Writing in Ecology

Skill in writing—like factual knowledge, critical thinking, and field experience—is an essential tool for the practicing ecologist. After all, writing is the major way ecologists communicate with each other. The hints in this handout are for students writing in ecology classes. If you take these hints to heart, writing class papers should be easier and more effective. But writing takes time and effort for everyone, and everyone can use some help. The real goal of this handout is to build writing skills that you can use to communicate your scientific ideas in any situation.

These suggestions have been improved by the good sense and writing talents of many associates. Prof. Don Zobel also contributed material directly to several sections.

The writing cycle

The two main types of papers in ecology are research reports and literature reviews. Although different in focus, each type requires similar skills in organization and writing. For either type of paper, first gather your information. The information you report in a research paper consists of background material, methods, results, and conclusions. A literature review summarizes the information published by others. The next step is to organize your material in a clear and logical arrangement. Look for distinct subtopics and put similar material together. Some writers work best at this point with an outline. Others prefer to shuffle note cards containing summaries of results or papers. It is often a mistake to simply sit and write. Rearranging an outline is much easier and less traumatic than performing major surgery on a complete draft.

Once you have a good outline, write the first draft. At this point, simply concentrate on setting words to paper (or characters to computer screen). Avoid the distractions of correcting spelling or grammar, worrying about citations, or formatting. Each of these details, although essential, can be attended to easily during the revision process.

Revising is crucial to effective writing. This is your opportunity to reshape and polish, and several revisions are usually required. While revising, think both as a writer--is this what you want to say?—and as a reader—does it make sense? Many revise each draft several times, once

for overall structure, once for clarity, another time for grammar and spelling. If you can, ask a colleague or friend to review a draft of your paper.

The last step is to write, type, or print out your final draft. Make sure everything is legible. Double-spaced text with ample (1") margins is easier to read and provides space for comments. Each page should be numbered.

The parts of the paper

Papers reporting research often contain sections entitled “Introduction”, “Methods”, “Results”, and “Discussion”. Other formats also work well, and literature review papers can take many forms. No matter what format they take, however, nearly all papers need to include three types of information.

1. The topic and its scientific context. Provide any necessary background information and explain why the topic is worth studying. It is usually a good idea to state your specific objectives. All this information belongs in the introductory section.

2. The findings. For research papers, these are your results. For literature reviews, these are the results and conclusions of the articles you are reviewing. Provide enough detail to be clear, but do not cloud your paper with irrelevant technicalities. Choosing the right level of detail to include is difficult but practice makes it easier.

3. Your interpretations. Draw your own conclusions about your research or the articles you are reviewing. What do your findings mean? What are their contributions to your topic? Do not leave your readers asking themselves “So what?”

Research papers, of course, must also include a section describing how you did the research. Include enough detail so the reader can tell if your methods were appropriate and your results valid.

Tables and figures can communicate much information quickly. After the abstract, the tables and figures are the parts of a paper most likely read. Therefore, the tables and figures must tell a complete story. Each must have a title and an explanatory legend. One effective legend style includes a 1-2 line summary of the major trends shown in the table or figure. All columns or axes should be clearly labeled. Define any special symbols. Each table and figure must also be mentioned in the text and its major message reported.

Citations

The body of scientific knowledge grows by building on the work of others. You do not need a citation for your own ideas, general knowledge, or obvious facts. But every specific fact or theory that you derived from reading someone else's work should have its source indicated in the text. To fail to acknowledge the source of one's information is a serious error.

In the text where you present the item needing citation, give the author and date of publication of its source. For example:

> *Abies grandis* is the dominant climax tree species at high elevations along the east slope of the Cascade Mountains (Saffe and Zound 1985).

Focus on ideas, not authors. A common stylistic mistake is to make the scientist the subject of each sentence. (Scientists can make fascinating subjects in studies of history and sociology, but you are writing in ecology.) Avoid styles like

> Jones (1945) said this ... Bazzaz (1981) concluded that ... Kumar (1984) found out other things ...

Such text is boring, wastes words, and hides the important ideas. A better style makes the message more important than the messenger:

> Most eastern deciduous forests are in some stage of recovery from recent disturbance (Jones 1945).

