

GUIDELINES FOR LAB REPORTS

The purpose of the lab reports is to give you experience in analyzing and interpreting data, as well as in presenting a description of your research using clear, concise writing. While such an effort is initially intimidating for many students, one goal of this course is to familiarize you with the process. You will find that if you follow some basic steps for the general structure of the lab report, the writing and analysis will be much easier. Here are some strategic hints for writing your reports:

1) Give yourself time. Data analysis, graph preparation, background research, thoughtful writing, and attention to the formatting criteria (below) WILL take more than one evening. DO NOT wait until the night before it is due to start your report.

2) Before sitting down to write a report, think carefully about the ecological question or phenomenon the lab exercise addressed, and then go over your data to see what conclusions can be drawn from them. It may help to think of the lab report as a written argument in which you state a question, present data relevant to that question, and then try to convince readers of the conclusions you have drawn.

3) Prepare an outline of each section with the important criteria to be included or points you want to make. Use the suggestions below as a guideline. That way, you won't accidentally leave out important components and needlessly lose points.

4) Don't plan on getting it all right in the first draft – you certainly won't. After you've written a first draft, let it sit a day or two. Then, read it over again with a fresh head, and you'll find that it is much easier to see which elements of your presentation are clear and which are not.

5) If you are having difficulty structuring or communicating your ideas, we urge you to take advantage of the services offered by the **Writing Center** (Wilson Library 324, 650-3219), especially for help with early drafts. Of course, we are also glad to offer advice if you are struggling.

6) Proofread your report! Rampant typographical errors and poor grammar are unacceptable. If the writing in your report shows minimal effort and little attention to these issues, it will be handed back to you ungraded and without comments. It will then be up to you to correct those issues. Any additional time it takes to do so past the due date will be marked as late.

ORDER OF REPORT SECTIONS

As with most scientific papers, each report should contain particular sections, in a particular order. **You are expected to follow this order**, as outlined below. Lab reports that do not follow this simple outline will be returned to you as unacceptable. Refer to the rubric handed out in class for additional guidelines.

Grading breakdown for full lab report (100 pts total):

1. Title	3 pts
2. Abstract	7 pts
3. Text	
Introduction	15 pts
Methods	15 pts
Results	15 pts
Discussion	25 pts
4. References	5 pts
5. Tables, Fig. captions, Figs.	15 pts

Text sections should be delineated with appropriate headings. You can have subheadings within each section if necessary, but be consistent with how they are structured. The use of subheadings can be very effective, particularly if the research features several components that are pieced together to form a cohesive story.

SECTION CONTENT

This section describes the basic components of each section of the lab report. Failure to incorporate these minimal suggestions will result in loss of points.

Title

- The title should be a meaningful description of the study you did; it should not just repeat the lab title from this manual.
- You can put the title at the top of the first page of text or have a separate title page.
- Of course, don't forget to put your name beneath the title. In addition, put the names of your group members as co-authors (**but each of you needs to write your own lab report**).

Abstract

- This is an overview of the major points of the whole lab report
- It should be approximately 250-300 words long.
- It should summarize the context, questions, results and major conclusions. Often you can put together key statements from the intro, methods, results, and discussion to construct your abstract. Of course, you will need to smooth out the writing to make it flow.

Introduction

- This should act as a “funnel”, starting out with the big context and gradually focusing in towards the specific questions that you will be addressing.
- Give a brief description of the context of the experiment. What big question(s) motivated this investigation?
- Present the primary hypotheses or objectives of the experiment.
- Give a brief description of the experimental system: what organisms or ecosystems were studied? You should include at least one reference that addresses work on the local streams that we are studying.
- In this section, and throughout the paper, try to write in the active voice rather than the passive voice.

- Be sure to cite appropriate references to set the context for your experiment. **NOTE: At a minimum, you should have at least one reference from each of the six categories we used in the literature assignment. You also MUST use the following two references in your intro: Morley and Karr (2002), Hachmöller et al. (1991).**

Methods

- The general purpose of a methods section is to describe your procedures in a manner that would allow readers to reconstruct your study.
- You must include sufficient detail so that someone coming to repeat your experiment could figure out exactly what to do. At the same time, you don't need to repeat everything in the lab manual.
- Things to describe:
 - What treatments were used?
 - What was the experimental design? (be sure to describe the number of replicates)
 - What variables were measured?
 - What procedures were followed?
 - If it is relevant, describe the field sites and any relevant weather conditions.

