Undergraduate Research in Ecology and Evolutionary Biology

How to Write - 2

Materials and Methods
and
Results

Lecture 4: 28 October 2013

Materials and Methods

- **This section describes exactly what you did and how you did it (or, in a proposal, what you will do and how you will do it)**

- **It must have enough detail for someone to repeat your work exactly (think of it as a recipe for your study)**

- **Because it is what you did, Methods are always written in PAST TENSE in a paper. In a proposal, write in present tense.**

- **Use sub-sections (with sub-headings) to separate important categories**

- **Arrange sub-sections (and sub-headings) to:**
  - **Create a logical structure for project and subsequent Results section**
  - **Link methods to questions and tests of hypotheses.**

Materials and Methods

Typical Sub-Sections (you may use some or all of these)

1. **Study Site (or system)**
2. **Study Organism(s)**
3. **Design**
    a. **Sampling or observational design (i.e. Field work)**
    b. **Experimental design - Laboratory**
    c. **Experimental design - Field**
4. **Methods**
    a. **Field**
    b. **Laboratory**
5. **Laboratory Analyses**
6. **Statistical Analyses**

Materials and Methods

1. Study Sites

- Where ?
- When ?

Example

We sampled shrubs from maritime chaparral communities in four areas at Fort Ord, 3 - 4 km inland from Monterey Bay on the central California coast (Fig. 1 and Table 2).

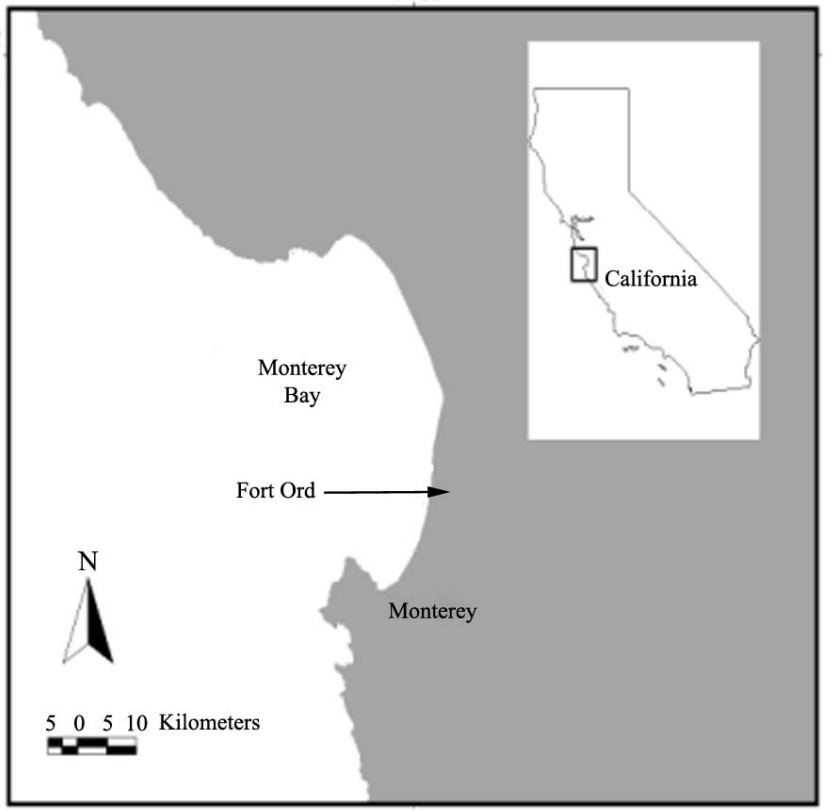

Fig. 1

Table 2

Site	Study Area	Latitude Longitude
FOBase	Parker Flats (PF)	36° 38’ 12.4” N 121° 46’ 38.7” W
	Suicide Corner (SC)	36° 37’ 47.1” N 121° 47’ 35.9” W
FONR	Area F	36° 40’ 57.4” N 121° 46’ 48.9” W
	Area N	36° 40’ 42.8” N 121° 46’ 23.5” W

Materials and Methods

2. Study Organism(s)

- Species names
- Details relevant to your theme?

Example

Monterey ceanothus, *Ceanothus cuneatus* var. *rigidus* (Nutt.) Hoover, and sandmat manzanita, *Arctostaphylos pumila* Nutt. (Hickman 1993) are both species endemic to central California. They have fire-resistant, 'refractory' seeds that may germinate following rain within a year or two after a fire (Keeley 1991, Odion and Tyler 2002). . . .

Ceanothus usually grows as a tall shrub with a single main stem, while *Arctostaphylos* is a low prostrate shrub with multiple stems rising from underground roots, and can be several meters across . . .

Note: Botanical nomenclatural conventions for citing taxonomic authorities (i.e. who described the species)

Zoological nomenclatural conventions are simpler

Materials and Methods

3. Design

- Conceptual basis
- Treatments and replication

- Indicate WHY you used a particular design:

Examples

To explore effects of soil pH on plant distributions in the field, we sampled the same species growing on four different soils . . .

We used a field experiment to explore effects of soil pH on plant growth, by planting seedlings in four sites with different pH soils . . .

We quantified effects of soil pH on plant growth in a laboratory experiment using the same soil, but with pH adjusted to four levels . . .

- JUSTIFY your design by indicating why it is appropriate for testing the hypothesis

Materials and Methods

3. Design

- **Writing**

- **First make a LIST of points, then expand to WRITE one or more paragraphs**
- **Include all details necessary for reader to understand and repeat the design**
- **Use figures or tables if they simplify or clarify the details**
- **Essential information may include:**
  - **a. Random vs. non-random components**
  - **b. Field, laboratory, greenhouse, aquaria . . .**
  - **c. Number and nature of treatments**
    - **describe qualitatively (= labels)**
    - **describe quantitatively (values and/or ranges)**
  - **d. Number of replicates for each part of design**

Example

The largest shrubs or stems in each area were selected to maximize chances of linking age to fire histories. Replication was limited because both species are considered rare and 'fairly' endangered (CNPS 2010); we used at least three live plants of each species from each area.