Direct quotation is one way to give credit to the authors whose information you are using. But because quotations can disrupt the text and distract the reader from your story, it is best to use quotations sparingly. There are only two situations in which direct quotation is necessary in a science article. In some circumstances it is important to present exact wording. For example, a treatment might be called "beneficial" or "not detrimental," which can be important because they mean different things statistically. Another use of quotation is to use contrasting statements to establish a controversy, which can be an effective tool in generating interest in your paper if you aim to resolve the controversy. If you do copy text directly from a publication, enclose it in quotation marks and add the page number to the reference in the text. For example:

> Extensive field surveys in the central Cascade Mountains support this controversial conclusion: "*Abies grandis* is scarcely present on many sites and should not be considered the climax dominant" (Ico and O'Clast 1990, p. 348).

You must list in the Literature Cited section all citations given in the text, and cite in the text all references listed in that section. List references alphabetically by the last name of the first author. There are several acceptable ways in which to present a reference. Once you choose a format, follow it consistently. Many biological journals use the following format:

Books: Peters, R. H. 1991. A Critique for Ecology. Cambridge University Press, Cambridge.

Articles: Pickett, S. T. A., S. L. Collins, and J. J. Armesto. 1987. Models, mechanisms and pathways of succession. The Botanical Review 53:335-371.

Avoid the use of footnotes; although common in other disciplines, footnotes are seldom used in scientific writing.

Do not cite material from an article's Introduction, unless it is an independent and new concept. Otherwise you would be citing secondary material.

Citing scientific articles is a way to support your argument and acknowledge the work of others. But use citations only in support of your paper's objectives. An indiscriminate use of citations produces a muddy style and distracts from your own contributions.

Style and usage

An effective scientific style produces a paper that is easy and interesting to read, understandable, and hard to misinterpret. According to William Strunk, style is "what is distinguished and distinguishing" about your writing. It makes little sense to prescribe a single, proper style. After all, writing is a personal accomplishment: communicating your ideas with your words. Nevertheless, there are some elements of good style to strive for and others best avoided in a scientific article. Here are some suggestions.

■ *Present valid conclusions based on good evidence.* Show us, don't tell us. Unsupported statements are unconvincing. For example, "*Abies amabilis* is more fire sensitive" is a correct comparison with Douglas-fir, but it does not say anything about the mechanisms involved. A better statement is "The thin bark of *Abies amabilis* makes it more susceptible to being killed by surface fires."

■ *Always be precise*. For example, writing "A blow-down changes the light environment" communicates little about the direction of the change and its ecological consequences. A more informative statement is "A blow-down increases the light available to other plants."

■ *Do not use a term to define itself*. Saying "vegetative reproduction is reproducing vegetatively" does not convey much information.

■ *Avoid unspecified pronouns*. A statement like "This decreases diversity" can be ambiguous. An improvement is "This process decreases diversity." Even better is to spell out what you mean: "Competitive exclusion decreases diversity."

■ *Omit needless words*. Long, convoluted sentences don't sound impressive, they sound confused. Here are some examples (some courtesy of Day [1983] and Mack [1986]) of verbose phrases and concise alternatives. Most of the verbose examples are from research articles submitted to *Ecology*. Which versions would *you* prefer to read?

Verbose	⇨	*Preferred usage*
In my opinion it is not an unjustifiable assumption that	⇨	I think
On the basis of evidence available to date	⇨	Consequently
in order to provide a basis for comparing	⇨	to compare
a large number of	⇨	many
in the vicinity	⇨	nearby
showed a tendency toward higher survival	⇨	had higher survival
plays a role in the promotion of	⇨	promotes
X is dependent on Y	⇨	X depends on Y
of great theoretical and practical importance	⇨	useful
this result would seem to indicate	⇨	this result indicates
devastated with drought-induced desiccation	⇨	killed by drought
it is of interest to note that	⇨	(leave out)
separated by a maximum distance of 10 m and a minimum distance of 3 m	⇨	3 m -10 m apart

■ *Tense has special meaning in scientific articles*. Give specific results in the past tense. For example, a good style is "Seed production of plants exposed to herbivores was 125 seeds/m^2." State definite general conclusions (that is, the "truth" as we know it now) in the present tense. For example, "Herbivory *reduces* seed production." Similar rules hold when you refer to the research and conclusions of others: "Jenkins (1976) *showed* that herbivory *reduces* seed production."

