

# ECOLOGY FIELD COURSE

# BIOC52H3



# Syllabus

## Course Description

This course offers the unique opportunity to experience hands-on learning through an informal natural history walk, 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. 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 why invasive species can outcompete native relatives, how succession and the intermediate disturbance regime shape plant diversity, how a specific tree influences tree regeneration in the understory, and how stomatal density is 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 fieldwork will happen in the Highland Creek Ravine adjacent to UTSC's campus. While field outings will often happen with the whole class, you are also expected 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: 1 - 3 PM, Oct 16

## Course instructor

Ivana Stehlik

Department of Biological Sciences

Office: SW563C, Phone: 416-287-7422

Email: [ivana.stehlik@utoronto.ca](mailto:ivana.stehlik@utoronto.ca)

Office hours: Tue, 11 AM – 1 PM; Thu 12 – 2 PM

## Cost

For one project, you are expected to print a poster at a cost, depending where you print it, around \$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 fieldwork 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 three full-length scientific 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.

## Missed term work policy

*Missed term work due to illness.* Rather than submitting a Verification of Student Illness form (doctor's note) in your request for accommodation, you should submit a Self-Declaration of Student Illness form to Jennifer Campbell, CC-ing Ivana Stehlik (note your documentation must indicate the event will occur on the date of the assignment, indicating the days in which you were ill). This form is meant to take the place of the more typical medical form.

*Missed term work not due to an illness.* Examples of possible documentation that can be submitted again to Jennifer Campbell, CC-ing Ivana Stehlik (note your documentation must indicate the event will occur on the date of the assignment):

- A death certificate or funeral notice
- A police accident report
- Travel ticket or flight itinerary for non-vacation or personal matters
- A letter from a Coach or Varsity Administration for UofT Varsity activities
- Record of a visit to an emergency room
- E-mail sent directly to the Course Coordinator from a Disability Consultant at AccessAbility Service
- Samples of reasons that are NOT acceptable include personal travel (vacations), medical prescriptions, weddings, work commitments

Please note the following aspects related to this Self-Declaration of Student Illness form:

1. Similar to the submission of a medical form, YOU ARE RESPONSIBLE for contacting Jennifer Campbell, the administrative staff in your department to make arrangements for an accommodation for this work.
2. You may use the Self-Declaration of Student Illness form ONLY for term assignments. For any term exams in this course, you will need to submit a Verification of Student Illness form. For the final exam, you will need to follow the typical procedures for petitioning to write a deferred exam.

3. You may use the Self-Declaration of Student Illness form up to five times in a course. If you require an additional accommodation for a term assignment, you must then use the standard UTSC Verification of Illness Form.

4. Submitting a false Self-Declaration of Student Illness form constitutes academic misconduct, and could be subject to sanctions under the Code of Behaviour on Academic Matters.

Please submit any Self-Declaration of Student Illness forms in the same fashion as you would have a previous Verification of Student Illness form. Accordingly, you will need to submit this form to Jennifer Campbell, Course Coordinator within three days of the missed term work.

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

#### **Project 1 (herbivore damage)**

Agrawal, A., P. M. Kotanen, C. E. Mitchell, A. G. Power, W. Godsoe and J. Klironomos. 2005. Enemy release? An experiment with congeneric plant pairs and diverse above- and belowground enemies. *Ecology* 86: 2979-2989.

#### **Project 2 (intermediate disturbance hypothesis)**

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

#### **Project 3 (hemlock)**

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 CO<sub>2</sub> 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 papers to turnitin as implemented on Quercus 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.

