

## Scientific Process

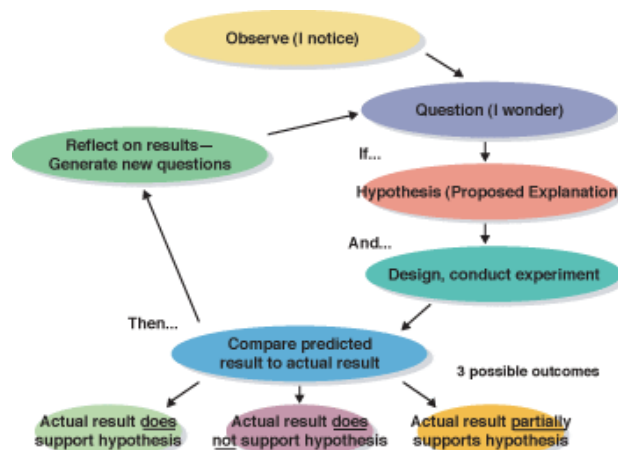


Figure 1. Steps of the scientific process.

## Guidelines and Template for NREM 301L Lab Reports

In this writing intensive course, you are required to write laboratory reports in a “research paper” format. As you work on your writing skills throughout the semester, please make use of the following resources:

- **This guideline/template document**
- Instructor/TA feedback on current and/or previous assignments
- Avoid common errors in student research papers (See sections on “**What to avoid**” throughout this document)
- Instructor/TA office hours
- **This guideline/template document**
- Did we mention **this guideline/template document**?

### 1. General Form of a Research Paper

One objective of organizing a research paper is to allow people to read your work selectively. When one reads a paper, they may be interested in just the methods, a specific result, the interpretation, or perhaps they just want to see a summary of the paper to determine if it is relevant. To this end, the vast majority of scientific journals require the sections that you will use, submitted in the order listed in this document. Some journals, however, require a combined Results and Discussion, or include Materials and Methods after the body of the paper. The well-known journal, *Science*, on the other hand, does away with separate sections altogether, except for the abstract. Most scientific journals, however, use the format outlined here.

### 2. General Style Requirements

Length

- 4-6 pages **typed**.

To make the report readable:

- Use a **12-point standard font**, such as Times, Geneva, Bookman, Helvetica, etc.
- Text should be **double spaced** on 8 1/2" x 11" paper with **1" margins**; **Single-sided**
- **Number pages** consecutively
- Place tables first, and then figures, **properly numbered and labeled**, in order at the end.

What to avoid:

- Placing a heading at the bottom of a page where the following text begins on the next page (insert a page break),
- Dividing a table (or figure) across multiple pages- confine each table (or figure) to a single page,
- Submitting a report with pages out of order or missing.

In all sections of your paper:

- Use normal prose, including articles ("a", "the," etc.),
- Stay focused on the research topic of the paper,
- Use paragraphs to separate each important point, and use topic sentences for each paragraph,
- Insert a blank line before the first line of each paragraph or indent the first line of each paragraph,
- Present your points in logical order,
- Use **present** tense to report well accepted facts - for example, "Grass is green,"
- Use **past** tense to describe specific results - for example, "When herbicide was applied, the grass turned brown,"
- Avoid informal wording, don't address the reader directly, and don't use jargon, slang terms, or superlatives,
- Avoid using superfluous images. Include only those figures/tables necessary to present the results.

### 3. Title

Use an informative title. "NREM 301L Lab 5 Report" would **not** be an informative title.

### 4. Introduction

#### General intent

The purpose of an introduction is to acquaint the reader with the rationale (justification) behind the work, with the intention of defending its importance. It also places your work in a theoretical context and enables the reader to understand your objectives, hypotheses and overall experimental design.

#### Format requirement

Approaches to writing an introduction vary widely. However, for lab reports in this class use the following approach. Your introduction **must include these four items**.

1. Describe the importance of the study: Why was the study undertaken in the first place? What is its significance and/or justification? Provide a broad context.
2. Provide a rationale I: State your specific objective(s)
3. Provide a rationale II: State your hypothesis(es), and describe the reasoning that led you to this hypothesis (i.e., What was your reasoning?). A hypothesis is a statement, not a question.
4. Provide a brief (1-2 sentence) overview of how you addressed your objective(s) and tested your hypothesis(es).

Style:

- Use past tense except when referring to established facts.
- Organize your ideas, making one major point with each paragraph. To make the points listed above, you will need a **minimum** of two paragraphs: one for number 1, and one for numbers 2-4.
- Be concise, and present background information only as needed in order to support a position. The reader does not want to read everything you know about a subject.
- State the objective precisely - do not oversimplify.
- As always, pay attention to spelling, clarity and appropriateness of sentences and phrases.

## Writing objectives

“Good” objectives should be measurable in terms of whether the statements are accomplished or not. Listed below are examples of verbs that are considered appropriate to create good objectives (i.e., measurable).

