

# ECOLOGY FIELD COURSE

# BIOC52H3



# Syllabus

## Course Description

This course offers the unique opportunity to experience hands-on learning through four group and individual research projects in a small-class and in-person 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 and some interesting and big topics in ecology. You will learn how to design research projects, test hypotheses by collecting data, write scientific papers, and prepare a poster.

## You will investigate

- one of the most important mechanisms of why invasive species can outcompete native species in their introduced range (project 1),
- how the level of human and natural disturbance influences plant diversity levels and plant invasion into natural habitats across different successional stages (project 2),
- the influence of environmental factors on the density of stomata (project 3),
- whether the behavior of grey squirrels conforms to the optimal escape theory (project 4)

Some of the projects and their data collection will happen in Highland Creek valley close to the campus (projects 1 and 2) and by students individually in the field close to where they live (projects 3, 4). In projects 1, 2 and 4, individual students will contribute towards a class data set to increase the size and hence statistical strength of the projects, while students will collect their own individual data in project 3.

## Course details

Ivana Stehlik

Department of Biological Sciences

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

Course time: Mon, 10 am – 3 pm

Virtual office hours: by email appointment

## What is needed in this course

- If you do not have an inclination and openness towards developing your (scientific) writing skills and get ready to write A LOT, this course is not for you! You will write three full-length papers and the text to one poster in this course.
- Stamina, timeliness and good work ethic. The workload is relatively 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.
- Good time management skills: there are A LOT of deadlines in this course!
- For the fieldwork, you need sturdy, rain-, dirt- and cold-proof cloths and an openness to go off asphalted trails and into the dirt. In case of rain, rubber boots are highly advantageous, as they will also protect you and your nice shoes from mud (off-trail bushwhacking!).

## Evaluation

Data collection and mailing of data to the TA (0.7% each for each of the 3 projects)	2%
Quizzes on required reading (4 projects, 1.5% each)	6%
Best-of-three papers	32%
Intermediate-of-three papers	22%
Worst-of-three papers	13%
Poster	25%

### **Penalty for failing to contribute (properly) to class data sets (aka data collection)**

All projects are dependent on each student collecting data in a consistent way, so that the amassed data is comparable across students and be merged into one large data set, which each student will get access to for analysis. In the field of ecology, the use of large data sets is crucial, as only large data sets allow researchers to separate 'random noise' from a 'biological signal', enabling to support or reject hypotheses. It is hence crucial that each student very thoroughly read the instructions on how to collect the data for each project, how to format the excel tables to send to the TA, and what the deadlines are. Should a student completely fail to collect data without adequate documentation (due to the fault of the student; see missed term work policy), this will result in an automatic 50% penalty to the grade of the associated paper. Should a student collect the data in a way which makes the data useless to contribute to the class data set (due to the fault of the student and not due to mitigating circumstances), this will result in an automatic 25% penalty to the grade of the associated paper. On the other hand, if you do everything correctly and send in the data formatted in the correct way and on time, you will get 0.5% per project for a maximum of 2%.

### **Penalty for late submission of assignments**

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**

If you miss term work (including term tests) due to illness you must self-declare within 48 hours via Acorn. Please note it is mandatory for you to fill in the notes field within the self-declaration tool on Acorn to specify what term work you are missing and applicable due dates to be considered. For some additional instructions on how to declare illness please review the following resource

<https://help.acorn.utoronto.ca/blog/ufags/how-do-i-declare-an-absence/>

If you are missing term work for another reason including: short-term illness under the care of a Physician or someone affiliated with Health and Wellness, disability reasons, a family death, vehicle accident, essential travel that is not vacation related, or varsity activities must e-mail the course instructor and Jennifer Campbell (jac.campbell@utoronto.ca) in advance or within 48 hours of the term work due date. Please note all documentation will be verified for authenticity by Jennifer Campbell and any accommodations (if applicable) will be determined by the course instructor.

Please note that we understand that life happens and you may miss term work for valid reasons and we will help you navigate through those situations. Please remain in communication with our departmental admin office as well as your course's teaching team.

## **Accessibility**

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach the course instructor and/or the AccessAbility Services Office as soon as possible. Enquiries are confidential. The UTSC AccessAbility Services staff (located in S302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or [ability@utsc.utoronto.ca](mailto:ability@utsc.utoronto.ca).