<b>Date</b>	<b>Course activities; important due dates for marks</b>
Mon, Sep. 9	Course intro, Natural history hike in Highland Creek Ravine (HLC)
Sun, Sep. 15	Due: online quiz on required reading of project 1 (herbivory)
Mon, Sep. 16	Field and lab work on Project 1 (HLC; herbivory )
Mon, Sep. 16 by midnight:	submit field data (correctly formatted) to TA
Sun, Sep. 22	Due: Online quiz on required reading of project 2 (disturbance)
Mon, Sep. 23	Field work on project 2 (HLC; disturbance)
Mon, Sep. 30	Lab work on project 2 (disturbance) Instructions on how to write a good scientific paper
Mon, Sep. 30 by midnight:	submit plant ID data (correctly formatted) to TA
Sun, Oct. 6	Due: Online quiz on required reading of project 3 (hemlock) Due: Online quiz on required reading of project 4 (stomata)
Mon, Oct. 7	Introductory field work on project 3 (HLC; hemlock) Introduction on project 4 (stomata) Stats on project 2 (disturbance)
Mon, Oct. 7 by midnight:	submit your data on seedling occurrence to TA
<b>Fri, Oct. 11</b>	<b>Due: Report on project 1 (herbivory)</b>
<b>Oct. 12-18</b>	<b>Reading week</b>
Sun, Oct. 20	Due: Proposal project 3 (hemlock) Due: Proposal project 4 (stomata)
Mon, Oct. 21	Discussion of writing quality of project 1 (herbivory) Discussion of proposal on project 3 (hemlock) Discussion of proposal on project 4 (stomata)
<b>Sun, Oct 27</b>	<b>Due: Report on project 2 (disturbance)</b>
Mon, Oct. 28	Independent field work project 4 (stomata)
Sun, Nov 3	Due: Progress report on project 3 (hemlock)
Mon, Nov 4	Lab work project 4 (stomata) Discussion of progress report on project 3 (hemlock)
Mon, Nov. 11	Discuss writing quality of project 2 (disturbance) How to make and present a good poster
<b>Sat, Nov. 16</b>	<b>Due: pdf of poster on project 4 (stomata): send to TA</b>
Sun, Nov. 17	Due: print poster on project 4 (stomata)
Mon, Nov. 18	Poster presentation session on project 4 (stomata)
<b>Sun, Nov. 24</b>	<b>Due: Report on project 3 (hemlock)</b>
Mon, Nov. 25	How to give a good presentation
Mon, Dec. 2	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 200 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](http://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  $\chi^2$  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.

## 4. 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.

#### **5. 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.

#### **6. 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.

#### **7. 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 invasive plants outcompeting natives?

### Common milkweed vs dog-strangling vine

#### Background

##### Introduction

During field trips, the instructor observed that common milkweed (*Asclepias syriaca*) might suffer higher levels of herbivore damage than its relative dog-strangling vine (*Cynanchum rossicum*), both in the family of Asclepiadaceae. Also, dog-strangling vine dominates the habitats it occurs in much more than common milkweed (in fact, it often forms monospecific stands), even though both species are of a similar size and both grow through seeds and spread through subterranean rhizomes. The question tested in this project is whether the native species indeed suffers higher levels of damage through enemies and if yes, why this might be the case.

#### Materials and methods

##### Leaf collection

The TA or course instructor will communicate to you the location where and how you will sample your leaves. Half of the class will sample near the SW building, while the other half will sample further away, led by the TA.

##### Analysis of leaf damage

Estimate the herbivory damage of each collected leaf. Using the acetate paper with grid cells, estimate the fraction of the damaged leaf area as the damaged leaf area divided by the whole leaf area (fraction damaged = damaged leaf area/total leaf area).

To do so, first check whether there is any damage at all on a given leaf (even the smallest blemish should be considered which could also include damage inflicted by fungi, bacteria or viruses). If a leaf is spotless, score its fraction damaged leaf area as 0. If there is damage, put the leaf under the acetate paper. With a water-soluble marker, trace the outline of the leaf onto the acetate paper. If there is herbivore damage along the leaf edge, reconstruct the original outline of the leaf as closely as possible. Now count how many full and partial grid cells are contained in the traced outline of the (reconstructed) leaf on your acetate paper. In a second step, count the full and partial grid cells of the damaged leaf area. Then divide the number of damaged grid cells by the total number of grid cells of the (reconstructed) leaf. For the next leaf damage assessment, clean the acetate paper using water and paper tissue. Repeat the counting procedure for all your sampled leaves.