■ *Use scientific names properly*. Underline or italicize scientific binomials (genus and species). Always capitalize the genus. Do not underline, italicize, or capitalize the common names for plants. Always spell out the genus at its first mention in a paragraph; you can abbreviate subsequent genus names to the initial. The next example shows these rules in action:

> The abundance of *Pinus monticola* (western white pine) in the Rocky Mountains is declining because of the spread of white pine blister rust. Other species, such as *Picea engelmanii* (Engelmann spruce) and *Abies lasiocarpa* (subalpine fir) are unaffected by the disease. It is unclear how the loss of *P. monticola* will affect overall forest productivity.

■ *Proper usage will help get your ideas across*. Misuse hurts your credibility. If your grammar or spelling is unreliable, your science might be, too. Proper usage involves two steps, knowing the rules and proofreading for errors. If you are rusty on the rules, get a good book on usage. If you are tempted to skip proofreading because you think you have few errors in your manuscript, remember this variant of "Murphy's Law": The chance of an error remaining in your article increases with the degree of embarrassment the error will cause you.

Here are some hints on proper scientific usage based on common transgressions in past class papers.

> Data. The word is plural and requires a plural verb: "The data are convincing."
>
> Species is both plural ("many species are annuals") and singular ("this species blooms early").
>
> Do not be mislead, "ecotype" is a locally adapted population, not a type of ecosystem.
>
> The citation is part of its sentence. Do not insert it after the period. Correct: "Fungi decomposed 50% of the litter (Allen 1988)." Incorrect: "Fungi decomposed 50% of the litter. (Allen 1988)"
>
> Note the difference between symbols and abbreviations. m, cm, sec, and pH are symbols, so they do not have periods. Abbreviations, like etc., et al., and elev., require a period.
>
> Memorize the spelling of these words: occur, occurring, occurrence.

Which and that. "That" introduces a restrictive clause; "which" introduces a non-restrictive clause and is set off by commas. Notice the difference in meaning of these two sentences: "Plant growth that occurs after maturity does not affect fitness." "Plant growth, which occurs after maturity, does not affect fitness."

Prefaces should not stand as words: "post fire conditions" and "mid successional species" are incorrect.

"Affect" is a verb; "effect" is a noun.

"Cite" is a verb; "site" is a noun for a location; "sight" has to do with vision.

■ *Good writing in ecology should reflect the ideals of open-minded science and unbiased reporting*. One way to accomplish this is through inclusive (nonsexist) language. A common objection is that the use of inclusive language leads to an awkward style. Usually, however, nothing need be sacrificed to use inclusive language. Consider three common situations. The use of man or mankind to represent humanity collectively is ambiguous. For example, "man's destruction of the environment" could easily refer to the typical patriarchal need to exploit and control nature. If, instead, the statement was aimed at males and females collectively, several rewordings are more successful, such as "human destruction of the environment" or "anthropogenic pollution." Another problem is the use of male pronouns for all animals. "The yucca moth lays his eggs in the developing fruit" is ludicrous, since males do not lay eggs. A common miscue, especially in oral presentations, is to assume that an author is male: "Willson, in his book on Plant Reproductive Ecology, states ..." The author here is Mary Willson, a woman. If you do not know the author, a safer statement is "Willson's book on Plant Reproductive Ecology states ..."

■ Robert Day, in his entertaining book on scientific writing, offers these *Ten Commandments of Good Writing*.

1. Each pronoun should agree with their antecedent.
2. Just between you and I, case is important.
3. A preposition is a poor word to end a sentence with.
4. Verbs has to agree with their subject.
5. Don't use no double negatives.
6. Remember to never split an infinitive.
7. When dangling, don't use participles.
8. Join clauses good, like a conjunction should.
9. Don't write a run-on sentence it is difficult when you got to punctuate it so it makes sense when the reader reads what you wrote.
10. About sentence fragments.

Final admonitions

Writing a clear, concise, error-free summary of a complex technical subject is not easy. One key is careful organization and clear thinking. Another is a willingness to edit and re-edit your writing. A third is experience—practice might not make perfect, but it certainly helps. The reward for all these efforts is the communication of your ideas with clarity, precision, and grace.

Literature cited and other useful references

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