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

### **Project 1 (enemy release of invasive species)**

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

Liu, H., Stiling, P. 2006. Testing the enemy release hypothesis: a review and meta-analysis. *Biological Invasions* 8-7: 1535-1545.

### **Project 2 (effect of disturbance on invasive species)**

Bongers F., Poorter L., Hawthorne W.D. and Sheil D. 2009. The intermediate disturbance hypothesis applies to tropical forests, but disturbance contributes little to tree diversity. *Ecology Letters* 12: 798-805.

Jauni M., Gripenberg S. and Ramula S. 2015. Non-native plant species benefit from disturbance: a meta-analysis. *Oikos* 124: 122-129.

### **Project 3 (stomata)**

Woodward, F. I. 1987. Stomatal numbers are sensitive to increases in CO<sub>2</sub> from pre-industrial levels. *Nature* 327: 617-618.

### **Project 4 (Optimal escape theory in Eastern grey squirrels at different human densities)**

Bateman P.W. and Fleming P.A. 2014. Does human pedestrian behaviour influence risk assessment in a successful mammal urban adapter? *Journal of Zoology* 294: 93-98.

Dill L.M. and Houtman R. 1989. The influence of distance to refuge on flight initiation distance in the gray squirrel (*Sciurus carolinensis*). *Canadian Journal of Zoology* 67: 233-235.

## **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/Dean/Provost'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.

Date	Course activities and timing; important due dates for marks
Mon, Sep. 13	10 am - 3 pm: Introduction to course and project 1; fieldwork for project 1 (herbivory) 11.59 pm: online quiz on required reading of project 1 (herbivory)
Tue, Sep. 14	Submit correctly formatted data on leaf of leaf damage (project 1) to TA
Mon, Sep. 20	10 am - 3 pm: Introduction to project 2; field work on Project 2 in Highland Creek ravine (disturbance) 11.59 pm: online quiz on required reading of project 2 (disturbance)
Sun, Sep. 26	By 11.59 pm: download class data set on project 1 and run statistical analysis; create expected figure; submit results to TA
Mon, Sep. 27	10 - 12 pm: optional help with stats and excel of project 1 with TA 1 - 2 pm: instructions on how to write a good scientific paper 2 - 3 pm: instructions on project 3 (stomata) 11.59 pm: online quiz on required reading of project 3 (stomata)
Thu, Sep 30	10 am: Optional pre-submission deadline, paper 1
<b>Sun, Oct. 3</b>	<b>11.59 pm: paper on project 1 (herbivory)</b>
Mon, Oct. 4	10 am - 1 pm: species identification of project 2 1 pm: discussion of writing quality of paper 1 (herbivory) 11.59 pm: submit correctly formatted data of project 2 (disturbance) to TA
<b>Oct. 9-15</b>	<b>Reading week</b>
Fri, Oct. 15	Tell the prof about your stomata project (individual consult; what, which species; project 3; <b>online</b> )
Mon, Oct. 18	Field work project 3 (stomata; <b>individually outdoors</b> )
Thu, Oct 21	10 am: Optionally due pre-submission deadline, paper 2
<b>Sun, Oct. 24</b>	<b>Due: Paper project 2 (disturbance)</b>
Mon, Oct. 25	10 am - 3 pm: stomata assessment (project 3), bring in your collected and dried leaves
Mon, Nov. 1	12.00 pm: instructions on project 4 (squirrels) 1 pm: discussion of writing quality paper 2 11.59 pm: online quiz on required reading of project 4 (squirrels)
Fri, Nov. 5	1 - 5 pm*: check-in with prof on locations on field work of project 4 ( <b>online; your time slot TBA</b> )
Mon, Nov. 8	10 am - 1 pm: field work project 4 (squirrels), high density neighborhood ( <b>individually outdoors</b> )
Fri, Nov. 12	10 am - 1 pm: Field work project 4 (squirrels), low density neighborhood ( <b>individually outdoors</b> ) 11.59 pm: submit correctly formatted data on project 4 (squirrels) to TA
Mon, Nov. 15	Download class squirrel data, produce correctly formatted figure, work on squirrel paper ( <b>individually at home</b> ) 11.59 pm: submit correctly formatted figure on project 4 (squirrels) to TA
Thu, Nov. 18	10 am: optional pre-submission deadline, paper 3
<b>Sun, Nov. 21</b>	<b>Due: Paper on project 4 (squirrels)</b>
Mon, Nov. 22	1 pm: How to prepare a good poster
Mon, Nov. 29	10 am - 3 pm: work on poster ( <b>individually at home</b> )
By Sun, Dec. 5	Print poster on project 3 (stomata)
<b>Mon, Dec. 6</b>	<b>10 am – 3 pm: poster presentation project 3 (stomata)</b>