Results

- In this section, you should clearly describe your results both verbally and with figures and tables that summarize the general patterns in the data.
- You should avoid interpreting how particular results relate to the original question - save that for the Discussion section. Simply describe the results in the Results section.
- You can organize your results in whatever way is scientifically logical to make the points you want to make in the discussion. Sometimes this may be chronological, but not always.
- In the written portion of this section, be sure to refer to all tables and figures in the text.
- Coordinate your written results section with the presentation order of tables and figures (see section below).
- Where appropriate, you need to state the statistical significance of the differences among treatments, for example, as tested by ANOVA (analysis of variance). ANOVA is a method for assessing differences among treatments, which we will cover in class. Either present the statistics in the text, including level of significance, or include them in a table. In describing your results, it is not sufficient to just say "Treatment 1 was higher than than Treatment 2", without also describing whether or not those differences are statistically significant. For example, some typical results sentences might be as follows:

“There was no significant difference in copepod abundances in the bay compared to the creek ($p = 0.19$). However, the density of mysid shrimp was significantly greater in the bay than the creek ($p = 0.01$).”

Discussion

- Synthesize your findings. Start by thinking about the major points you want to make, and build from there.
- Did you accept or reject your hypotheses?

- What do your results say about the big questions that originally motivated the study, and that you developed in the introduction?
- How do your results relate to other findings in this area? Describe any similarities and explain any differences.
- Be sure to cite appropriate references, not only to illustrate how your results are similar to or different from other examples in the literature, but also in talking about the big questions that motivated your research. **NOTE: At a minimum, you should have at least one reference from each of the six categories we used in the literature assignment. You also MUST use the following two references in your discussion: Morley and Karr (2002), Hachmöller et al. (1991).**

References

- All sources for ideas or facts must be cited. See discussion of plagiarism, below.
- You must draw on at least eight outside sources for the introduction and discussion of your report. Acceptable references include your textbook or other books or peer-reviewed scientific journal articles from the library or on reserve. "Peer-reviewed" simply means that other scientists have commented on the appropriateness of the methods and conclusions prior to publication.
- At a minimum, you should have at least one reference from each of the six categories we used in the literature assignment:
 - a) Effects of land use on watersheds and streams;
 - b) Stream invertebrates as a tool for stream assessment;
 - c) Biotic indices/metrics as tools for stream/habitat assessment;
 - d) Padden Creek, Chuckanut Creek, or other Pacific Northwest stream studies;
 - e) Linking stream water quality to biodiversity, salmon habitat, or other ecosystem services (benefits people derive from natural ecosystems).
 - f) Effectiveness of stream restoration.
- You also MUST use the following two references in your intro and discussion: Morley and Karr (2002), Hachmöller et al. (1991).
- While you can use web sites for additional information, they must be cited properly (see below) and web sites do not count towards the eight reference minimum. Very few web sites have any kind of peer-review process to ensure high standards of scientific methodology. If you have questions about a particular site, be sure to ask us.
- Proper citation style is expected and is illustrated below. If you have any questions about this style, look in any recent issue of the journal *Ecology* for examples.

Citation style within the text

When you are writing and use ideas that you gained from other sources, you need to acknowledge this by putting the authors' names and the date of their publication in the sentence. Two examples:

1) Five interacting 'state-factors' typically influence the process of soil formation. These are climate, organisms, topography, parent material, and time (Jenny 1980).

2) MacArthur (1972) has suggested that there are more species where the environment is complex and therefore more easily subdivided.

How you list the authors' names in the text depends on how many authors there are:

One author (Jenny 1980)

Two authors (Smith and Jones 1897)

Three or more authors (Aber et al. 1989)

You should NOT include a page reference in the text citation for most journal articles (this will happen in the REFERENCES section at the end of your lab report). You MAY include a page number if you pulled a specific quote, fact or other tidbit of knowledge from a large book. Generally, you should avoid quoting directly from your sources, but if you do use any direct quotes, be sure to indicate them with quotation marks.

