

ECOLOGY FIELD COURSE

BIOC_{52H3}



Syllabus

Course Description

This course offers the unique opportunity to experience hands-on learning through informal natural history walks, group projects, and individual research projects in a small-class setting (cap at 15 students). The objective of this course is to introduce you to some of the most commonly used field research methods in the study of ecology. Also, you will learn how to design a research project, test a hypothesis and write a scientific paper, produce and present a poster and give a powerpoint presentation.

You will study ecological questions related to plants in their natural settings. The major topics will look at the cost associated to male and female reproduction in plants, how succession and the intermediate disturbance regime shape plant diversity, how a specific tree influences tree regeneration in the understory, and how stomatal density can be influenced by ecological conditions.

We will investigate these questions in a wide array of environments from early successional vegetation in old fields, flood plains to closed forests. Most of the field work will happen in the Highland Creek Ravine adjacent to UTSC's campus. While field outings will often happen with the whole class, be prepared to venture out to collect data also in groups of two and alone.

Time and Location

Course lecture time: Mon, 10 am – 3 pm

Location lectures: SW242

Location computer lab: BV466, 1 - 3 PM, Sep 26, Oct 3

Course instructor

Ivana Stehlik

Department of Biological Sciences

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Email: ivana.stehlik@utoronto.ca

Office hours: TBA

Course Website

Class information will be provided on the course website on the U of T Portal: portal.utoronto.ca. You will need your UTORid and your password to access the site. Please refer to instructions on how to access the course website on blackboard using the information in:

<http://www.portalinfo.utoronto.ca>

Cost

For one project, you are expected to print a poster at a cost, depending where you print it, between \$20 and \$40.

What is needed in this course

- All fieldwork is rain or shine, thus you need sturdy, rain- and cold-proof cloths. In case of rain, rubber boots are highly advantageous, as they will also protect you and your nice shoes from mud (off-trail bushwhacking!). As the time allocated to field work is up to 5 hours, anything not really rainproof will leave you MISERABLE under cold and/or rainy conditions.
- Brown-bag lunches: the course runs 10AM – 3 PM and while time will be allocated to eat, it will mostly not be possible to return to the food court to buy food – often we will eat our lunch outdoors
- stamina, timeliness and good work ethic to write 3 papers, one PPT presentation and one poster. The course load is heavy in this course, but you will get a lot out of it! On the bright side, there are no mid-term and final exams and no sitting through lengthy lecturing.

Evaluation

Data collection and mailing of data to the TA (1% each for projects 1, 2, 3)	3%
Quiz on required reading (4 projects, 1.5% each)	6%
3 project reports	60%*
Poster	17%
PPT presentation	14%

*one report (the worst) counts 10%, one counts 20% and one (the best) counts 30%

Penalty for late submission

There will be a penalty of 5% per day for assignments received late. Unless there are extenuating circumstances (e.g. medical reasons with an official UTSC doctor's note), a mark of zero will be applied to assignments submitted one week late or more. Workloads, malfunctioning computer equipment, lack of access to data and texts are not legitimate reasons for late submission. Let the course instructor know before the due date if you know you cannot hand it in.

Required reading (links to the reading can be found on the blackboard course web page)

Project 1 (Jack-in-the-pulpit)

Wheelright N.T. and Logan B.A. 2004. Proceedings of the National Academy of Sciences of the USA 101: 8051-8055.

Project 2 (intermediate disturbance hypothesis)

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs. Science 199: 1302-1310

Project 3 (hemlock): one member of the group should read and answer questions of paper 1, while the other member reads and works on paper 2 (of course, you can also work together on both papers).

Group member should then communicate with each other what they learned in the papers, as both are pertinent to the project.

Paper 1 - Molofsky J. and Augspurger C.K. 1992. Ecology 73: 68-77.

Paper 2 – Vandermast D.B., Van Lear D.H., and Clinton B.D. 2002. American chestnut as an allelopath in the Southern Appalachians. Forest Ecology and Management 165: 173-181.

Project 4 (stomata)

Woodward, F. I. 1987. Stomatal numbers are sensitive to increases in CO₂ from pre-industrial levels. *Nature* 327: 617-618.

Academic integrity policy

According to Section B of the University of Toronto's *Code of Behaviour on Academic Matters*, it is an offence for students to:

- use someone else's ideas or words in their own work without acknowledging that those ideas/words are not their own with a citation and quotation marks, i.e. to commit plagiarism.
- include false, misleading or concocted citations in their work.
- obtain unauthorized assistance on any assignment.
- provide unauthorized assistance to another student. This includes showing another student completed work.
- submit their own work for credit in more than one course without the permission of the instructor
- falsify or alter any documentation required by the University. This includes, but is not limited to, doctor's notes.

Violation of the Code of Behaviour on Academic Matters will force the instructor to provide a written report of the matter to the Chair/DeanProvost's and a penalty according to the U of T's guidelines on sanctions will be put into place.

Submission of reports to Turnitin

Students will be asked to submit their reports to **Turnitin.com** for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the Turnitin.com reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of the Turnitin.com service are described on the Turnitin.com web site:

<http://www.utoronto.ca/ota/turnitin/ConditionsofUse.html>

Turnitin.com is most effective when it is used by all students; however, if and when students object to its use on principle, the course offers a reasonable offline alternative. The student will then be asked to meet with the course instructor to outline and discuss the report before its final submission to demonstrate the process of creating the report according to the academic integrity policy.

Communication policy

Students are required to regularly and often check their UTOR email to receive announcements relating to the course. To inquire about course-related issues, students are strongly encouraged to solely use their UTOR email, as hotmail or other email providers are spam-filtered on a regular basis. It is the responsibility of the student to make sure his or her email reaches the instructor.