Cognitive Domain					
Knowledge	Comprehension	Application	Analysis	Syntheses	Evaluation
define	choose	Apply	Appraise	classify	appraise
identify	demonstrate	develop	Compare	design	assess
list	describe	employ	Contrast	develop	critique
name	explain	Relate	Deduce	modify	evaluate
recall	interpret	Use	detect	organize	judge
	select		distinguish	produce	validate
			evaluate	reconstruct	
			identify	restructure	

(Source: <http://ar.utmb.edu/areas/classes/htgwebgoalsobjectiveschild.asp>)

The following is an example of the objective, hypothesis, and experimental overview for a report:

*The objective of this study was to determine why the sky is blue. It was hypothesized that the sky is blue because particles in the atmosphere reflect incoming solar radiation in the blue spectrum of visible light. To test this hypothesis, two microcosms were established, one with and one without particles of an appropriate size for reflecting blue light, and the color of the sky in each microcosm was quantified by visual inspection.*

**IMPORTANT:** Remember that there were three objectives in the soil erosion study, and that we are testing one hypothesis.

## 5. Methods

### General intent

This should be the easiest section to write, but many students misunderstand the purpose of this section. The objective is to document general procedures so that another individual may use some or all of the methods in another study and/or to judge the scientific merit of your work. It is not to be a step by step description of everything you did, nor is it a set of instructions. In particular, it is not meant to tell a story.

### Writing a methods section

Clearly and concisely describe the methods used in the soil erosion study, including USLE and erodibility index. A key concept is to keep this section as concise as you possibly can. People will want to read this material selectively. The reader may only be interested in one formula or part of a procedure.

- Present methods under subheadings devoted to specific procedures or groups of procedures
- Generalize - report how procedures were done, not how they were specifically performed on a particular day. For example, report "*samples were diluted to a final concentration of 2 mg/ml protein*", and don't report that "*135 microliters of sample one was diluted with 330 microliters of buffer to make the protein concentration 2 mg/ml.*" Always think about what would be relevant to another investigator working on their own project.
- If well documented procedures were used, simply report the procedure by name (e.g., "*The point interception method was used to determine surface cover*"). No further detail is necessary.

## Style:

- It is awkward or impossible to use active voice when documenting methods without using first person, which would focus the reader's attention on the investigator rather than the work (e.g., “*We measured slope length three times with a meter tape.*”). Therefore when writing up the methods you should **use third person passive voice** (e.g., “*Slope length was measured three times with a meter tape.*”).
- Use normal prose in this and in every other section of the paper. Avoid informal lists, and **use complete sentences**.

## What to avoid:

- Methods are not a set of instructions.
- Omit all results – save it for the Results.
- Omit all explanatory information and background – save it for the Discussion.
- Omit information that is irrelevant to a third party, such as what color ice bucket you used, or which individual logged the data.

**Example Format Based on the USLE Lab (Also broadly applicable to all other lab reports)**

The methods section should include the following subsections.

- Site Description – Clearly and concisely describe the slope on which we worked. Although only one slope was characterized, we also worked on two additional “hypothetical” slopes:
  1. a slope only with surface cover,
  2. a slope without surface and canopy cover.

Mention these two hypothetical slopes in this subsection as well.

- Formulas/Calculations – In this subsection, describe that the USLE was used as a theory and tool to estimate potential soil losses from the studied slopes. Include brief descriptions of the USLE formula and its parameters. Include the equation within the text. Please make sure you describe that we considered only the surface-cover and canopy-cover subfactors for *C* in this study. The following is an example paragraph:

*In this study, the Universal Soil Loss Equation (USLE) was used to estimate potential soil losses in tons/acre/year (A) from three slopes:*

$$A = R \cdot K \cdot LS \cdot C \cdot P, \quad [1]$$

*where R is the rainfall erosivity factor (ft-ton / acre hr year), K is the soil erodibility factor (ton-acre-hr/acre ft ton), LS is the combined topographic factor that accounts for the effects of both slope length and steepness, C is the vegetative cover and management factor, and P is the erosion control practice factor.*

- Field/Parameter Measurements – Concisely describe the methods used to obtain each of the USLE parameters. For example, the method for obtaining a K value can be explained as follows.

*An appropriate K value for the soil was obtained from the soil erodibility nomograph (Lab 2, Appendix 5).*

- Sensitivity Analysis – Concisely describe the method/procedure by which we assessed the USLE factor that had the greatest impact on soil loss. Remember this “sensitivity analysis” was performed on the original slope (not hypothetical ones).

- Erodibility Index (EI) – In this subsection, describe the formulae that were used to determine potential best management practices for the slopes. Include brief descriptions of the formulae as well.

## 6. Results

### General intent

The purpose of a results section is to present (with text) and illustrate (with Tables and/or Figures) your findings/results. Make this section a completely objective report of the results. **Save all interpretation of results for the discussion.**

### Format requirement

Continue to be concise, using tables (and figures if appropriate), to present results most effectively. This part should not involve your thoughts on the results, but should be mere descriptions and presentations of the estimated soil losses, sensitivity analysis, and best management practices that were found to reduce soil losses.

