

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 largely distance-learning settings (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),
- experimentally how density and human touch influences establishment and growth of different plant functional types (project 3),
- whether the behavior of grey squirrels conforms to the optimal escape theory (project 4)

Given the online nature of this year's edition of BIOC52, data collection will be a mix of online work (projects 1 and 2), actual fieldwork (possibly projects 1, 2, but for sure project 4), and experimental work done by you at your home (project 3). The fieldwork can be done wherever you live (not confined to the Greater Toronto Area or even North America; contact ivana.stehlik@utoronto.ca if you feel your geographical location and/or time zone pose a difficulty on doing course work in BIOC52!). In all projects, individual students will contribute, as much as possible, towards a class data set to increase the size and hence statistical strength of the data set.

Course details

Ivana Stehlík

Department of Biological Sciences

Email: ivana.stehlik@utoronto.ca

Course time: Mon, 10 am – 3 pm

Virtual office hours: Thu 12 – 4 PM or 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.

- 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 (1% each for projects 1, 2, 3)	3%
Quizzes on required reading (4 projects, 1.5% each)	6%
Best-of-three papers	32%
Intermediate-of-three papers	22%
Worst-of-three papers	12%
Poster	25%

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

Projects 1, 3 and 4 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 20% 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), this will result in an automatic 10% penalty to the grade of the associated paper.

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

Missed term work due to illness. Please 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 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 (effect of competition and touch on different plant functional types)

- Henry H.A.L. and Thomas, S.C. 2002. Interactive effects of lateral shade and wind on stem allometry, biomass allocation, and mechanical stability in *Abutilon theophrasti* (Malvaceae). *American Journal of Botany* 89: 1609-1615.

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/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.

Date	Course activities and timing; important due dates for marks
Mon, Sep. 14	10 am – 3 pm: Introduction to course and project 1; Hike in Highland Creek, fieldwork for project 1 (in person or online); receive materials for projects 1, and 3
	11.59 pm: online quiz on required reading of project 1 (herbivory)
Fri, Sep. 18	11.59 pm: assessment of leaf damage in milkweed and dog-strangling vine, submit data to TA
Mon, Sep. 21	10 am – 3 pm: Introduction to project 2; field work on Project 2 in Highland Creek ravine (disturbance; in person or online)
	11.59 pm: online quiz on required reading of project 2 (disturbance)
Sun, Sep. 27	By 11.59 pm: download class data set on project 1 and run statistical analysis; create expected figure; submit results to TA
Mon, Sep. 28	12 – 1 pm: optional help with stats and excel of project 1 with TA (online) 1 pm: instructions on how to write a good scientific paper (online) For completely online students: deadline to get materials for project 3 (germination)
Thu, Oct. 1	10 am: Optional pre-submission deadline, paper 1
Sun, Oct. 4	11.59 pm: paper on project 1 (herbivory)
Mon, Oct. 5	1 pm: instructions on project 3 (growth and competition experiment; online) Count and presoak seeds for 36 hours (project 3)
	11.59 pm: online quiz on required reading of project 3 (growth and competition experiment)
Wed, Oct 7	Start growth and competition experiment (project 3; individually at home)
Mon, Oct. 12	1 pm: discussion of writing quality of paper 1 (herbivory; online)
Wed, Oct. 14	1 – 5 pm*: check-in with prof on progress of project 3 (online)
Oct. 16-23	Reading week
Thu, Oct 22	10 am: Optionally due pre-submission deadline, paper 2
Sun, Oct. 25	Due: Paper project 2 (disturbance)
Mon, Oct. 26	10 am – 3 pm: harvest and measure all experimental plants (project 3; individually at home)
Tue, Oct 27	11.59 pm: submit correctly formatted data on project 3 to TA (online)
Mon, Nov. 2	12.30 pm: instructions on project 4 (squirrel) (online) 1 pm: discussion of writing quality paper 2 (online)
	11.59 pm: online quiz on required reading of project 4 (squirrel)
Thu, Nov 5	Decide where you will hunt squirrels (project 4)
Fri, Nov. 6	1 – 5 pm*: check-in with prof on individual plan (what locations?) on field work of project 4 (online)
Mon, Nov. 9	Field work project 4, high human density neighborhood (squirrel; individually outdoors)
Fri, Nov. 13	1 – 5 pm*: check-in with prof on sampling in high-density area on field work of project 4 (online) Access class data set and assemble excel data for paper 3 (individually at home)
	Field work project 4, low human density area (squirrel; individually outdoors)
Tue, Nov. 17	1-3 pm: optional help session with data on project 3 (online)
The, Nov. 19	10 am: optional pre-submission deadline, paper 3 (online)
Fri, Nov. 20	1 – 5 pm*: check-in with prof on the second day of field work of project 4 (online) 1 – 5 pm*: optional help from TA for figure assembly project 3 (online)
Sat, Nov. 21	11.59 pm: submit correctly formatted data on project 4 to TA (online)
Sun, Nov. 22	Due: Paper on project 3 (growth and competition)
Mon, Nov. 23	1 pm: How to prepare a good poster (online)
Mon, Nov. 30	10 am - 3 pm: work on poster (individually at home)
Mon, Dec. 7	11.59 pm: poster on project 4 (squirrel), submit to Quercus