Date	Course activities; important due dates for marks
Thu, Sep. 1	Course intro, Natural history hike in Highland Creek Ravine (HLC) Introduction to project 1 (Jack-in-the-pulpit)
Sun, Sep. 11	Due: online quiz on required reading of project 1 (Jack-in-the-pulpit)
Mon, Sep. 12	Instructions on how to write a good scientific paper Field work on Project 1 (HLC; Jack-in-the-pulpit)
Sun, Sep. 18	Due: Online quiz on required reading of project 2 (disturbance)
Mon, Sep. 19	Field work on project 2 (HLC; disturbance)
Mon, Sep. 26	Lab work on project 2 (disturbance) Stats on Project 1 (Jack)
Sun, Oct. 2	Due: Online quiz on required reading of project 3 (hemlock) Due: Online quiz on required reading of project 4 (stomata)
Mon, Oct. 3	Introductory field work on project 3 (hemlock) Introduction on project 4 (stomata) Stats on project 2 (disturbance)
Fri, Oct. 14	Due: Report on project 1 (Jack-in-the-pulpit)
Sun, Oct. 16	Due: Proposal project 3 (hemlock) Due: Proposal project 4 (stomata)
Mon, Oct. 17	Discussion of writing quality of project 1 (Jack-in-the-pulpit) Discussion of proposal on project 3 (hemlock) Discussion of proposal on project 4 (stomata)
Mon, Oct. 24	Field work project 4 (stomata)
Sun, Oct 30	Due: Report on project 2 (disturbance) Due: Progress report on project 3 (hemlock)
Mon, Oct 31	Lab work project 4 (stomata) Discussion of progress report on project 3 (hemlock)
Mon, Nov. 7	Discuss writing quality of project 2 (disturbance) How to make and present a good poster
Sat, Nov. 5	Due: pdf of poster on project 4 (stomata); Due: print poster
Mon, Nov. 14	Poster presentation session on project 4 (stomata)
Sun, Nov. 20	Due: Report on project 3 (hemlock)
Mon, Nov. 24	How to give a good presentation
Sun, Nov. 27	Due: PPT on project 3 (hemlock)
Mon, Nov. 28	PPT presentations on project 3 (hemlock)

How to write a report

In a tutorial, you will be provided with in-depth information on how to write a good science paper. The information below is complementary to this in-class information, but does not include all tips and tricks on how a good science paper should be written.

1. Individual subunits

The length of the text (references, figures and tables excluded) should be 2500 - 3000 words and consist of the parts outlined below. This text length however is an approximation and should not be followed 'religiously'; it can be better to hand in a very clear and concise paper with fewer than 2500 words than a paper within the word limits which 'rambles on about non-important stuff'. Thus, unless indicated below with an asterisk (*; where the word limit NEEDS to be observed), please use your best science-writing common sense.

Title

Abstract: 150 to 250 words*

Key words: 6*

Introduction: approx. maximum of 1000 words

Methods: approx. maximum of 300 words

Results: approx. maximum of 200 words

Discussion: approx. maximum of 1000 words

References (do not count toward word count of a report)

Title. Concise title potentially containing the main finding of your study.

Abstract. The abstract should explain to the general reader why the research was done and why the results should be viewed as important. It should be able to stand alone; the reader should not have to get any information from the main paper in order to understand the abstract. The abstract should provide a brief summary of the research, including the purpose, methods, results, and major conclusions. Do not include literature citations in the abstract. Avoid long lists of common methods or lengthy explanations of what you set out to accomplish. The primary purpose of an abstract is to allow readers to determine quickly and easily the content and results of a paper. The following breakdown works well: purpose of the study (1-2 sentences), outline of the methods (1-2 sentences), results (1-2 sentences), conclusion (no introduction to this section, no discussion/guesses, no citations).

Key words. List 6 key words. Words from the title of the article may be included in the key words. Each key word should be useful as an entry point for a literature search if your report were to be published. Key words should be listed in alphabetical order and not repeat words used in the title.

Introduction. A brief Introduction describing the paper's significance should be intelligible to a general reader. The Introduction should state the reason for doing the research, the nature of the questions or hypotheses under consideration, and essential background. The introduction is the place where you can

show the reader how knowledgeable you are with a given field, without being too lengthy. Close the introduction with your main hypothesis/question(s). A typical introduction should contain four paragraphs (see oral instructions on how to write a good introduction).

Methods. The Methods section should provide sufficient information to allow someone to repeat your work. A clear description of your experimental design, sampling procedures, and statistical procedures is especially important.

Results. Results generally should be stated concisely and without interpretation. Present your data using figures and tables; guide your reader through them.

Discussion. The discussion section should explain the significance of the results. Distinguish factual results from speculation and interpretation. Avoid excessive review. Structure your discussion as follows. 1. First paragraph - restate your major findings concisely and then relate to the literature. 2. Discuss the problems that might have been present to influence your findings. 3. Compare your findings with those of others; examine why differences occurred and why this may have been so.

References. Use the correct format (also see the formatting of the literature in the course manual). You should list at least 12 references beyond those provided in the lab instructions.

2. Formatting your report, writing tips

Use the formatting style of the journal of "Ecology." It might seem tedious to you to have to follow the many rules the journal prescribes, but adhering to one style makes a paper more organized, increases readability and bad formatting typically is a sign that the contents are also of sub-par quality.

Formatting of species names. When mentioning a species in English, also provide the Latin name, at least the first time. Latin names have to be in italics and the first time a Latin name is mentioned, the genus name (first part of the official binary name) has to be spelled out, later on it can be abbreviated, such as in the following example: "Common milkweed, *Asclepias syriaca*, is a hermaphroditic perennial common to Southern Ontario. The leaves of *A. syriaca* are toxic to cattle."

Formatting of references. In the body of the text, references to papers by one or two authors in the text should be in full, e.g. Liang and Stehlik (2009) show *blablabla*. Or: *Blablabla* (Liang and Stehlik 2009). If the number of authors exceeds two, they should always be abbreviated; e.g. Campitelli et al. (2008) show *blablabla*. Or: *Blablabla* (Campitelli et al. 2008). If providing more than one reference in brackets, the order should be chronological with the oldest first and the younger ones later. In the case of two studies from the same year, the order should be alphabetical. E.g. *Blablabla* (Zuk 1963; Korpelainen 1998; Stehlik and Barrett 2005, 2006; Stehlik et al. 2008)."