Materials and Methods

4. Methods

- What you did
- How you did it

- First make a LIST of points, then expand to one or more paragraphs
- Present in same order as sequence followed in study
  (e.g., field measurements → lab measurements → lab experiments → . . .)
- Give all details necessary for reader to gather and record the same kinds of data in the same way, using the same instruments or tools
- Use figures or tables if they simplify or clarify the details
- Indicate what each process was used for
- JUSTIFY your methods.
  - Indicate why appropriate for testing hypotheses
  - Provide some background on analytical techniques (especially lab instruments and genetic analyses)

Materials and Methods

4. Methods

- What you did
- How you did it

Examples

To obtain wood rings, we cut slabs through the main trunk of each *Ceanothus* and the largest accessible stem of each *Arctostaphylos*, excavating below ground level around each trunk/stem to maximize chances of including the oldest rings.

We used standard dendrochronological methods to process and analyze cross-sectional slabs, including cross-dating and indexing ring widths (Fritts 1976, Wimmer and Vetter 1999, Cherubini et al. 2003, Schweingruber 2007, Speer 2010) (see Appendix).

Materials and Methods

5. Laboratory Analyses

- What you did
- How you did it

- **What measured**
  - name property (e.g., length, [CO_2] . . .)
  - state units (e.g., mm, ppmV . . .)
    (Use S.I. (Systeme Internationale units)
  - state precision (e.g., +/- 2 mm)
- **Technique used**
  - give citations for standard, published methods
  - describe non-standard methods in full detail
- **Instruments**
  - give Brand Name and Model Name/Number
- **Calibrations**
  - how calibrated
  - what standards used

Materials and Methods

6. Statistical Analyses

- What tests used
- Indicate which data/experiment analyzed by each test
- Name statistical software packages (and subroutines)
- Indicate probabilities considered significant (if non-standard)

Example

We used SAS® (9.1.3) for stepwise multiple regressions of ring widths and climate variables, and simple regressions for the ring number and stem diameters (both with Proc Reg). We used ANOVAs for the germination experiment (Proc Mixed).

Note: In scientific writing, use the words:
"significance, significant, significantly . . ."
ONLY in statistical contexts,
NEVER as colloquial synonyms for "important, large, interesting, . . .)

Results

ORGANIZATION

- **This is where you PRESENT, DESCRIBE PATTERNS and SUMMARIZE your data**
- **This section is strictly FACTUAL**
- **Do NOT Interpret or discuss their meaning (that goes in the Discussion)**

- **Use sub-headings to separate different aspects of the work.**
- **If possible, use same sub-headings (in same order) as in the Materials and Methods**
    1. **allows reader to refer easily to relevant Methods and Analyses**
    2. **strengthens logic by repeating sequence.**

- **Show most results in Figures and/or Tables**
- **Organize Figures/Tables in same sequence as topics in Materials and Methods**

- **DESCRIBE the trends, differences, similarities, or anomalies THAT YOU SEE in the data in each Figure or Table**
- **Do not expect the readers to do this for themselves.**

Results

WRITING the RESULTS - 1

- Write a separate paragraph for each Table or Figure
- Say everything you want to say about that Table/Figure BEFORE moving to next

- Description of each Table/Figure should be self-contained
- DON'T cross-reference to previous or later Tables/Figures

- Use PAST TENSE for most results (because it all happened in the past)

> Prey density tripled in the absence of predators.

- EXCEPTION - Use PRESENT TENSE for results of models (because it should always be true if run in same way with same parameters)

> Prey densities triple when predator densities are set at zero.

- Remember the Writing Guidelines

  Start each important point with a clear statement in which the data, organisms or processes you are studying is the subject of the sentence (review writing guidelines about strong vs. weak sentences)

Results

WRITING the RESULTS - 2

For each Table/Figure:

- **Describe results qualitatively and quantitatively in the text (i.e., state direction and magnitude of any trend or difference)**

NOT	**X and Y are "correlated"**
YES	**X and Y are "positively correlated"**

- **Indicate supporting data by noting Tables/Figures in parentheses at end of sentence**

NOT	**Results are shown in Figure 3.**
NOT	**Figure 3 shows biodiversity declined with addition of nitrogen.**
YES	**Biodiversity declined with addition of nitrogen (Fig. 3).**

- **Start with general statements about overall trends or effects, then describe subsets of the data, and finally describe any special points or anomalies in the data**

Results

WRITING the RESULTS - 3

Don't give *P*-values without indicating the magnitudes and direction of effects

DO NOT start a sentence with the statistics

NOT Snails affected barnacle abundance (*P* = 0.12)

NOT A t-test (*P* = 0.012) showed that barnacles were more abundant without predatory snails.

YES: Barnacles were twice as abundant without predatory snails (t-test, *P* = 0.012).

Figures and Tables

- **Show most results in figures and/or tables.**

- **Present data and statistics only in one place (text, graph *or* table).**

- **Provide legends for each:**
  - **Use complete sentences.**
  - **Explain each symbol (in legend or on figure)**
  - **Explain the meaning of error bars or ± (standard error, standard deviation, range).**

- **By convention:**
  - **Legends for Tables go at the top**
  - **Legends for Figures go at the bottom**

- **Legends should give the reader all the information needed to interpret the Table/Figure independently of the author's interpretation.**

- **Legends should NOT contain the author's interpretations of the data – they belong in the Results text**