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 Stehlík (2009) show *blablabla*. Or: *Blablabla* (Liang and Stehlík 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; Stehlík and Barrett 2005, 2006; Stehlík et al. 2008).“

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

Citing articles in scientific journals:

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

Citing whole books:

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

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

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

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

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

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

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

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

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

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

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

Grading scheme for reports

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

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

Exemplary (A; 2 pts): Title clearly identifies the main question solved. Abstract includes all sections of the paper and is a coherent whole that can be understood. Key words are informative and complement the title. Accomplished (B; 1.5 pts): Title identifies the project. Abstract does not include all sections of the report. Key words are OK.

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

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

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

2. Introduction (4 pts. max)

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

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

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

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

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

3. Material and Methods (4 pts. max)

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

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

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

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

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

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*) might 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.

Background reading (connected to Quercus quiz)

- 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.

Materials and methods

Leaf collection

Under normal or slightly relaxed physical distancing rules, the TA or course instructor would communicate to you the location where and how you will sample how many leaves per student. The leaf collection will entail the sampling of one leaf of the third-highest leaf pairs per plant individual. Under complete physical distancing, each student will get access to digital photos of previously collected leaves of common milkweed and dog-strangling vine. Each student will assess the same number of digitized leaves and contribute towards a class data set.

App-based analysis of leaf damage using BioLeaf (Android) or old-style (with acetate paper)

Estimation of herbivore damage using BioLeaf (for Android)

Step 1: download and install BioLeaf on your smartphone

Step 2: open BioLeaf

Step 3: choose a leaf picture from the imported gallery of leaves allocated to you.

Step 4: the app will automatically identify the region (outline) of the leaf. The app chooses (by default) an image without reflection (glare or uneven illumination on leaves; Fig. 1: left). With glare existing on the leaf, choose ‘image with reflection (Fig. 1: right). In this case, you can adjust the slider and visually assess whether the app’s algorithm captured the entire leaf area including the part reflecting some light.