# 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

## Why do invasive plants often outcompete native species? Phylogenetically controlled approach using Common milkweed and Dog-strangling vine

### Background

#### Introduction

During field trips, the instructor observed that the native common milkweed (*Asclepias syriaca*) seems to suffer higher levels of herbivore damage than its related, invasive dog-strangling vine (*Cynanchum rossicum*), both belonging to the family of Asclepiadaceae. By retaining larger leaf areas, the invasive species can allocate more resources to growth and reproduction in comparison to the native species and outcompete its native competitors (enemy release hypothesis). The question tested in this project is whether the native common milkweed indeed suffers higher levels of damage through its herbivorous enemies. This project does not test whether dog-strangling vine dominates common milkweed, but whether a lack of specialized herbivores on dog-strangling vine might help to turn dog-strangling vine more competitive in its introduced ecosystem compared to its closest relative common milkweed. By comparing herbivore damage in two related species, one native and one invasive, we are assuming that the two species generally 'behave' similarly but that one of the few differences between the species is the fact that one is native and one is invasive.

#### 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
Fatima	MW	38	6	0.158
Fatima	MW	43	7.5	0.174
Fatima	MW	51	7	0.139
Fatima	MW	39	5.5	0.141
Fatima	DSW	-	0	0
Fatima	DSW	-	0	0
Fatima	DSW	22	1.5	0.068
Fatima	DSW	24	3	0.125

### Data analysis

Download the assembled class data set with the information on all leaves the class worked on from Quercus. 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. Note that this is a one-sided test, as we have the specific expectation that herbivory levels should be lower (not higher) in dog-strangling vine as compared to common milkweed. If we were to expect just a difference between the two species without an a priori expectation which one should exceed which, this would be a two-sided test.

Run a T-test to test whether herbivory levels indeed differ in common milkweed and dog-strangling vine. You can either run a T-test with whatever statistical program you are already used to or you can use a free online program (example provided here), using the following step-by-step instructions.

(1) In your web browser, go to the URL:

<http://www.graphpad.com/quickcalcs/ttest1.cfm?Format=C>

Read the website thoroughly, and consider what boxes should be selected given the data set.

(2) Choose data entry format: How many rows of data do we have? More than 50, therefore choose the option, "Enter or paste up to 2000 rows."

(3) Enter data:

What labels should you choose? You are comparing herbivory levels of common milkweed and dog-strangling vine, so use CM and DSV for labels. What values do we enter? You can simply copy the rows into the "Values" section of "2. Enter data" from the excel spreadsheet.

(3) Choose a test: What test should you choose? Click on "Help me decide" to determine the test to be used for this analysis. Hint: use the "Unpaired t test". This is due to the fact that we did not collect the leaves in DSV and CM in logical pairs. If we for example sampled one DSV and one CM milkweed leaf PER LOCATION or one DSV and one CM leaf by date throughout the year, these samples would be paired and hence we would run a paired T-test. In this study, we only aimed at having (roughly) the same number of leaves per

species, but the leaf samples of the two species are collected independently from each other (albeit close to each other to control for the environment). This hence asks for an unpaired T-test.

(4) View the results: Select “Calculate now”. Your analysis is immediately calculated and returned to you on the next page. Make sure to include in your text and figure the standard error (named SEM on the website) and sample sizes. Take the two means and standard errors per species and create two figures in excel.

