# 3. QUESTIONING APPROACHES


## 3.1. *Questioning approaches*

- How to determine the ***approaches*** and what you can ***learn***?

- Answer: the ***questions*** you ask.

- Scientific investigation (activities): ***empirical*** [1] or ***theoretical*** [2] approaches.

- Approaches (broad) in Ecology: ***theoretical***, ***empirical***, and ***applied***.

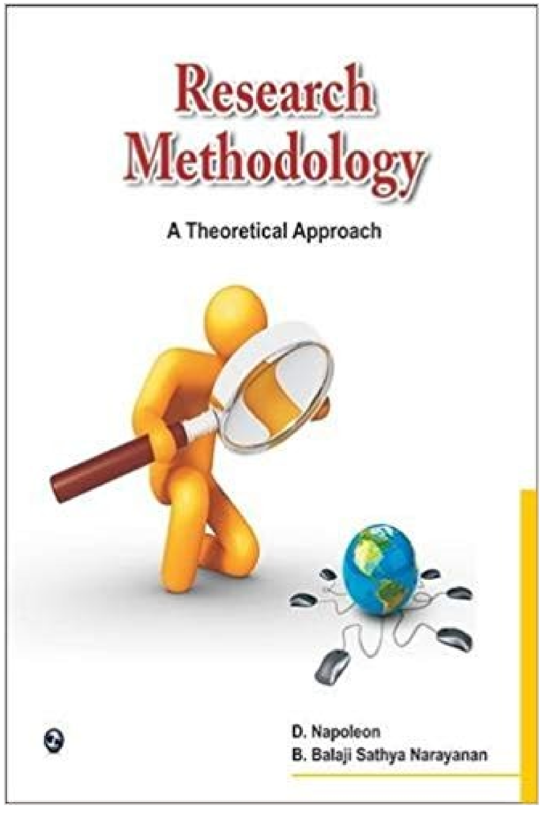
[1] based on what is experienced, on observation or seen rather than on theory;

[2] a hypothesis or opinion not based upon actual knowledge.

1. **Theoretical:** deals with the *mathematical* world [1]:

- can be *inspired* by real-world phenomena;
- we do not need to *gather* /*analyze* the data from those phenomena.

➢ It is the *physics* of *ecology*: [2].




[1] E.g. It is most ***useful*** for exploring what ***might*** be if we make certain ***mathematical assumptions***.

It is the most ***prestigious*** part of the ecology:

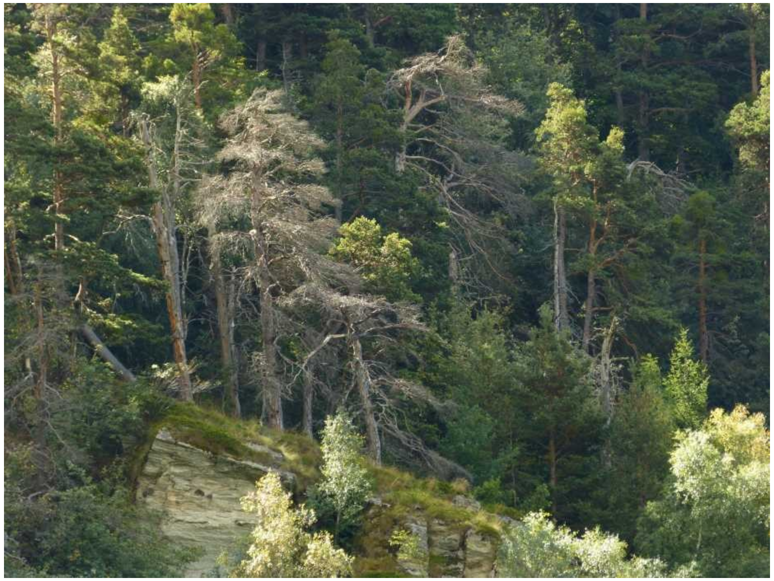
it involves ***elegant mathematics*** (1);

it does not get involved in all the ***complexities*** of real-world ecological systems (2);

[2] carries on in its ***own world*** and partly ignored by most of those working in the other two broad areas of ecology.

2. **Empirical**: trying to understand how the natural world works at the level of *individuals*, *populations*, *communities* and *ecosystems* [1]:

- the *gathering* /*analysis* of data from *phenomena* observed in the *real* world;
- purely *observational* field studies;
- hypothesis-driven lab exps., fieldwork or any other *gathering* of data.