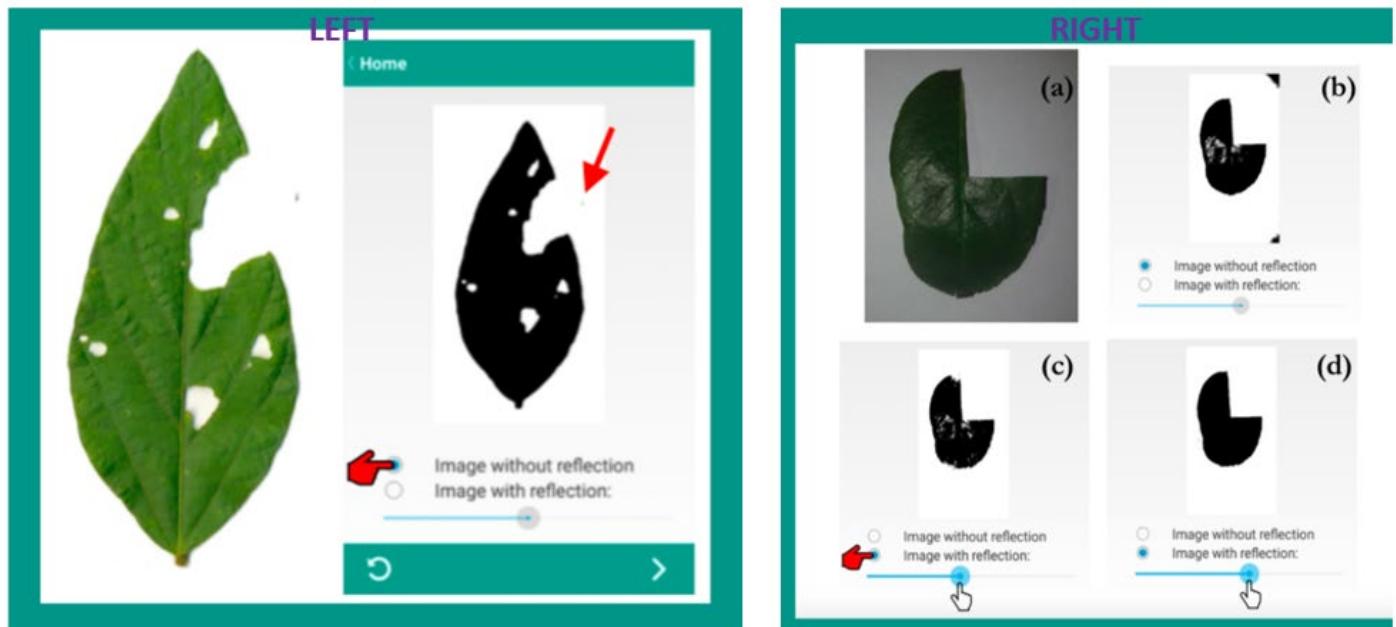


Fig. 1. How to make sure the app recognizes the entire leaf even if there is some glare or reflection of light of the leaf. The left image is for the default state (leaves without glare), in which ‘image without reflection’ is chosen. The right image is for leaves with some amount of glare, where you need to manually choose the second option ‘image with reflection’ and then adjust the slider to make sure the entire unharmed leaf area is recognized by the app.

Step 5: If the leaf only has internal damage, you can go directly to the next step (‘No curve reconstruction’; Fig. 2: left). If part of the leaf edge is missing due to herbivory, you will need to reconstruct the outline of the missing leaf (‘with curve reconstruction; Fig. 2: right image). To do that, first zoom into the picture (Fig. 2: a) and set the control points of the leaf margin (b, c). There need to be three control points: two (green: b, c) at the two edges of the missing leaf margin and one mid-point (blue: c). At any moment, you can reset the control points in case you did not set them precisely. You can also create as many curve reconstructions per leaf as needed.