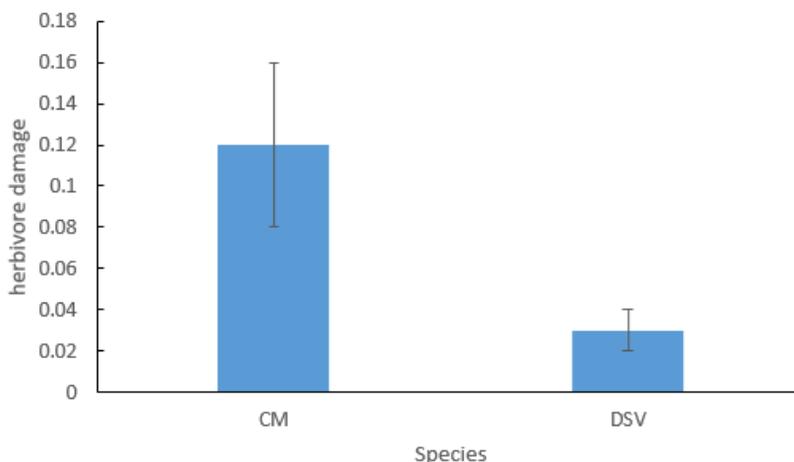
(5) You now have to adjust for the fact that we need a one-sided, unpaired T-test. Remember, because we have an a priori expectation, which of the two damage averages is larger (CM), it is one-sided. In many t-tests, it is possible to choose between the two one- or two-sided options. The T-test calculator used here does not have this option. This means that we have to adjust for this testing mode ourselves after running the test. Let’s assume, as a completely fictional example, that for your two-sided T-test, your calculated P value is  $P = 0.02$ , your t-value is  $t = 2.68$ , and your df [degrees of freedom] = 156. You now need to divide the P-value by a factor 2 in order to get the P-value of the one-sided test. Thus the correct parameters you need to provide in your paper in your result section of this fictional example are  $P = 0.01$  (making the result stronger as compared to the two-sided test),  $t = 2.68$ , and  $df = 156$ .

## 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.

## Figure needed in the report

Create a figure using the following (fake) example (Fig. 1). In particular, you need the average herbivore damage per species and their standard errors. Please note that the standard error for CM is not the same as for DSV. You will also have to change the standard excel output to resemble a graph type more commonly used in scientific publications.



**Fig. 1.** Overview what type of figure is expected from you in your paper for this project. Note that this figure is based on fake data and you will have to create the figure based on the data provided in the excel file of project 1 created by the whole class together, assembled by the TA and made accessible to you TBA. After making a standard bar graph, make sure to add the labels of axes. If you do not know how to do this, google for help online ('how to add labels of axes in excel'). Add solid and black lines to the x and y axes. Remove the ugly and unnecessary background lines in the chart by clicking on them and deleting them. Most

importantly, add individual error bars. Note that herbivory levels in CM and DSV will have differently sized error bars! If you do not know how to do that, watch the 1-min youtube tutorial: [https://www.youtube.com/watch?v=OGutc\\_I0jE](https://www.youtube.com/watch?v=OGutc_I0jE). Add major tick marks to the inside of the Y axis.

### **Time line of project 1**

Sep 13, 10 am – 3 pm: introduction, fieldwork

Sep 13, 11.59 pm: quiz on Quercus

Sep 14, 11.59 pm: submit assessment of leaf damage to TA

Sep 26, by 11.59 pm: download class data set on project 1 and run statistical analysis; create expected figure; submit results to TA (individual work at home)

Sep 27, 12 - 1 pm: optional help with stats and excel of project 1 with TA

Sep 27, 1 pm: instructions on how to write a scientific paper

Sep 30, 10 am: optional pre-submission of complete draft of paper to [jvana.stehlik@utoronto.ca](mailto:jvana.stehlik@utoronto.ca)

Oct 3, 11.59 pm: submission of paper to Quercus

Oct 4, 10 am: discussion of writing quality paper 1

# Project 2

## Effect of disturbance on native and invasive plant species diversity

### Background

The “intermediate-disturbance hypothesis” suggests that at intermediate levels of disturbance, biodiversity should be the highest (Fig. 1), as disturbance prevents competitively dominant species from excluding other species from the community (Catford et al. 2012). There is also evidence that disturbance facilitates the invasion of habitats by non-native species (Jauni et al. 2015).

We will test how disturbance influences both native and invasive plant species in the Highland Creek ravine. In particular, we will investigate whether (1) the intermediate disturbance hypothesis is supported in our sites for both native and invasive species; (2) whether the diversity patterns of native and non-native species differ and if yes, why should they be different; and (3) what makes species more or less able to thrive at different levels of disturbance?