Citation style in the "References" section at the end

Journal article

Aber, J. D., J. K. Nadelhoffer, P. A. Steudler, and J. M. Melillo. 1989. Nitrogen saturation in northern forest ecosystems - hypotheses and implications. *BioScience* 39: 378-386.

Book

Jenny, H. 1980. *Soil Genesis with Ecological Perspectives*. Springer-Verlag, New York, New York, USA.

Edited book

Mooney, H. A., W. E. Winner, and E. J. Pell, eds. 1991. *Response of Plants to Multiple Stresses*. Academic Press, San Diego.

Chapter from an edited book

Chapin, F. S., III. 1991. Effects of multiple environmental stresses on nutrient availability and use. Pages 67-88 in Mooney, H. A., W. E. Winner, and E. J. Pell, eds. 1991. *Response of Plants to Multiple Stresses*. Academic Press, San Diego.

Web sites

Author, Date, title of web site or article, full web address

Tables, figures, and figure legends

- The purpose of figures and tables is to provide a quick visual summary of the data. Data should be presented with both means and some estimation of the amount of variation (standard error is best, but standard deviation is also fine).
- DO NOT SHOW THE RAW DATA.
- Do not duplicate data in tables and figures – use only one or the other for any given set of numbers.
- Number tables and figures according to the order in which you refer to them in the text (e.g., Table 1 is the first table referred to, Table 2 next, etc.).
- Include only tables and figures that you describe in the text.
- Make sure to label the axes of all figures, including units of measure (e.g. Distance, m).

- Pay attention to the scale of axes in figures. Choosing a very small scale (for example a temperature range of 11.9-13.2) will exaggerate what is in fact a minor difference among treatments into a difference that appears much greater.
- Most journals accept only black and white figures; this format is completely acceptable for this class. Be sure any lines or bars from different treatments are easily distinguishable from each other.
- If you decide to use color figures, that is also fine. Color is now commonly used in a variety of situations (posters, slides, computer presentations, even some journals), so you are welcome to experiment with this format. Here are a couple of guidelines to follow with color figures:
 - 1) color can help get your message across, but too many different colors or wild color schemes can be more confusing than helpful;
 - 2) as with B&W, make sure lines and bars from different treatments are easily distinguishable;
 - 3) pick a simple color scheme and stick with that format throughout;
 - 4) many people - especially men - are red/green color blind, so it is not advisable to use both of those colors as the basis of your color scheme.
- Each table and figure should have a short descriptive caption that explains any abbreviations, symbols, lines, categories, etc. The table or figure caption must give enough information so that someone can interpret your table or figure without having to read the text.
- Put table captions at the top of each table.
- Figure captions go on a separate page, after the tables but before the figures themselves (see Order, above). Alternatively, you can put each figure caption beneath the appropriate figure.

REPORT LENGTH AND PRESENTATION

- Grades will reflect your analysis and interpretation of data as well as the clarity and conciseness of your writing.
- The text section for your full stream ecology paper should be approximately 8-10 double-spaced pages in 12 point font, with one inch margins all the way around - we need room to write comments. This page length does not include pages for references, figures, and tables.
- Reports should be printed single-sided, but in the interest of minimizing paper waste, I'll accept reports printed on already-used paper (e.g., copier scrap), as long as the paper is neat and the report easily legible..
- Presentation is important to the extent that it helps to understand your data and ideas, but fanciness is not necessary – there is no need to submit your paper in a binder.

PLAGIARISM AND WORKING IN GROUPS

Plagiarism will not be tolerated. All writing must be your own (including table and figure legends) and any ideas not your own must be properly cited. We encourage you to work within your lab group to analyze the data, figure out the best way to make graphs, interpret your results, and discuss what they mean. But when it comes to writing the report, you must do that on your own. If there are blocks of text in common between multiple lab reports, all people involved will get no credit for the lab report. Similarly, if you lift full sentences or paragraphs of

text from other sources (books, articles, lab manual, web sites), you will also get no credit for the lab report. With proper citation style, and writing ideas in your own words, there should be no reason for plagiarism to happen. If you have any questions, please talk with your instructor or your TA, and visit Western's web site on plagiarism:
<http://www.ac.wvu.edu/%7Esoc/plagiarism.PDF>.