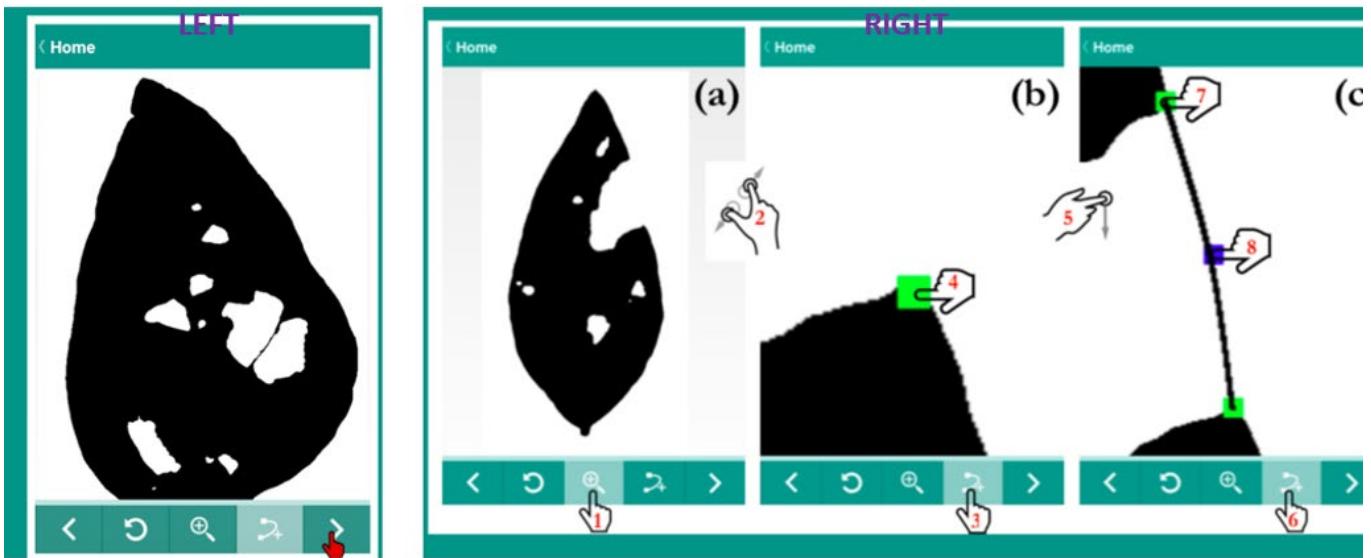


Fig. 2. No curve reconstruction (no peripheral leaf damage; left) or with-curve reconstruction (right: a-c). See text for details.

Step 6: Getting the defoliation result. With or without a potential curve reconstruction, you can now decide if the reconstructed region (Fig. 3: red) indeed represents the area attacked by insects. If you are not satisfied, return to the previous step and redo the curve. If you are satisfied, note down the percentage lost to defoliation as indicated in figure 3 (blue arrow). Make sure to also keep track of the species identity (common milkweed versus dog-strangling vine) along with the missing percentage.

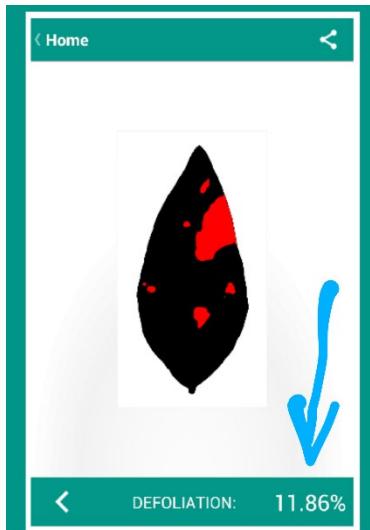


Fig. 3. Defoliation percentage.

No android phone? Old-style assessment of herbivore damage

Using the acetate paper with grid cells and a water-soluble marker (get from Ivana Stehlík), estimate the percentage of the damaged leaf area as the damaged leaf area divided by the whole leaf area. To do so, first check whether there is any damage at all on a given leaf. If there is none, score the 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.

Percent damaged = (Number of grid cells damaged / total number of grid cells of leaf (harmed and unharmed)) multiplied by 100.

For the next leaf damage assessment, clean the acetate paper using water and paper tissue. Repeat the counting procedure for all your sampled leaves.

Last step for both app-based and old-style approaches: Assemblage of excel spreadsheet with all your leaf data. In an excel spreadsheet, enter your data into a table (using the organization shown in Table 1). Upon completion, submit your data to the TA who will then assemble a class data file and send it to everybody for analysis and write-up.

Table. 1. Organization of the data table. MW: common milkweed; DSV: dog-strangling vine.

Student name	Plant ID	Fraction leaf damage [%]
Fatima	MW	15.8
Fatima	MW	17.4
Fatima	MW	13.9
Fatima	MW	14.1
...
Fatima	DSV	0
Fatima	DSV	0
Fatima	DSV	6.8
Fatima	DSV	12.5
...

Data analysis

Download the assembled class data set with the information on all leaves the class worked on from Quercus TBA. 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.