In an excel spreadsheet, enter your data into a table (using the organization shown in Table 1). Upon completion, submit your data to instructor. The instructor will assemble a class data file and send it to everybody for analysis and write-up.

**Table 1.** Organization of the data table.

Student name	Plant ID	Total leaf area (# grids cells)	Damaged leaf area (# grid cells)	Fraction leaf damage
Jane	MW	38	6	0.158
Jane	MW	43	7.5	0.174
Jane	MW	51	7	0.139
Jane	MW	39	5.5	0.141
Jane	DSW	-	0	0
Jane	DSW	-	0	0
Jane	DSW	22	1.5	0.068
Jane	DSW	24	3	0.125

### Data analysis

Download the assembled class data set with the information on all leaves the class worked on. Use the data collected by all students to test the null hypothesis that the herbivory damage does not differ between common milkweed and dog-strangling vine. The alternative hypothesis is that there is lower damage in dog-strangling vine.

To test whether herbivory levels indeed differ between females and hermaphrodites, you can carry out a 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 unpaired t-test). Contact your TA if you have any problems or questions.

Because the alternative hypothesis is directional (lower damage in dog-strangling vine as opposed to milkweed), you will need to do a one-tailed t-test. 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  $\alpha = 0.10$ .

### 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

## Intermediate Disturbance Hypothesis in the Highland Creek Ravine

### Background

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 in regard to the various types of disturbance regimes. The questions addressed are threefold: (1) Is the intermediate disturbance hypothesis supported in our sites?; (2) what are the patterns (number of species and species cover) 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 six habitats representing six approximate durations since disturbance or intensities 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 4x4 m quadrat and assess species diversity in each one of them. Try to find all species which are found in the quadrat, and also include any trees which might be present above your quadrat. Collect a sample from each plant species with as many identifying characters as possible, ie flowers or fruits, and basal and upper leaves. Label each collected sample with location ID.

#### Cover of plots (native vs invasive) in the field

For each species per plot, note the approximate cover this species has. Keep track of this in a notebook. This will allow us to estimate the dominance of native versus invasive species. Once we have identified all the species, add up all individual cover data for all native versus invasive species and assemble a table as outlined in Table 1.

#### Species identification in the lab

We will try to ID all species 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. We will also determine whether a plant is native or invasive. Assemble the species ID per plot and the info whether a species is native or invasive. Assemble a table as outlined in Table 2.

#### Cover of plots (native vs invasive)

We will try to ID all species 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. We will also determine whether a plant is native or invasive. Assemble the species ID per plot and the info whether a species is native or invasive

**Table 1.** Organization of data collection looking at plot cover by native versus invasive species across a disturbance gradient using fictive plot examples per individual group of students. Every group should use this exact layout as this will simplify the data analysis of this group project for the TA. Plant Status refers to whether a plant is native (N) or invasive (I).

Group Name	Plot Type	Plant status	Cumulative cover [%]
A	1	N	5
A	1	I	20
A	2	N	15
A	2	I	30
A	3	N	25
A	3	I	75
A	4	N	75
A	4	I	25
A	5	N	90
A	5	I	15
A	6	N	100
A	6	I	4

**Table 2.** Organization of the data collection looking at the number of native and invasive species across a disturbance gradient using fictive plant examples per individual group of students. Every group should use this exact layout as this will simplify the data analysis of this group project. Plant Status refers to whether a plant is native (N) or invasive (I).

Group Name	Plot Type	Plant ID	Plant Status
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	Tatarian 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, added up all the cover percentages of native and invasive species per plot, you should enter all this information into an Excel-spread sheet and mail it to the TA (by midnight of the lab day). Again: it is imperative that you use the same design of the two tables as shown above (Tables 1, 2), as this will make it easier to pasted together all the data for the class data analysis. Should 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.