LITERATURE CITED

- Hachmöller, B., Matthews, R.A., and D.F. Brakke. 1991. Effects of riparian community structure, sediment size, and water quality on the macroinvertebrate communities in a small, suburban stream. *Northwest Science* 65: 125-132.
- Morley S.A., J.R. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. *Conservation Biology* 16:1498-1509.

CHECKLIST FOR GRADING LAB REPORTS

The following page has the grading rubric that will be used for both drafts and the final version of your lab report. You can use this checklist to make sure you have included all the important components of your lab report.

Score _____

Title: _____/3pts

- _____ Informative, meaningful, concise description of study
- _____ Below title, lists author and co-authors (group members)

Abstract: _____/7pts

- _____ Describes the “big picture” (i.e. context for research)
- _____ Questions and hypotheses clearly presented
- _____ Briefly describes overall approach and methods
- _____ Summarizes the results
- _____ Uses past tense to describe methods and results
- _____ Explains the primary conclusions drawn from the study
- _____ Appropriate length (250-300 words)

Introduction: _____/15pts

- _____ Introduces overall context for experiment
- _____ Enough background info. to understand relevance (i.e. should explain why the research is important)
- _____ States the questions to be addressed by research
- _____ Briefly describes the study system
- _____ States the hypothesis to be tested
- _____ Relevant literature citations integrated into text

Materials & Methods: _____/15pts

- _____ Provides an overall description of what was done
- _____ Describes the study organisms and/or sites
- _____ Describes all measurements conducted including
 - _____ parameters measured
 - _____ protocol followed
 - _____ equipment used
 - _____ # replicates
- _____ Describes data analysis procedures used
 - _____ data averaged across class vs. group only
 - _____ comparisons made & statistical tests done
- _____ Experiment can be duplicated based on described methods
- _____ Appropriate level of detail
- _____ Written in past tense

Results: _____/15pts

- _____ Cites all figures & tables in the same order they appear
- _____ Describes all patterns and trends in the data
 - _____ Notes which are statistically significant
- _____ Does not repeat data found in figures & tables, but does describe the patterns
 - _____ Cites p-values for any statistics (if not found in a table or figure)
- _____ All measurements taken are presented in some way
- _____ Avoids describing procedures and/or interpreting results
- _____ Written in past tense

Discussion: _____/25pts

- _____ Provides clear synthesis of experimental findings
- _____ Addresses all hypotheses & questions stated in the introduction
- _____ Avoids detailed description of the data
- _____ Synthesizes results of different parts of the experiment
- _____ Integrates experimental results with observations/results found in the literature
- _____ Notes any caveats or problems with the experiment & possibilities for future research
- _____ Closes with broad conclusions
- _____ Relevant literature citations integrated into text
- _____ Reflects depth of thinking and critical analysis of results

References: _____/5pts

- _____ Correct formatting
 - _____ Alphabetical order
 - _____ In text citations
 - _____ Reference list
- _____ All cited references are referred to in the text
- _____ All references referred to in the text are cited
- _____ At least 8 relevant, peer-reviewed sources

Tables and Figures: _____/15pts

- _____ Listed in the order referred to in the text
 - _____ All tables first, all figures second
- _____ Avoids repetition of data between tables and figures
- _____ Appropriate formatting, contains St Dev when appropriate
- _____ Reports relevant p-values

TABLES

- _____ Appropriate captions above the tables
- _____ Appropriate column/row headings
- _____ Describe all abbreviations and symbols
- _____ Includes units for all measurements

FIGURES

- _____ Appropriate captions (separate page or below fig.)
- _____ Appropriate axis labels, incl. all units of measure
- _____ Consistent use of color/pattern to represent different treatments

Writing Style & Mechanics

- _____ Clearly & concisely written
- _____ Free of spelling & grammatical errors
- _____ Appropriate use of headings & sub-headings
- _____ Paragraphs have topic sentences
- _____ Smooth transitions between paragraphs
- _____ Logical & orderly progression of information throughout
- _____ Avoids over use of passive voice