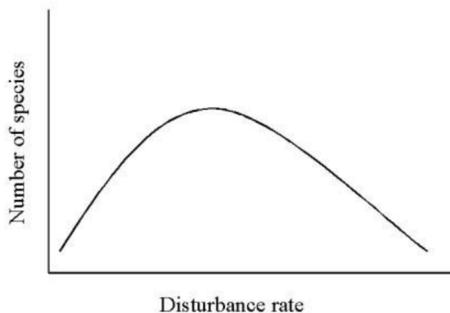


Fig. 1. Expectation of biodiversity as a function of the frequency and intensity of disturbance.

### Data collection

#### Locations

In the Highland Creek ravine, we will assess five habitats representing five approximate durations since disturbance (from very common/yearly to very rare disturbance) or intensities of disturbance (from very strong disturbance to low-impact disturbance). In particular, the habitat with the most frequent and highest level of disturbance will be located just adjacent to Highland Creek, while late-successional hemlock forests on the slopes of the Highland Creek ravine enjoy the lowest levels of disturbance. For the write-up of your paper, keep track of where the sites are and what characterizes them, thus what the types of disturbances are (there is more than one and they are fundamentally different in their mode of action).

#### 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. Store each collected sample in one of five separate bags per plot (label bags).

## 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 1.

**Table 1.** 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, you should enter all this information into an Excel-spread sheet and mail it to the TA (by midnight of the lab day). Use the same design of the table as shown above (Table 1), 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 a large class data set and upload it 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 outlined in Table 2. 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 1, but bigger.

**Table 2.** 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	...	...
...	...	...	...

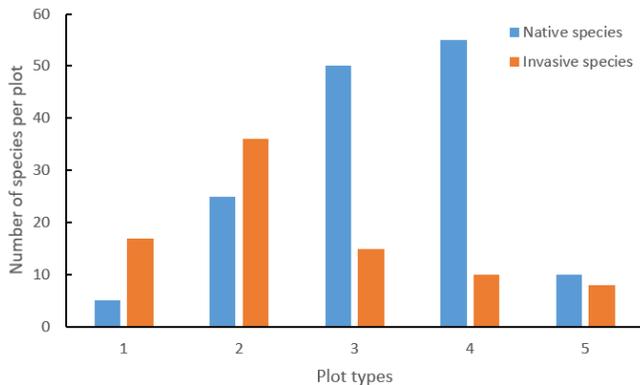
## Statistical analysis

The data analysis of this type of project cannot be done using a simple T-test. In addition, the necessary analysis needs specific software or more complex coding beyond the simple enter-and-click capacities in excel or free online stats packages. Instead of a statistical analysis, the paper on this project will rely on descriptive data visualization, thus without the important information and all-pertinent support typical for biological research for whether the pattern observed is indeed different from an random (non-significant) 'background noise.' Descriptive data analysis is hence inherently weak, because we cannot say with statistical support whether the pattern we have found indeed is biologically relevant and different from being the result of pure chance.

In case you are a stats buff, the correct analysis would entail the use of two-Way ANOVAs, 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. The numbers of native and invasive species would be the dependent variables while plot type (disturbance regime) would be the predictor. After running the ANOVA and seeing whether disturbance regime has a significant influence on the number of natives/invasives, there would be a consecutive analysis to see whether the pattern conforms to the intermediate disturbance hypothesis. Is the pattern of species diversity across decreasing disturbance intensity indeed hump-shaped? In order to test this statistically, post-hoc Tukey would be used (in the case of a significant ANOVA), which plots significantly differ from other plots.

## Figure needed in the report

For the descriptive data visualization, create a figure fitting the following (fake) example (Fig. 2). In particular, you need the total number of native and invasive species for each of the five plot types (extract this information on your own from the excel data file which you can access on the Quercus course website). When creating the figure comparable to figure 2, you will also have to change the standard excel output to resemble a graph type more commonly used in scientific publications (see the figure text in Fig. 2 for more detail on what is required from you).