Mortality in pine forests in the Valais, Switzerland (Photo: T. Thrippleton)
http://www.fe.ethz.ch/en/research/stand-and-landscape-dynamics/

[1] i.e. scientific method of ***inquiry*** and ***observation*** through ***experiments***: it does not care about solving practical ecol. / environ. problems, but its assumed that the info. they provide will be ***useful*** ***now*** or in the ***future***.

It ***seeks*** but rarely ***finds*** it because all individuals and species differ in how they play the ecol. game of survival.

The ***details*** of empirical ecology are ***boring*** to politicians, business people, etc.

3. **Applied**: *real-world* (usually management) *questions*.

- e.g. managing ecosystems for conservation;
- sustainable harvest;
- animal pest and weed control etc.

Applied Ecology
https://www.mtu.edu/gradschool/programs/degrees/applied-ecology/

➢ An applied ecologist: a conservation *biologist*, a *forester*, or an agricultural *scientist* [2].

[2] It is about ***solving real*** world ***problems***, e.g. declining ***populations*** and ***extinctions*** of plants and animals; climate ***change***; the impacts of climate change on ecosystems, etc.

# 3.2. *Methods in Ecology: observation*

**Observation** of patterns;
Manipulative **experiments**;
**Modeling** (model building).

https://www.pitzer.edu

Plant survey:
https://www.intechopen.com/chapters/46032

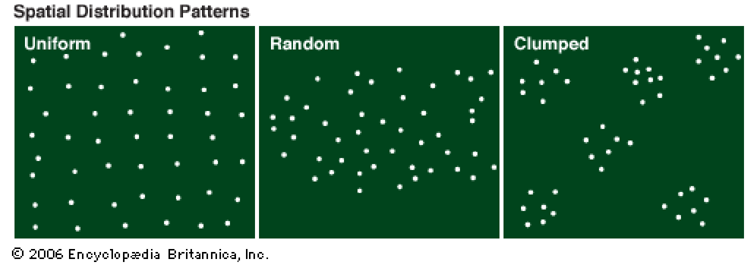
## 1. *Observation*:

- *essential* in natural ecosystems [1];
- absolutely *necessary* [2].

➢ You need thoroughly *observe* your system with no manipulation ***before*** exp. start.

[1] provide us with ***factors*** and ***processes***; allow us to ***generate*** hypotheses and to ***test*** models;

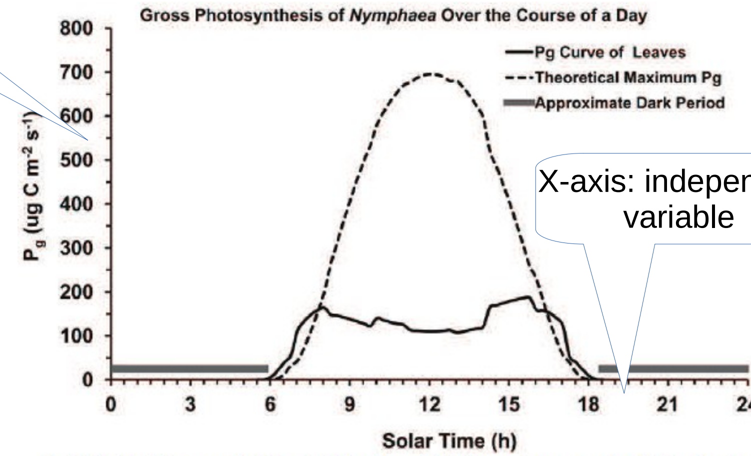
[2] to provide the ***insights*** for making good ***experiment*** and ***models***.




- *Continue* to monitor your system [1], even after you have set up you ***manipulations***.

- Keeping a field *notebook* may help you with *observations* [2].

- To *observe* and *quantify* a **pattern** in nature is an *excellent* way to begin an exp. [3].




R. J Ritchie, Photosynthesis in the Blue Water Lily (Nymphaea caerulea Saligny) using PAM fluorometry, 2012, Int. J. of Plant Sci.,173(2):124-136

[1] the natural ***variation***;

[2] it is difficult to ***remember*** the details you observe, even those if they do not seem ***relevant***, often later on some of them may be unexpectedly ***valuable***;

[3] e.g. it is often helpful to ***represent*** the ***pattern*** as a ***figure*** with one variable on the x-axis and the other on the y-axis.