All references cited (and read by you!) in the main text should be included in "Literature cited." References should be in alphabetical order and their formatting should follow the format exemplified below.

Citing articles in scientific journals:

Michaels., D. R., Jr., and V. Smirnov. 1999. Postglacial sea levels on the western Canadian continental shelf: revisiting Cope's rule. *Marine Geology* 125:1654-1669.

Citing whole books:

Carlson, L. D., and M. Schmidt, eds. 1999. *Global climatic change in the new millennium*. 2nd ed. Vol. 1. The coming deluge. Oxford Univ. Press, Oxford, U.K.

Citing individual articles/chapters in books (if the individual chapters have different authors than the book):

White, P.S. and S. T. A. Pickett. 1985. Natural disturbance and patch dynamics: An introduction. Pp. 3-13 *in* S. T. A. Pickett and P. S. White, eds. *The Ecology of Natural Disturbance and Patch Dynamics*. Academic Press, San Diego, California, USA.

Citing a webpage (avoid as much as possible, cite a paper or book instead):

IUCN, Conservation International, and NatureServe. 2004. Global amphibian assessment. Available at www.globalamphibians.org. Accessed October 15, 2004.

Formatting of tables. Tables (if present) should NOT be inserted in your text, but follow, one table per page, after your Literature cited. Give a brief description what the table is about (table caption) and introduce the parameters stated in the table in a text inserted above the table (see examples in all project descriptions). The description should be self-explanatory, thus the reader should not be forced to read the main body of text in order to understand the message of a table. Each column and row in the table should be labeled (with units if necessary). If mentioning a species name, provide the spelled out Latin name (in italics). In the table, round numbers to two meaningful digits.

Formatting of figures. The design of a figure should clearly convey a major result, thus scale your data appropriately. Label all axes with sufficiently large font and meaningful labels. Keep it simple; do not use unnecessary elements such as 3D diagrams if not absolutely necessary as based on the data structure. Similarly as tables, figures should NOT be inserted in your text, but follow, one figure per page, after your tables. Give a brief description what the table is about (figure caption) and introduce the parameters stated in the figure in a text inserted below the figure (see examples above). The description of the figure should be self-explanatory, thus the reader should not be forced to read the main body of text in order to understand the message of a figure. Also, each axis in a plot should be labeled (with units) and each bar in a bar chart should be labeled. If mentioning a species name, provide the spelled out Latin name (in italics).

References to tables and figures in the text. In your text, refer to figures as follows: 'In the spring, temperatures are higher than in the winter (Fig. 1).' Or: Figure 1 shows that temperatures are higher in the spring than in the winter. In your text, refer to tables as follows: 'In the spring, temperatures are higher than in the winter (Table 1)'. Or: Table 1 shows that temperatures are higher in the spring than in the winter.

Formatting of statistical references. In the text, the results of a statistical test should be cited in parentheses, in support of a specific statement. Example: Xylem tension at the top of trees was significantly higher (25 bars) than at the bottom (20 bars) of the tree ($P < 0.05$). When mentioning the result of a statistical test, always provide the P value, R^2 or χ^2 were applicable, mean values, sample sizes and standard errors or confidence intervals. Format your text according to the following example.

“There was a significant difference in the frequency of flowering between low and high elevation sites, with greater bias among low than high elevation populations (average flowering frequency: low elevation = 0.93, SE = 0.01; high elevation = 0.78, SE = 0.02; $\chi^2 = 35.04$, $P < 0.0001$; df = 1).”

Miscellaneous. Avoid quotations - paraphrase your sources instead while making sure you are not plagiarizing.

grading scheme for reports

When writing the report, you should also consider the criteria and grading scheme that will be used to evaluate your report. The maximum number of points a student can reach is 24.

1. Abstract, title, and key words (2 pts. max)

Exemplary (A; 2 pts): Title clearly identifies the main question solved. Abstract includes all sections of the paper and is a coherent whole that can be understood. Key words are informative and complement the title.

Accomplished (B; 1.5 pts): Title identifies the project. Abstract does not include all sections of the report. Key words are OK.

Developing (C; 1 pts): Title does not identify the work. Abstract only a listing of facts. Key words could be more informative

Beginning (D; 0.5 pt): Either abstract, title or key words are missing.

Fail (F; 0 pts): Abstract, title and key words are missing.

2. Introduction (4 pts. max)

Exemplary (A; 4 pts): Presents the background information and previous work in a concise manner that directly leads into the question(s) being addressed and the purpose of the research.

Accomplished (B; 3 pts): Gives a listing of the facts and previous work but does not tie them together and show how they lead to the purpose of the present work and the questions being addressed. It does have the question(s) being addressed and some purpose for doing them.

Developing (C; 2 pts): Gives very little background or information. May include the question(s) but does not identify their purpose for addressing them.

Beginning (D; 1 pt): Does not include background or previous work does not identify the purpose, the project, or the question(s) being addressed.

Fail (F; 0 pts): No introduction present.

3. Material and Methods (4 pts. max)

Exemplary (A; 4 pts): Presents easy to follow steps which are logical and adequately detailed.

Accomplished (B; 3 pts): Most of the steps are understandable; some lack detail or are confusing.

Developing (C; 2 pts): Some of the steps are understandable; most are confusing and lack detail.

Beginning (D; 1 pt): Not sequential, most steps are missing or are confusing.

Fail (F; 0 pts): No Materials and Methods present.

Results (4 pts. max)

Exemplary (A; 4 pts): The description of the results is concise and complete. The figures and tables contain all the information needed to understand the data. All the figures and tables flow in a clear and understandable fashion and are referred to in the text. Relevant statistical parameters are provided accurately and completely.

Accomplished (B; 3 pts): Most of the descriptions of the results are complete. Some figures and tables information is missing. The student fails to refer to all figures and tables in the text. The sequence of figures and tables could be improved. Some relevant statistical parameters are missing or wrong.

Developing (C; 2 pts): Many of the results are incomplete, missing or in a wrong sequence. Most relevant statistical parameters are confusing and lack detail. Fails to refer to figures and tables in the text. Figures and tables are missing information.