**Fig. 2.** Overview of what type of figure is expected from you in your paper for this project. Note that this figure is based on fake data and you will have to create the figure based on the data provided in the excel file of project 2 found on the Quercus course website. After making a standard bar graph, make sure to add the labels of axes. If you do not know how to do this, google for help online ('how to add labels of axes in excel'). Add solid and black lines to the x and y axes. Remove the ugly and unnecessary background lines in the chart by clicking on them and deleting them. Add major tick marks inside the Y axis.

## Time line of project 2

Sep 20, 10 am – 3 pm: Introduction, fieldwork

Sep 20, 11.59 pm: quiz

Oct. 4, 10 am – 1 pm: species ID

Oct. 4, 11.59 pm: submit correctly formatted data set to TA

Oct 21, 10 am: optional pre-submission of complete draft of paper 2 to [ivana.stehlik@utoronto.ca](mailto:ivana.stehlik@utoronto.ca)

Oct 24, 11.59 pm: submission of paper 2 to Quercus

Nov 1: discussion of writing quality paper 2

# Project 3

## 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 stomata. 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, but also the more water is lost through evapotranspiration.

In this project, you will test how leaf stomatal density can vary under different environmental conditions and why patterns are as you find them. 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

Based on what was discussed in class, come up with an environmental contrast that might affect stomatal density and formulate a hypothesis 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. In an individual meetup, you will need to tell your professor what hypothesis you are testing, with which species and where.

#### 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). Absolutely stay away from leaves with hairs, as it will be impossible to get the nail polish off!!!

#### Data collection

In the field, collect 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.

#### Leaf storage until at home after the collection

After your return from the field, dry the leaves in a big and heavy book or between newspaper pages weighed down by books. Make sure you keep track which leaves belongs to which category. Every few days, check on the leaves to make sure they are not moldy! Don't forget to bring your dried leaf samples to class on the day of the lab analysis.

**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)**

Sep 27: introduction to the project

Sep 27: 11.59 pm, quiz

Oct 15: Tell the prof about your stomata project (individual consult; what, which species)\*

Oct 18: Field work (done individually by students in locations of choice)

Oct 25: lab work on your field-collected leaves

Nov 22: introduction on how to make a poster

Nov 29: work on poster (at home)

By Dec 5: print poster

Dec 6, 10 am – 3 pm: poster presentation

\*with personally arranged timeslots per student

# Project 4

## Optimal escape theory in grey squirrels at different human densities

### Background

In order to survive, animals need to strike a balance between avoiding their predators and becoming their next dinner, while they also need to forage for food themselves. Animals should hence be under selective pressure to distinguish between real threats followed by a fleeing response and benign stressors and continued foraging. This tradeoff is defined in the optimal escape theory.

The grey squirrel (*Sciurus carolinensis*) is one of the most common mammals in North America and has adapted to live in heavily human-dominated environments. The grey squirrel exists in different color morphs, occurring at different local densities, grey, brown-black, and black color morphs. These morphs are produced by a single deletion in a gene associated with melanin production. For this experiment, the color of the squirrel does not matter. While humans do not actively predate on grey squirrels, humans nevertheless represent 'predation-free predators' and squirrels will flee when approached too closely by humans. This project will investigate the level of habituation of grey squirrels to human approach and compare whether there is a difference in fleeing distance in squirrels living in densely populated human neighborhoods like downtown Toronto and squirrels living in some of GTA's larger parks or more extensive green areas.

### Data collection

#### Locations and timing of data collection

This project has one dedicated Monday to collect data, while you will also use the same amount of time to collect data on the Friday after the Monday (both days: 10 am – 1 pm, squirrels are most active in the morning). On the Monday, each student should assess squirrel fleeing distance in an area with high human densities with presumably a higher squirrel density, while the second field day should happen in green areas (where students can put their honed squirrel hunting skills to good use 😊). On both days, set aside three hours for the actual data collection. This time should not include the travel time to get you to the second location but the actual time spent hunting down squirrels!

Unless you live in the countryside with rolling pastures and fields near your home, the high-density area can most likely happen near your doorstep. For the second data collection day, you will most likely have to do a little bit of planning and travel a little bit. Do not just choose a small parkette near you! The second sampling site needs to be a location where squirrels naturally do not encounter humans that often and where their food collection depends on natural plant sources as opposed to human bird feeders or garbage. In other words, we need a clear enough contrast to see whether squirrel behavior in high human density areas is modified compared to 'wilder' squirrels.