If, e.g., the relationship appeared ***linear*** /ˈlɪnɪə/, an experiment with two ***levels*** of independent variable may be appropriate.

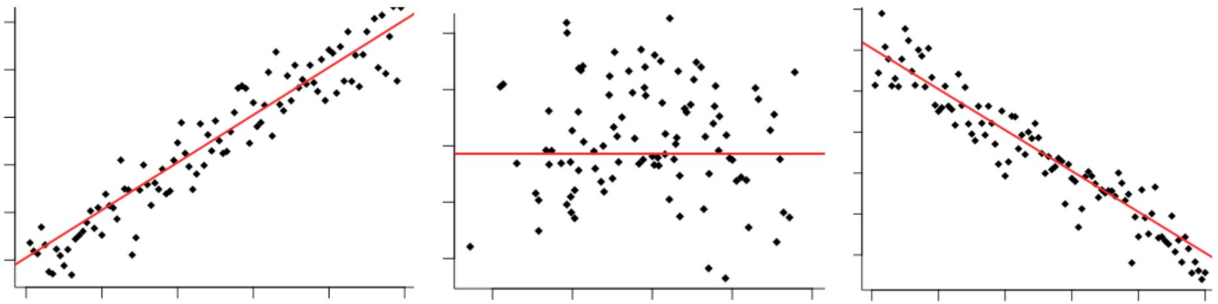
e.g. if the number of pollinators and seed set is linear; an exp. ***with*** and ***without*** pollinators is relevant.

If, e.g., the relationship is ***nonlinear***, an experiment with two levels of e.g. of pollinators will be not so ***informative*** as an exp. with many levels, i.e. level 1, 2, etc.

- *Observation* (in some cases) may even *replace* exps. to gain ecol. understanding due to:

- many processes are *difficult* to manipulate;
- important ecol. *processes* often occur at *large* scales;
- some ecol. processes are simply *hard* to manipulate in any realistic way;
- in some cases an exp. is *problematic*;
- *extrapolation* of results from small-, to larger-scale is difficult to *justify*.

- *Limitations*: *observation* can be applied to *test* hypotheses, but not enough to *establish* causality /kɔːˈzalɪti/.[1]



Positive correlation, zero correlation, negative correlation. https://medium.freecodecamp.org

[1] In fact correlation implies causation, but we cannot ***infer*** the direction of **causation** kô ˈzāSHən without some scientific "spy, or track".

e.g. a correlation between **SOM** and tree cover could be due to trees preferring organic soils, or leaf litter contributing to **SOM**, or another variable simultaneously affecting tree distributions and **OM**.

## 3.3. *Methods in Ecology: manipulative experiments*

Setting up controlled study on a rocky shore

https://www.biosch.hku.hk/ecology/porcupine

- ME: vary only *one* thing (factor, or at most a few) [1].
- The experimenter *controls* that variable [2];
- The *effect* [3] can be done by statistical tests.

[1] the word “experiment” refers not only to manipulative ***experiments***; an experiment is a series of observations ***intentionally*** planned to address a scientific question;

[2] i.e. any ***responses*** can be contributed to the ***manipulation*** (if an exp. has been set up properly, i.e. treatments assigned ***randomly*** to each replicate);

[3] whether caused by ***chance*** or by the ***manipulation***.

Examples of Manipulative Experiments on Forest Trees.

***Left***: Whole-tree warming experiment to measure carbon uptake and release in eastern Australia.

***Right***: Experimental branch warming experiment to measure phenological responses at the Tomakomai canopy crane site, Japan

https://www.researchgate.net

Trends in Ecology & Evolution

ME can help to establish *causality*.

- ME take *time* [1] and are not always *possible* [3].

[1] often we need ecol. info. ***now*** (or yesterday);

[3] e.g. ***ethical*** concern keep us from conducting exp. on ***rare*** species.

## 3.4. *Methods in Ecology: model building*

- ***Modeling***: attempts to ***generalize*** (to distill) the cogent /ˈkəʊdʒ(ə)nt/ factors/processes that produce the community ***pattern*** [1] we observe.

Why model?

- ***Abstractions*** of real world ***system*** or ***process***;
- Help to define ***problems*** more ***precisely*** and ***concepts*** more clearly;
- Provide ***approach*** for analyzing observation data, providing statistical ***inference***, communicating results;
- Allow for ***predictions***.