Beginning (D; 1 pt): Figures and tables inaccurate or wrong. Figure or table are missing. Does not provide any relevant statistical evidence.

Fail (F; 0 pts): No Results present.

4. Discussion (4 pts. max)

Exemplary (A; 4 pts): Presents a logical explanation for findings and addresses the questions. Additionally, suggests what the next experiments would be. Refers to relevant figures and tables.

Accomplished (B; 3 pts): Presents a logical explanation for findings and addresses some of the questions. Fails to refer to all relevant figures or tables.

Developing (C; 2 pts): Presents an illogical explanation for findings and addresses a few questions. Fails to refer to relevant figures and tables.

Beginning (D; 1 pt): Presents illogical explanations for findings and does not address any of the questions suggested in the introduction.

Fail (E; 0 pts): No Discussion present.

5. Clarity (4 pts. max)

Exemplary (A; 4 pts): The paper is easy to read and flows expertly. Language is sophisticated without being jargonistic. Terms of analysis and argumentation are clearly laid out and well-defined.

Accomplished (B; 3 pts): The paper is well written but suffers from some significant grammatical inconsistencies or spelling errors. Language is clear but lacks scholarly depth. There are some lapses in definition and explication of terms. Segue between points in the analysis are weak.

Developing (C; 2 pts): There are significant but not quite major problems in grammar and spelling. Language is unclear and/or shallow. Terms are not well defined and analysis leaps erratically from point to point.

Beginning (D; 1 pt): Major problems with grammar and spelling. Language is murky, confused and difficult to follow. There is a paucity of definitions or context for analysis.

Fail (F; 0 pts): Language is sub-par for university, riddled with grammatical and spelling errors. The argumentation is difficult to follow and lacks any sense of flow.

6. Format (2 pts. max)

Exemplary (A; 2 pts): A cover page provides pertinent information. The bibliography follows a recognized scholarly style. Citations are thorough and well documented throughout the paper.

Accomplished (B; 1.5 pts): Citations and bibliography are solid but not thorough, with some noticeable omissions.

Developing (C; 1 pt): Citations are weak and/or the bibliography is incomplete.

Beginning (D; 0.5 pt): There are next to no citations and/or no bibliography or it does not follow a scholarly style.

Fail (F; 0 pts): The paper does not follow a scholarly format.

Project 1



Are males cheaper than females?

Male and female costs of reproduction

Background

On hikes in the Highland Creek ravine, the instructor noticed that Jack-in-the-pulpit (*Arisaema triphyllum*) produces leaves of different sizes. In particular, there seems to be a size difference between females, males and non-reproductive juveniles. Interestingly, Jack-in-the-pulpit has a labile sex expression: in any given year, a Jack-in-the-pulpit plant either does not produce any flowers at all (it is asexual), it can reproduce as a male or as a female. From year to year, however, an individual has the ability to change its sex expression among all three of those sexual states (a reproductive system called sequential hermaphroditism).

The aim of this project is twofold: (1) Is the observation of the instructor valid, ie is there a significant difference in leaf size between asexuals, female and male individuals? (2) If there indeed is a difference, why would the three genders differ in their leaf sizes?

Data collection

Field work will be done in groups of two. Once the outdoor data is collected, each student will get the whole assembled data set for the analysis and write-up. Use Table 1 as a template for data collection in your field notebook.

Field work

Leaf size measurement. In your “allotted” (by TA or instructor) subpopulation of Jack-in-the-pulpit in the Highland Creek ravine, measure the length of the longest leaflet (Fig. 1).

Sex expression. Determine the sex expression of each plant by first looking for an infructescence (stalk with berries; Fig. 1) and where one is found, the individual should be recorded as female. In an absence of an infructescence, search for an evidence of a withered (male) florescence, i.e. a hole near the base of a leaf stem (Fig. 1; arrows for the location of a potential hole). If such a hole can be found, the individual should be recorded as male. Where no fruit or evidence of an inflorescence is found, the individual should be recorded as asexual.

Table 1. Layout of the table for entering your field data. Under Sex record the sex expression of each plant. F: female; M: male; A: asexual.

Group	Plant	Sex	Length [cm]
Jane&John	1	F	10
Jane&John	2	F	9.5
Jane&John	3	M	10.5
Jane&John	4	M	9.4
Jane&John	5	A	8.5
Jane&John	6	A	8
...

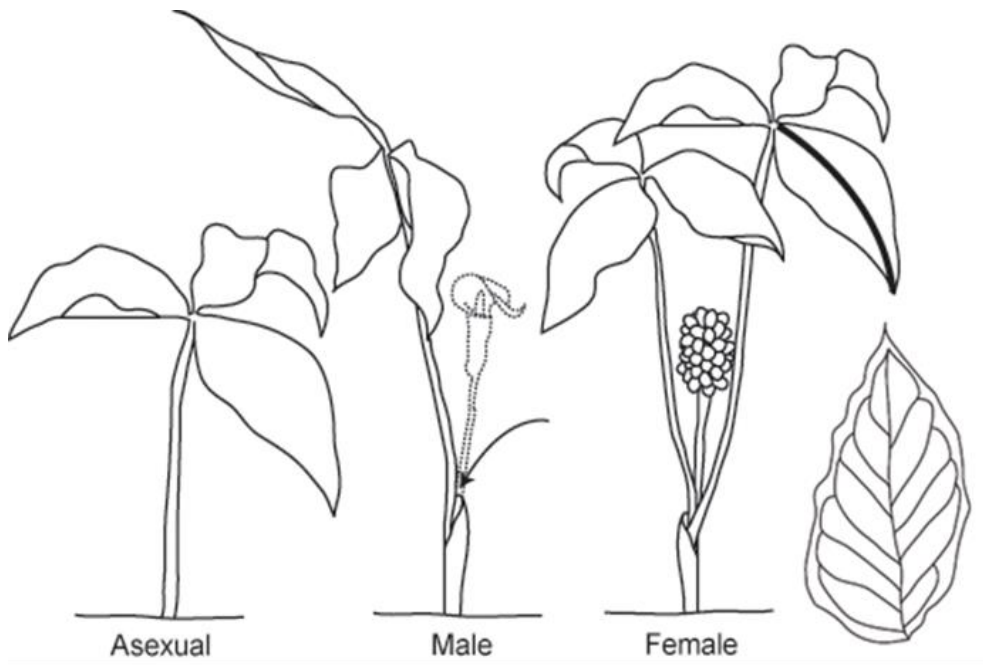


Fig. 1. Drawings of Jack-in-the-pulpit (*Arisaema triphyllum*) in the field in late summer to early fall, i.e. when flowering is over. Asexual plants only produce one, typically small leaf (left). Males typically have a sheath with a lateral hole where previously the male inflorescence (now decayed) was inserted (middle; arrow). Females typically have a centrally inserted infructescence with many bright, shiny and red berries (right). The thick line on one of the female leaves depicts how you should measure the length of the largest leaflet of the largest leaf (in all three genders).