### Content:

- Summarize your findings in both text and tables/figures. Reformat the tables if appropriate. Place **tables at the end of the document**, in the order in which they are referenced in the text. If used, Figures always come after all Tables.
- In the text, describe each of your results, pointing the reader to observations that are most relevant.
- Provide a context, such as by describing the question that was addressed by making a particular observation.
- Each time a table is referenced in the text, place the table # in parentheses at the end of the sentence (e.g., “*The R factor had the greatest impact on the estimate of soil loss (Table X).*”).

### What to avoid:

- Do not discuss or interpret your results, report background information, or attempt to explain anything.
- **Do not** create a sentence just to point out the existence of a table (i.e., do not say something like “*Table X has information on which factor had the greatest impact on the estimate of soil loss.*”).
- Never include raw data or intermediate calculations.
- Do not present the same data more than once.
- Text should complement Tables (or Figures), and not simply repeat the same information.
- Do not confuse Tables with Figures - there is a difference. If you do not understand that difference, simply ask your instructors/TA.

### Style:

- As always, use past tense when you refer to your results, and put everything in a logical order.
- In the text, refer to each table as “(Table 1),” “(Table 2),” etc. (figures should be numbered in the same way, but separately). Table and Figure citations should always be at the end of a sentence, in parentheses (e.g., “*The sky was blue (Table 1)*”, and not “*Table 1 shows that the sky was blue*”).
- Place tables, properly numbered, in order at the end of the report.

Figures and tables:

- Each Table must be numbered consecutively, have a clear title indicating the contents of the Table (e.g., “*Table 1. USLE and component parameter estimates*”). Table headings should be placed **at the top** of a Table.
- Each table must be sufficiently complete that it could stand on its own, separate from text (i.e., someone could look at the Table and Table heading without reading the text and understand what the data mean).
- If you use Figures (and you will in subsequent labs), each Figure must be numbered consecutively and have a clear title indicating the contents of the Figure. The Figure heading should be placed **at the bottom** of a Figure.

**IMPORTANT:** You must clearly distinguish material that would normally be included in a research article from any raw data or other appendix material that would not be published. In fact, such raw data or appendix material should **not** be included at all unless requested by the instructor.

## 7. Discussion

### General intent

The discussion section provides an interpretation of your results and discussion of your conclusions within the context of your original objectives and hypotheses. To do so, you will use evidence from your experiment and, if appropriate, generally accepted knowledge and/or information from other sources. While not required, if you use information from other sources, you must clearly indicate where it came from by providing an in-text citation and include the full citation in the Literature Cited section (see page 7 for more info). The significance of your findings should also be clearly described.

### Format requirement

Interpret your data in the discussion *in appropriate depth*. This means that when you explain a phenomenon you must describe mechanisms that may account for the observation. If your results differ from your original hypothesis, explain why that may have been the case, and what you learned.

- Research papers are not accepted if the work is incomplete. Draw what conclusions you can based upon the results that you have, and treat the study as a finished work. Do not simply dismiss a study or part of a study as "inconclusive."
- You may want to suggest future directions, such as how the experiment might be modified to accomplish another objective/hypothesis or expand upon the original objective/hypothesis.
- One experiment will not answer all questions. So keep the big picture in mind (e.g., Where do you go next?). The best studies open up new avenues of research. What questions remain?

Style:

- When you refer to information, distinguish data generated by your own studies from published information or from information obtained from other students (verb tense is an important tool for accomplishing that purpose).
- Refer to work done by specific individuals (including yourself) in past tense.
- Refer to generally accepted facts and principles in present tense. For example, “*Doofus, in a 1989 survey, **found** that anemia in basset hounds **was correlated** with advanced age. Anemia **is** a condition in which there is insufficient hemoglobin in the blood.*”
- **Clearly state whether your data support/do not support your hypothesis(es).**

What to avoid:

- The biggest mistake that students make in discussions is to present a superficial interpretation that more or less restates the results. It is necessary to suggest *why* results came out as they did, focusing on the mechanisms behind the observations.
- You will rarely, if ever, prove or disprove a hypothesis with a single study and, in as much, you should avoid using these terms. **Your data will “support” or “not support” your hypothesis(es).**

## 8. Literature Cited

Please note that in this introductory laboratory course, you will **NOT BE REQUIRED** to provide references for your lab reports beyond the lab handouts. However, if you chose to cite outside sources such as textbooks, papers from scientific journals, etc., you need to provide proper documentation of these references in a Literature Cited section at the end of the lab report. Citation formats can follow any style used in any scientific journal and at a **MINIMUM** should include: 1) author(s), 2) year of publication, 3) title of paper or book, 4) publisher, and 5) volume and page numbers. This is a very important part of the process when publishing the results of a study.