[1] e.g. the ***behaviors***, population ***dynamics***.

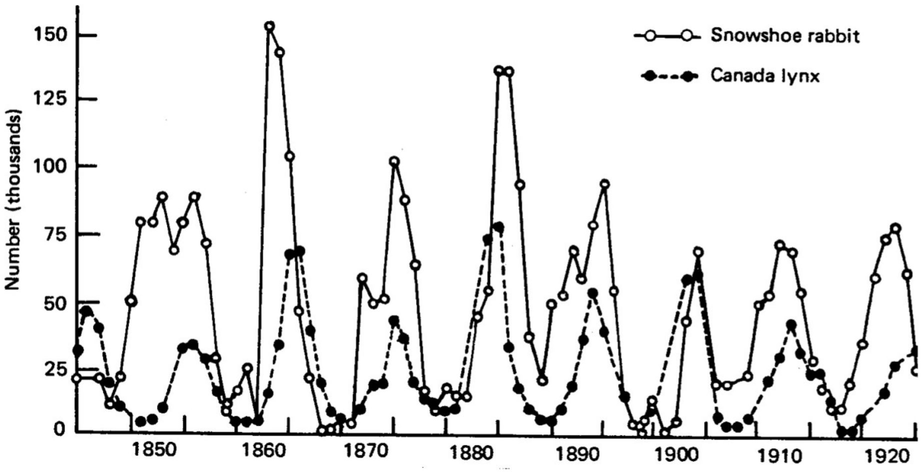
- Models: ***general*** or ***specific***.

- GM helps us to ***formulate*** the logical ***links*** between ***variables*** [1].

- SM uses measured ***parameters*** and allows us to make ***prediction*** [2].

A. Lotka

V. Volterra




Numbers of snowshoe *hare* and Canada *lynx* furs sold to the Hudson's Bay Company. Canada lynxes eat snowshoe hares (From E.P. Odum, Fundamentals of Ecology, 1953) `https://math.libretexts.org. The Lotka-Volterra Predator-Prey Model`

[1] simulation or process-based models, i.e. can simulate the process or dynamics over time: model's conclusions can be applied to a wide range of real-life ***systems*** (it captures some basic ***essence*** that applies to many possible systems);

[2] analytic (correlative) models, relatively simple (often linear) systems, can be described by a set of equations. Due to limited data availability may be possible only for a ***limited*** number of subjects (ecosystems, communities, or species).

- Good SM can allow develop ***new*** hypotheses about how nature ***works*** (and how to manage ecosystem) [1].

- Often, the ***consequences*** /***results*** are well ***known*** and very ***visible***, while the processes that ***caused*** those results are more difficult to asses.


[1] E.g. ***white-tailed deer*** (північний олень, right) colonized Atlantic Canada and replaced ***caribou*** (олень білохвостий, left). Efforts to reestablish caribou have failed. The hypothesis for ***caribou*** decline was competition for food resources.

This, however, was not supported by data and it is appeared that mortality to ***caribou*** was caused by a sheared parasite, a meningeal worm.

***Deer*** are the usual host for the worm, they are much more tolerant of infection than ***caribou***.

The both ***deer*** and ***caribou*** ingest snails, which are intermediate host for the worms.

More ***deer***, more shared parasites and less ***caribou*** (Bergerud & Mercer, 1989).

### 3.5. *Noninvasive and nondestructive observations in ecology*

- NIN and NDS *observations* of entire system may help to *understand* who the *players* are and how they *interact* with one other [1].

- Ecologist like to *manipulate* their system. Why?

- The investigator *disturbs* the system and can *observe* **effect** and **cause**.

- Understanding ***cause*** and ***effect*** is *critical*, *powerful* and *difficult*.

[1] In other words who's doing what?
Nothing more can be *obtained*.

- *Observations* only allow us to make conclusion based on *correlations*.

- *Correlations* almost always *implies* **causation**, but by itself, cannot *resolve which* of the two correlated variables might have *caused* the other [1].

- MEs are very *powerful* tool to establish *cause* and *effect*.

- It is easier to get exp. work published than if you doing studies relying on *observations* and *correlations*.

[1] e.g. ***homeless*** population and ***crime*** rate might be correlated. You can say that ***homeless*** population is correlated with ***crime*** rate, or ***crime*** rate is correlated with ***homeless*** population, which are different statements, and correlation does not imply that either is true.