Your TA will then assemble all the data of all individual groups of students into two large class data set and upload them to Quercus, from where you should download them to use during the data analysis lab dedicated to this project. These two data sets will have the internal structure as outline in Table 3 and 4. Lastly, the TA will also assemble a table containing all the species found in at least one plot per disturbance regime, thus representing the actual species identities across plots, a table similar to Table 2, but bigger.

**Table 3.** Organization of the data for the statistical analysis testing for a correlation between level of disturbance and the cover of native and invasive species, based on data from Table 1 and compiled for all class groups.

GroupName	PlotType	Cover Natives	Cover Invasives
A	1	...	...
B	1	...	...
C	1	...	...
...	...	...	...
A	2	...	...
B	2	...	...
C	2	...	...
...	...	...	...
A	3	...	...
B	3	...	...
C	3	...	...
...	...	...	...
A	4	...	...
B	4	...	...
C	4	...	...
...	...	...	...
A	5	...	...
B	5	...	...
C	5	...	...
...	...	...	...
A	6	...	...
B	6	...	...
C	6	...	...
...	...	...	...

**Table 4.** Organization of the data for the statistical analysis testing for a correlation between level of disturbance and the number of native and invasive species, based on data from Table 2 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	...	...
...	...	...	...
A	6	...	...
B	6	...	...
C	6	...	...
...	...	...	...

### Statistical analysis

Run one Two-Way ANOVA, testing for a correlation between level of disturbance and plant diversity per plot and between level of disturbance and the number of native/invasive species. Run another Two-Way ANOVA to test for a correlation between level of disturbance and cover by native/invasive species. You will receive verbal explanation on how ANOVAs work and how to run the tests in the tutorial.

After running the ANOVA and seeing whether disturbance regime has a significant influence of percent covers of natives/invasives and the number of natives/invasives (hopefully...), you will want to figure out whether the pattern conforms to Connell's intermediate disturbance hypothesis. Is the pattern of species diversity across decreasing disturbance intensity indeed hump-shaped? In order to test this statistically, you will run post-hoc Tukey tests to see (in the case of a significant ANOVA), which plots significantly differ from other plots. Again, you will receive verbal explanation on how Tukey tests work and how to run the tests in the tutorial. Generally speaking, averages which do not differ significantly from each other, will be depicted with the same letter in the figure, while plot averages which differ from each other will be depicted with different letters (fictitious examples in Figs 1 and 2).

### Figures

Produce two figures to include in your paper, representing the results of your two Two-Way ANOVAs. Figure 1 should plot the number of native and invasive species per disturbance regime, including standard errors in all data points and an indication of how averages per plot differ from each other (Fig. 1). Figure 2 should represent the cover percentages of native versus invasive species per disturbance regime, again with standard error bars and the results of the post-hoc Tukey analysis (Fig. 2).

### Tables

You will need to provide three tables in your papers: Table 1 showing the results of your two-way ANOVA analysis testing for a correlation between the number of species and disturbance regime, showing plot number, averages of numbers of natives and invasives, standard errors, the degrees of freedom (df), the p-value and the F value (Table 1). Table 2 should show the results of your other one-way ANOVA testing disturbance regime and cover of natives and invasives. This table should include plot number, averages of covers of native and invasive species, standard errors, the degrees of freedom (df), the p-value and the F value (Table 2). As a third table, you should include what species were found in which plot, as the identity of species is important and some species might be driving the pattern more strongly than others.

### **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. It is important that you include and cite all necessary elements into your paper as a backbone of your narrative.

- two figures including SE and the results of the Tukey test
- two ANOVA output tables
- one table with the species per disturbance regime

# 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 whether there are fewer seedlings under hemlock canopies. Because this 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.
- 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). 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.

#### Must-does

- use at least 40 g of hemlock tissue to extract allelo-chemicals per 4 liters of water
- use 20 seeds per treatment, thus for example 20 seeds for tap water, 20 seeds for allelo-water, 20 seeds for normal forest soil pH and 20 seeds per hemlock soil pH

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)**

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 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<sub>2</sub> 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.

### 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 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.

### **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 11), print poster by Sunday Nov 12 and bring it to class on Monday Nov 14

Week 10: Poster session