Data analysis

Class data set assembly

Once you have completed all measurements in the field, enter all this information into an Excel spreadsheet using the same layout as in Table 1.

Statistical analysis

Using the assembled class data file, specify the predictor LeafSize as continuous and the response parameter Sex (A: asexual; M: male; F: female) as categorical. Run a 1-Way ANOVA for Sex x Leaf Size. From the analysis, retrieve the mean leaf size per sex including standard errors.

Figures

Plot the relationship between mean leaf size and Sex including standard errors.

Project report

Please follow the tips and rules outlined in the chapter “How to write a report”. Also read and consider the evaluation criteria and grading scheme.

Project 2



How much disturbance is beneficial? Intermediate Disturbance Hypothesis in the highland Creek Ravine

Background

Species diversity varies greatly between different habitats and across time. Different factors influence diversity, but disturbance is believed to be one of the main factors shaping the variation in diversity across space and time (Connell 1978). The “intermediate-disturbance hypothesis” (Connell 1978) suggests that disturbance prevents competitively dominant species from excluding other species from the community, and that there is a trade-off between species' ability to compete and their ability to tolerate disturbance.

We will test the intermediate disturbance hypothesis in the Highland Creek ravine with the main disturbance of flooding, across a gradient from very common flooding (on a floodplain) to uncommon flooding (forest). The questions addressed are threefold: (1) Is the intermediate disturbance hypothesis supported in our sites?; (2) what are the patterns of both native and non-native species diversities across this gradient and why should they be different?; and (3) what makes species more or less able to thrive at different levels of disturbance?

Data collection

Locations

In the Highland Creek ravine, we will assess five habitats representing five approximate durations since disturbance or intensity of disturbance. For the write-up of your paper, keep track of where the sites are and what characterizes them.

Estimation of species diversity in the field

In each location, each student group (2-3 students) will lay out a 3x3 m quadrat and assess species diversity in each one of them. Try to find all species with are found in the quadrat, and also include any trees which might be present above your quadrat. Collect a sample from each plant species and try to identify as many species as possible in the field, alone or with the help of you instructor. In the case of an unknown species, collect as many identifying characters as possible, ie flowers or fruits, and basal and upper leaves. Label each collected sample with location ID and, if known, the species name.

Species identification in the lab

If a plant cannot be identified in the field, we will try to ID it in the lab based on the sample you collected. We will make an exhibition of ID-ed reference plants in order for you to try and match your unknown plants with the growing body of ID-ed references. Later determine whether a plant is native or invasive (using plant ID books or online references; Table 1).

Table 1. Organization of data collection using fictive plant examples. Everybody should use these exact classes as this will simplify the data analysis of this group project. PlantStatus refers to whether a plant is native (N) or invasive (I).

GroupName	PlotType	PlantID	PlantStatus
A	1	Dandelion	I
A	1	Herb1	N
A	...	...	...
A	2	Heal-all	N
A	2	Common plantain	I
A	...	...	...
A	3	Alternate-leaved dogwood	N
A	3	Bittersweet nightshade	I
A	...	...	...
A	4	Bittersweet nightshade	I
A	4	Tartarian honeysuckle	I
A	...	...	...
A	5	Sugar maple	N
A	5	American beech	N
A	...	...	...

Class data set assembly

Once your group has completed all the plant identifications and the determination whether a plant is native vs. invasive, you should enter all this information into an Excel-spread sheet and mail it to the TA (date of mailing TBA).

It is imperative that you use the very same format in the Excel-spread sheet (sequence of columns and names), so that the individual files can easily be pasted together for the class data analysis. Thus strictly use the format introduced in Table 1 and if you fail to do so, you will not get the grade associated with sending in the data. Please note that each cell of your final Excel-spread sheet should contain information (it should never be blank), thus you will need to, for example, fill in your group name or the number of the habitat into each cell in these columns. Only with a data entry for each and every cell, a data point can be identified unambiguously.

Once you are given the class data set, construct a new spread sheet based on the spread sheet with the raw data (Table 1), forming the basis of the statistical analyses. This new spread sheet should have the following columns (Table 2): GroupName, PlotType, #Natives, and #Invasives.

Statistical analysis

Run two 1-Way ANOVAs, one for each of #Natives and #Invasives against plot type. Use post-hoc Tukey tests to test which plot type was significantly different from any other (if any).

Figures

Plot the graphs of each ANOVA analysis, including standard errors in all data points, with the number of native and invasive plant species per plot type. The ANOVA analysis will calculate the diversity means and standard errors for each quadrat. Plot these values (separate for native and invasive diversities) against the disturbance regime (plot types 1 through 5).