To give you an example for the GTA, Highland Creek Ravine (and any other of our green valleys dissecting the GTA from north to south), the Rouge Urban National Park, High Park, or Downsview Park should be good. In these locations, look for squirrels in wooded areas. It will most likely be much harder to find squirrels in these areas and you will need to be patient and persistent in your search.

### Behavioral assessment

In your data collection site, think of your squirrel hunting as an extended three-hour walk, where whenever you see a squirrel going about its own business on the ground, you switch mode from walking around and

start with the data collection. Thus criss-cross your chosen neighborhood on your walk in a lookout for squirrels. Avoid the same street so that the likelihood to sample the same squirrel twice is reduced.

In your hand, carry a 'thing' which you can drop on the ground and which will not roll away. You will drop this 'thing' in the moment when the squirrel switches from minding its own business to fleeing from you (see more details below). This 'thing' could be a flat pebble, cap of a plastic pen, a rubber band or many other 'non-rolly' or non-bouncy things (not your phone or money 😊).

Here are the steps to make your data collection meaningful and comparable across all students in this course:

(1) A squirrel needs to be busy foraging on the ground and, at least at the start, not responding to our presence. This is not met if the squirrel is up and sitting on its hind legs, scanning its surrounding.

(2) As soon as you see a squirrel meeting condition (1), memorize visually where it is sitting, using small landmarks such as fallen plant parts (leaves, bark, sticks), patterns on the pavement or in the sand or vegetation to pinpoint each squirrel's location.

(3) Having satisfied condition (2), start running fast towards the squirrel (think of yourself as an eager 3-year old or dog... 😊). This run is a simulated predator attack.

(4) During your running spurt, closely observe the squirrel and as soon as it starts darting away, let your 'thing' fall to the ground to help you identify your location at which the squirrel got alerted and started fleeing.

(5) Because you memorized where the squirrel was sitting while minding its own business, and because you have marked the spot of your location when the squirrel started darting away, you can now measure the distance between these two points by counting your own feet it takes to connect these two spots. Take note of this distance.

(6) Repeat throughout your walk and the duration of the data collection (3 hours).

(7) At home, measure the exact length of your foot (in the shoe you used in the field) to calculate all individual squirrel fleeing distances.

(8) Assemble an excel table (using the sample Table 1) and send to TA on TBA date.

**Table 1.** Organization of the data table. L: low (human) density; H: high (human) density.

Student name	Location [L; H]	Flight distance [m]
Sharanja	L	4.30
Sharanja	L	6.25
....	...	...
Sharanja	H	12.23
Sharanja	H	9.75
....	...	...

## Statistical analysis

Download the assembled class data set with the information on all squirrel flight distances the class collected from Quercus. Test the null hypothesis that the flight distances do not differ in the two location types (high versus low human density). The alternative hypothesis is that there is shorter flight distance in squirrels habituated to humans as compared to more wild squirrels. Similarly as for the herbivory project, we do not just expect that there will be a significant difference between flight distances in rural and city squirrels, but that the city squirrels are more used to humans and hence take flight at shorter distances compared to their rural counterparts. This thus again asks for a one-sided, unpaired T-test. Run a T-test in the same way you did for the herbivory project, with all the details outlined there (project #1).

## Figure needed in the report

You will need the same type of figure as the one of project 1 (conceptually and formatting-wise).

## Time line of project 4

Nov 1: introduction to project

Nov 1, 11.59 pm: quiz

By Nov 4: decide where you will hunt squirrels (high and low human density areas)

Nov 5, 1 - 5 pm\*: check-in with prof on fieldwork plans (online)

Nov. 8: fieldwork in high human density area

Nov. 9: Tell prof how your field work went (trouble-shooting)\*

Nov 12: fieldwork in low human density area

Nov 12, 11.59 pm: submit correctly formatted data to TA

Nov 15: work on squirrel data to produce figure

Nov 15, 11.59 PM: submit correctly formatted figure to TA

Nov 18, 10 am: optional pre-submission of complete draft of paper 3 to [ivana.stehlik@utoronto.ca](mailto:ivana.stehlik@utoronto.ca)

Nov 21: submit paper to Quercus

\* with personal timeslots per student, TBA