For instance, the underlying cause could be a 3rd variable such as drug abuse, or unemployment.

- ***Exps.*** are limited by initial *intuition* and by *scale* and *realism*.

- *Observations* can provide the *intuition* to design exp. and provide info. over larger areas and longer time than an exp..

## 3.6. *Independent and dependent variable in an experiment*

- ***Independent*** (manipulated): represents a ***quantity*** that is being manipulated in an exp. [1].

- We choose an independent variable based on the ***hypothesis*** /***idea*** we want to test. Why?

- We believe it may have some ***effect*** on (be a ***cause*** of) the process we are studying.

- **x** is often the variable used to represent the ***independent*** variable in an equation.

[1] the one that we ***vary*** *in an exp.,* and we have ***control*** over; a variable is something you're trying to ***measure***, it can be anything: objects, amounts of time, events etc,

the independent variable has just two values: one for the ***experimental condition*** (treatment) and one for the ***control condition***. (a baseline against which we compare the effects of the treatment).

- *<u>Dependent</u>* (responding): a quantity whose value *<u>depends</u>* on how the independent variable is manipulated [1].

- It is a *<u>response</u>* / responses that the subject makes [2].

- We chose it to measure. Why?

- We believed that it reflects the process the *<u>independent</u>* variable is supposed to affect.

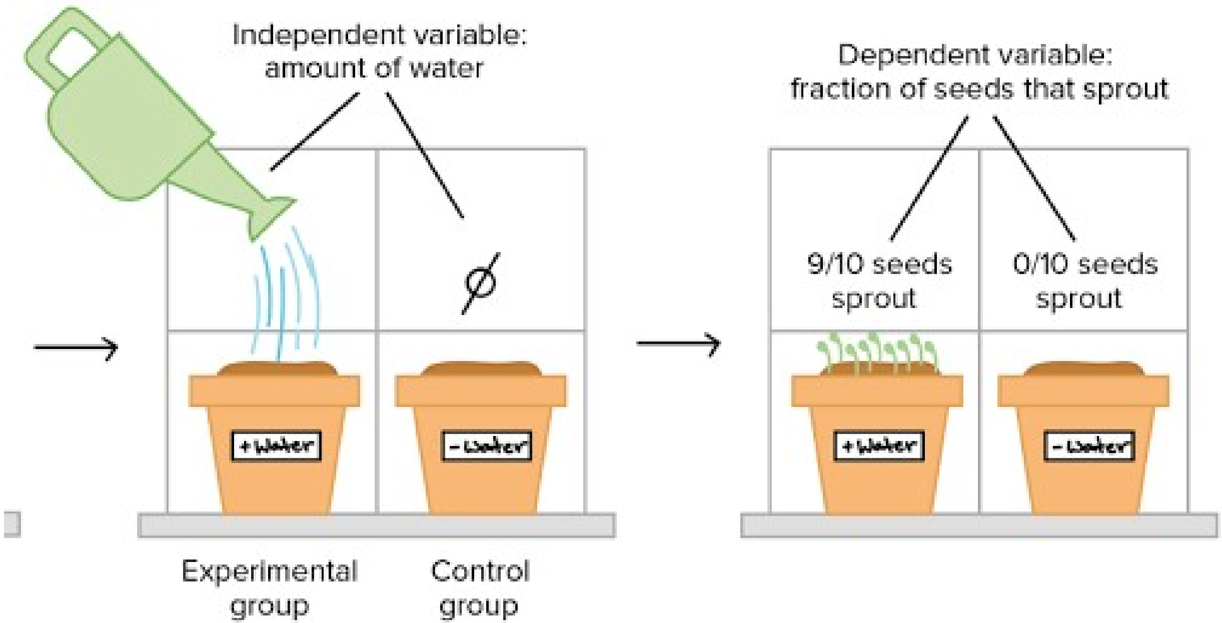
- **y** is often the variable used to represent the *<u>dependent</u>* variable in an equation.

[1] e.g. in the case of a poor performance of a student in an examination, the ***<u>independent</u>*** variables can be the factors like the student not attending classes regularly, poor memory, etc., and these will reflect the grade of the student i.e. the ***<u>dependent</u>*** variable is the test score of the student;

[2] response - the outcome being measured.

- All other *variables* must be kept the *same* throughout the investigation; they should be *controlled*.

- Those are called *controlled* *variables*.




Adapted from: https://www.khanacademy.org/