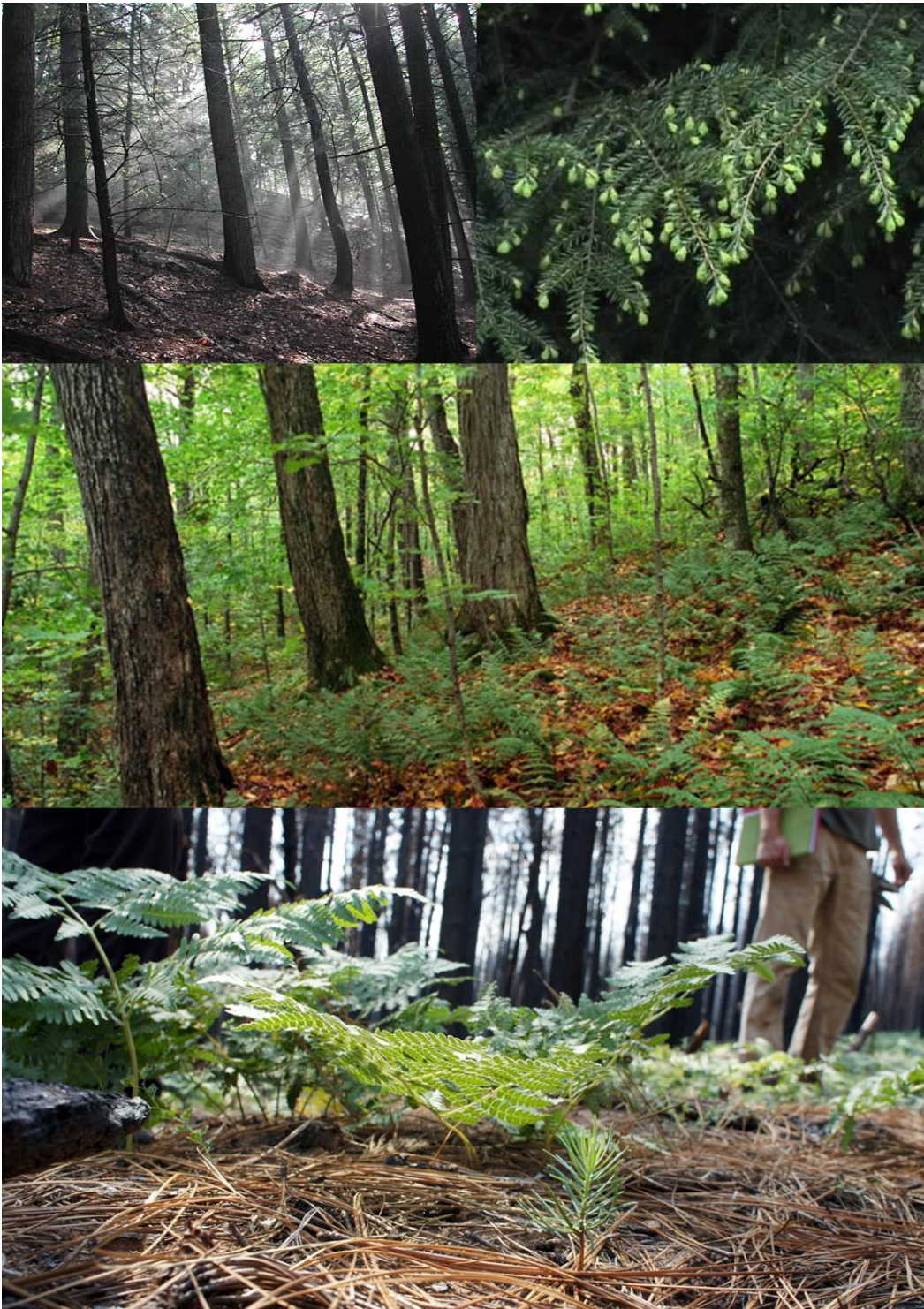
Project report

Please follow the tips and rules outlined in the chapter “How to write a report”. Also read and consider the evaluation criteria and grading scheme.

Table 2. Organization of data for the statistical analysis, based on data from Table 1 and compiled for all class groups.

GroupName	PlotType	#Natives	#Invasives
A	1	2	4
B	1	1	2
C	1	1	1
...
A	2	1	1
B	2	3	1
C	2	1	2
...
A	3	...	...
B	3	...	...
C	3	...	...
...
A	4	...	...
B	4	...	...
C	4	...	...
...
A	5	...	...
B	5	...	...
C	5	...	...
...

Project 3



Effects of Eastern hemlock on the establishment of tree seedlings

Background

On hikes in the Highland Creek ravine, the instructor noticed that fewer seedlings and saplings of broadleaved woody species seemed to grow beneath the canopies of eastern hemlock (*Tsuga canadensis*) trees than beneath the canopies of other tree species in the Highland Creek ravine. Since that time, a number of student projects have confirmed this pattern, but none have been successful in determining the mechanism by which eastern hemlocks inhibit the other species. To address this question, students will sample tree seedlings and saplings beneath hemlock and beneath canopies of deciduous trees to assess whether the observation of uneven distribution of seedlings of deciduous trees is in fact correct. In a second step, reasons behind this pattern will be investigated.

Procedure

This project differs from all other projects in this course because it takes 8 weeks from start to finish, thus the longest. In contrast to projects 1 and 2, it is the most open to your own investigative imagination.

In the first week of this project, we will conduct a brief orientation walk in the ravine, during which you will assess the spatial distributions of seedlings and saplings relative to eastern hemlock trees. We will then collect data to address the question: "Are the densities of seedlings and saplings of woody broadleaved plants lower beneath the canopies of eastern hemlock than beneath those of broadleaved trees?"

To address this question, each group of two students will sample seedlings and saplings beneath three hemlock and three sugar maple, red oak or beech canopies. So that the physical conditions and seed rain will be as similar as possible between the two canopy types, you should choose your hemlocks at random (making sure that no other group has sampled them, of course), but choose your deciduous trees such that they are the nearest canopy-level ones to each of the three hemlocks. We will identify and count the seedlings and saplings within a 2 x 2 meter quadrat to the southwest of the trunk of each of the trees sampled. There is nothing special about that location, of course. In fact, that is the point: by choosing the site to sample before we even look at the trees, we reduce the possibility of biasing our results by choosing sample sites on the basis of their seedling density. So just use a compass to lay out each quadrat such that its northeast corner touches the tree trunk. Within each quadrat, count the total number of seedlings/saplings of woody plants (beech, maple, hemlock, oak, shrubs, etc.) separately. Do not count herbaceous plants like grasses, forbs, mosses, etc.

