted; this makes it possible to replicate and verify results.

Reading Scientific Literature

- In peer-reviewed journals, submitted articles undergo review by a selection of scientists, so the research presented in the paper has been rigorously examined prior to publication.
- The process of peer-review is integral to validation of scientific findings, and helps scientists to understand and interpret their results from a variety of perspectives and to produce refined products.

Reading Scientific Literature

Structure of a Scientific Paper

- Most scientific papers start with a description of a problem and present results that lead to a conclusion about that problem.
- They generally follow this format: abstract, introduction, methods, results, discussion, conclusions.
- Although formats and conventions may vary from journal to journal.

Reading Scientific Literature

<u>Major Sections of a Scientific Paper</u>

The title

- The title includes the primary species or ecosystem covered, the geographic location, and the type of study.

The by-line

- The by-line provides the author and the institution where the author was when the paper was written, and/or when the investigation was conducted.
- The relative contribution of each author to the manuscript determines the sequence of authors

Reading Scientific Literature

<u>Major Sections of a Scientific Paper</u>

Key words

- Five to eight key words that describe the main topics in the article.
- These key words are terms that are commonly used in the literature and are chosen with the objective that other researchers will search for those terms when they look for articles on the topic of the article.

Reading Scientific Literature

<u>Major Sections of a Scientific Paper</u>

Abstract

- The abstract captures all the most important points of an article. It is short, generally 250 words or less.
- An abstract encompasses the paper's objectives and scope (why the study is important), results (what were the major findings), and main conclusions (what do the findings really mean).
- The abstract is essentially a miniature version of the main paper (with the four major parts of the main paper – introduction, methods, results, and discussion – reduced to one to three sentences).
- All information contained in the abstract should be in the body of the paper.

Reading Scientific Literature

READING

“Writing an Abstract”

Reading Scientific Literature

Major Sections of a Scientific Paper

Introduction

- The introduction provides readers with a broad research context that sets the stage for justification of the study, and explains why they should be interested.
- States the problem/question clearly at the outset. Summarizes the most relevant literature so the reader understands how your research relates to earlier research. Puts research into context and describes the problem the question that the article is attempting to solve or answer.

Reading Scientific Literature

Major Sections of a Scientific Paper

Materials and methods

- This section explains to the reader the process used to obtain evidence to answer the central question. This allow the reader to evaluate whether the methods were well designed – that is, whether the methods provide an effective means for obtaining evidence.
- Ideally, enough information is presented so that if readers wanted to, they could replicate the study. An essential characteristic of a good scientific study is that the results should be reproducible if another researcher employed similar methods and materials.
- For field-oriented research, the article should provide a good description of the study area.

Reading Scientific Literature

Major Sections of a Scientific Paper

Materials and methods

- The following topics are typically described: geographic location, altitude, general climate data, geology, soils, historical background, and general information on vegetation and or characteristic fauna.
- Procedures are described including the dates (duration and sampling dates), location (e.g., latitude and longitude coordinates), as well as when the research was undertaken, be it a field or a laboratory study. Also included are details that might influence the data, such as the time of study and seasonal factors, such as temperature or weather.
- The materials section also describes instruments/tools, sampling devices, or other equipment used.

Reading Scientific Literature

Major Sections of a Scientific Paper

Study organisms

- Provides taxonomic information about the organism being studied. Generally, common names for species are avoided because these names are often used inconsistently from one region to another.
- A common name may also be provided in parentheses after the first use of the species name, if this is deemed useful.
- Some publications (especially those aimed at a broader, non-scientific audience) may have a policy where common names are preferred; this may be more typical for well-known groups of species such as some species of birds or mammals.

Reading Scientific Literature

Major Sections of a Scientific Paper

Results

- The results summarize findings, drawing the reader's attention to especially important results, typically using tables and figures that present the data in more detail.
- Reports major findings (versus statistically significant findings) that are directly relevant to the justification and objectives outlined in the introduction.
- Results also include what was *NOT* found, as this can help the reader to better understand the problem.

Reading Scientific Literature

Major Sections of a Scientific Paper

Results – Figures and tables

- Tables, graphics, and statistics provide supporting data for a scientific report's results. They are used when visual aids can more quickly and effectively convey key points or results, and they make it easier for the reader to see important trends or comparisons from collected data that supports the arguments and conclusions of the research paper.

Reading Scientific Literature

Major Sections of a Scientific Paper

Discussion

- The discussion is where results are interpreted, setting them in the context presented in the introduction.
- The Discussion answers the questions: “What do these findings mean? Why were these results found?”

Reading Scientific Literature

Major Sections of a Scientific Paper

Literature Cited

- The last section of a paper is a list of the literature referenced in the paper.
- Note that “cited references” and “literature cited” are used interchangeably to denote the references (also called citations) that appear at the end of an article or book. Usually this list is presented in alphabetical order by author.

Reading Scientific Literature

PRACTICUM

“Reviewing Scientific Writing”

Why is Scientific Research Important for Conservation?

- Research in conservation is essential for understanding how the natural environment is affected by human activities.
- Comparatively less research is undertaken in the world's most biodiverse countries, and the science conducted in these countries is often not led by researchers based in-country; local scientists are also underrepresented in important international fora.
- Examining the distribution and intensity of threats and species' distribution and density helps when designing protected area networks, determining reserve boundaries or creating corridors that link isolated populations.
- Research is also important when deciding where to invest time and effort in protection or research activities, and provides empirical data to evaluate existing management strategies.
- These data are essential for IUCN Red List of Threatened Species assessments, which should be based on actual population size and status.