Use the data collected by all groups to test the null hypothesis that the mean density of woody seedlings and saplings does not differ between hemlocks and deciduous trees. The alternative hypothesis is that there are fewer seedlings under hemlock canopies.

Because the alternative hypothesis is directional (fewer seedlings under hemlock canopies), you will need to do a one-tailed t-test. Note that when you are doing a one-tailed test, the alpha levels for statistical significance are half of those for two-tailed tests, for which the tables of critical values are written. To get the correct critical value of t for a one-tailed test at $\alpha = 0.05$, use the column for $\alpha = 0.10$.

Assuming that we find a difference in seedling/sapling density beneath hemlocks and maples in the first part, your group should discuss factors that might be responsible for it. After doing so, your group should propose to test two different working hypotheses to explain the difference. You are free (encouraged!) to come up with other hypotheses, of course, but a few suggested ones include:

- Light intensity is lower beneath hemlock canopies, such that germination and/or growth of woody seedlings is inhibited.

- The canopies of hemlock trees act as "umbrellas" that shed seeds of broadleaved trees to the side, such that areas beneath hemlock crowns receive fewer colonists.
- Hemlocks alter soil pH in such a way that germination or growth of broadleaved plants are inhibited.
- Hemlocks produce allelochemicals, which either leach from the stems or foliage or are exuded from the roots, and which inhibit either germination or growth, or both.

Each lab group will formally propose two different working hypotheses to investigate, one of which must deal with allelopathy (chemical inhibition via compounds produced by hemlock; alteration of soil pH does not count here). Each group will work independently of the others, and write a 1-2 page proposal that:

- 1) Presents the statistical analysis and conclusion from the first part of the investigation (the analysis discussed above);
- 2) Poses two hypotheses about the mode of inhibition (e. g., what is it about hemlock trees that results in lower densities of other plants near them), one of which deals with allelopathy. The other hypothesis can focus on another factor of your own choosing, assuming that your instructor approves it;
- 3) Briefly describes a series of experiments or other data collection procedures that you will use to test these hypotheses. Here again, be sure that you state explicitly what sorts of data you'll collect and how you will analyze them, including statistical tests, etc;
- 4) Contains a brief list of materials that you will need to do your study. You can use limited space in the greenhouse, pH meters, and just about anything else within reason.

Be aware that we cannot realistically subject maple or other tree seeds from the forest to experiments you might think of to assess the effect of different pH's, soil extracts, etc., since this year's seeds will not germinate until next spring. Instead, if you plan a "bioassay," consider using seeds from a widely available and rapidly germinating plant (such as sunflower, alfalfa, or lettuce - all of which are often used in these kinds of experiments).

Calendar of events for this project (compare time table of the course on page 5)

Week 5: Intro of the project, hemlock seedling survey, submit seedling data to TA, do statistical analysis on class data set, write proposal

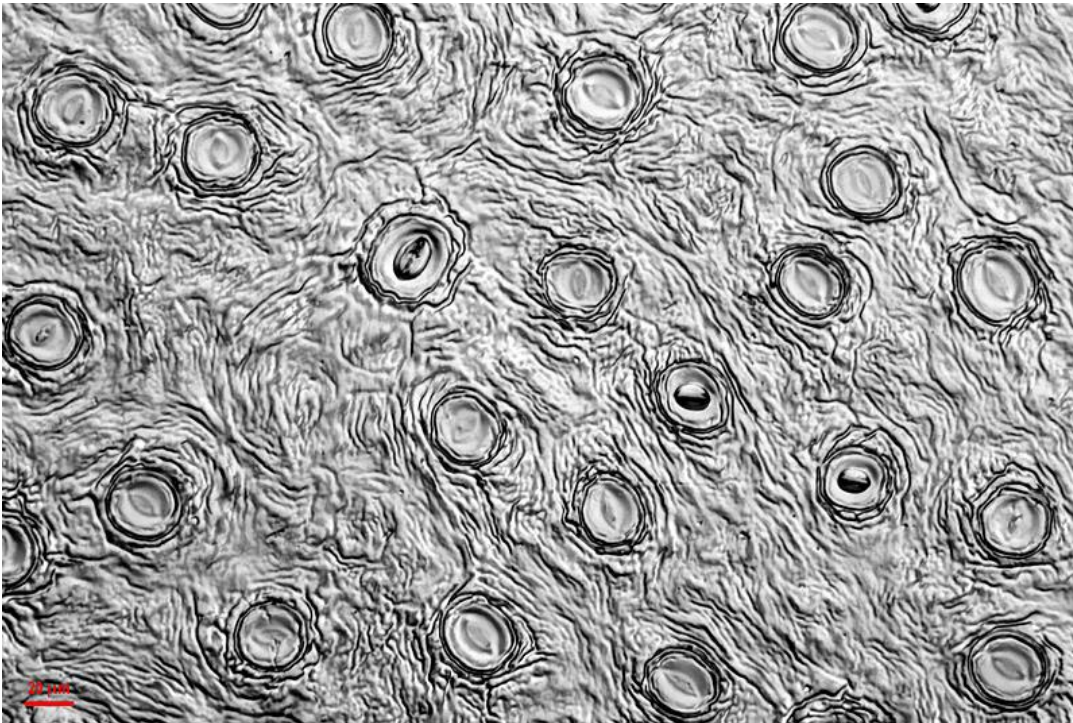
Week 6: Proposals due. Start collecting data as soon as your instructor has approved your proposal.

Week 8: Progress report due: you will need to show your instructor your experiments, show her the data you have collected thus far, address any issues you may have encountered etc.

Week 11: Formal (individual) lab report due

Week 12: Group oral presentation of results using PowerPoint

Project 4



Environmental Correlates of Leaf Stomata Density

Background

Vascular plants engage in gas exchange using leaf stomata which are typically located on the lower side of leaves. The two adjacent guard cells (Fig. 1) control gas exchange through actively opening and closing the stomates. In addition to this behavioral control, plants can exert control over their gas exchange by varying stomata density during leaf development. The higher the stomatal density, the more CO_2 can be taken up, and also the more water is transpired.

In this project, you will test how leaf stomatal density can vary under different environmental conditions and why patterns are as you find them. Similarly as in project 3 (hemlock), this project is driven by you and your ideas. You will come up with your own hypothesis for a specific abiotic contrast and plant species, design your own sampling design, and collect data using the technique of making clear nail polish impressions of leaves, analyze your data, reason why your patterns are as they are, compare them to published evidence, and present it to the class in a poster presentation session.

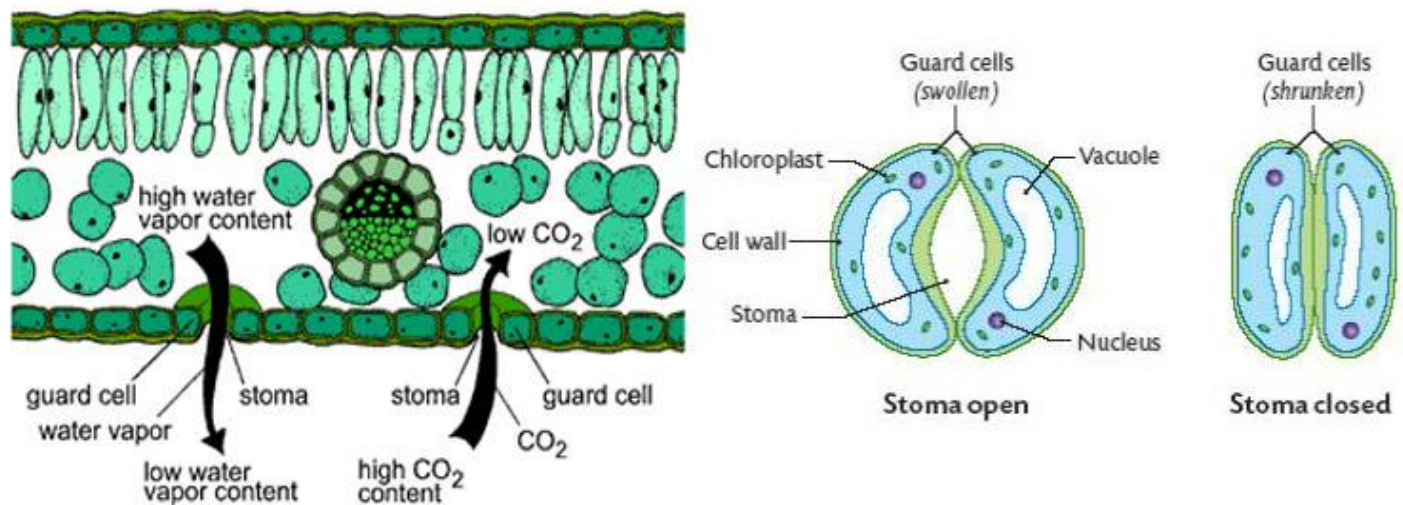


Fig. 1. Location of stomata on the lower leaf side (left) and guard cells controlling gas exchange in a stoma (right).

Materials and Methods

Hypothesis creation

Come up with an environmental contrast that might affect stomata density and formulate a hypothesis about which way you would expect stomata density to vary and WHY. Decide on a place where you intend to collect leaf samples. You will probably have to travel to the sites to make sure it will work before presenting your proposal to the instructor.

Study sites

You can collect your data from plants located either on the UTSC campus, in the Highland Creek ravine or in nearby residential gardens. Your choice of plants includes ornamental evergreen ground cover plants, shrubs, and trees (such as grasses and weedy perennial forbs, hollies, and other evergreen shrubs). Data

collection does not work well on dead (and thus dry) plant material. Absolutely stay away from leaves with hairs, as it will be impossible to get the nail polish off!!!

Data collection

In the field, obtain the leaf upon which you wish to census stomata. Keep track under what environmental conditions and in which location you collected all samples and apply an ID code to each leaf sample, keeping track of these data in your notebook. Sample 30 individuals (with one leaf each) per environmental category, for a total of 60 samples.

Lab work

1. Apply a rather thick swath of clear nail polish on the side you wish to census stomata (typically the leaf underside).
2. After the nail polish has dried (several minutes), obtain a square of the provided tape (package sealing tape, NOT scotch tape). Stick your tape piece to the area that contains the dried nail polish swath.
3. GENTLY, peel your nail polish swath from the leaf completely. You will see a cloudy impression of the leaf surface now attached to your tape piece (hereafter referred to as your "leaf impression").
4. Tape your leaf impression to a clean slide and use scissors to cut off the excess tape.
5. Use a pen and write the ID code of each leaf directly on the slide.
6. Focus your leaf impression and observe the stomata (see Fig. 1 and title page of this project).
7. Search around on your impression to find an area that subjectively appears to have a high density of stomata. That is, move the slide around until the field of view is away from the edge of the impression and so that there are no dirt blobs, no thumbprints, no damaged areas, and no big leaf vein impressions in view.
8. Count all stomata you see and record it using the layout shown in Table 1.
9. Repeat the previous two steps three times, and the highest number of the three will be your one data point from this impression.
10. Repeat all steps above for leaf impressions in each treatment group.

Statistical analysis (on your own and outside lab time)

To test whether leaves collected under your two environmental extremes indeed differ in their stomatal densities, you can carry out the Student's t-test. You can do this either in any stats program of your choice or use free online T-test calculators (e.g. <http://www.graphpad.com/quickcalcs/ttest1.cfm>; using the setting of up to 50 rows and unpaired t-test). Contact your TA if you have any problems or questions.

Table 1. Setup of the excel table for the data collection.

# stomata env 1	# stomata env 2
7	4
9	6
11	2
8	4
6	6
8	5
... (30 samples)	... (30 samples)

Calendar of events for this project (compare time table of the course on page 5)

Week 5: Intro of the project, write proposal

Week 6: Proposals due, talk to your instructor for approval of your proposal

Week 7: Field work on stomata

Week 8: Bring samples collected in the field into lab for analysis

Week 9: Poster making tips. Send in pdf of your poster (Sat, Nov 12), print poster by Sunday Nov 13 and bring it to class on Monday Nov 14

Week 10: Poster session