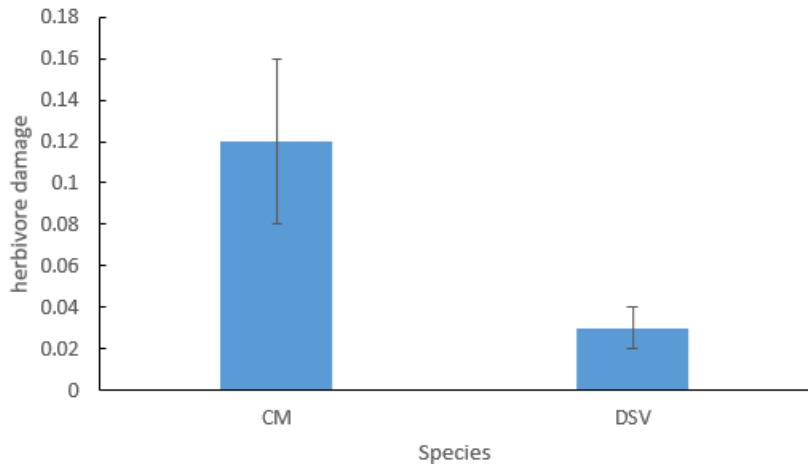


Fig. 1. Overview what type of figure is expected from you in your paper for this project. Note that this figure is based on fake data and you will have to create the figure based on the data provided in the excel file of project 1 created by the whole class together, assembled by the TA and made accessible 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_I0JjE. Add major tick marks to the inside of the Y axis.

Time line of project 1

Sep 14, 10 am – 3 pm, Highland creek ravine: Introduction, fieldwork (in person or virtual)

Sep 14, 11.59 pm: quiz on Quercus (online)

Sep 18, 11.59 pm: submit assessment of leaf damage to TA (online)

Sep 27, by 11.59 pm: download class data set on project 1 and run statistical analysis; create expected figure; submit results to TA (individual work)

Sep 28, 12 - 1 pm: optional help with stats and excel of project 1 with TA (online)

Sep 28, 1 pm: instructions on how to write a scientific paper (online)

Sep 28: for completely online students, deadline to get materials for project 3 (germination and growth)

Oct 1, 10 am: optional presubmission of complete draft of paper to ivana.stehlik@utoronto.ca (online)

Oct 4, 11.59 pm: submission of paper to Quercus (online)

Oct 5, 10 am: discussion of writing quality paper 1 (online)

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 an intermediate level of disturbance prevents competitively dominant species from excluding other species from the community. In contrast, too extreme or too frequent disturbance removes all but the very fast growing species which can complete their life-cycle in the short window between disturbance, or which have an inherently high stress resistance (Bongers et al. 2009). 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 that might be the case; and (3) what makes species more or less able to thrive at different levels of disturbance?

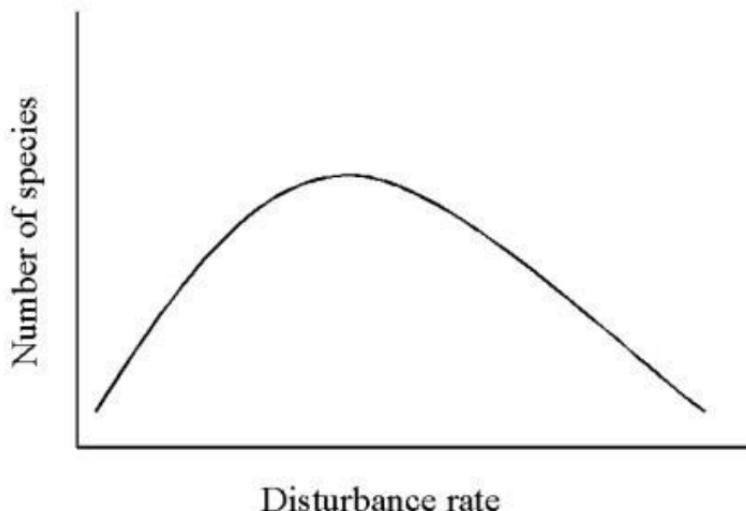


Fig. 1. Expectation of biodiversity as a function of the frequency and intensity of disturbance.

Background reading (connected to Quercus quiz)

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.

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. The intermediate disturbance levels will be located further up for the river and in early to later-successional forests. 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 and at what typical time scales or disturbance intensities are at play (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 will lay out a 4x4 m quadrat and assess the species diversity in each one of them. Try to find all species with present in the quadrat, and also include any trees which might be present above your quadrat. Collect a sample from each plant species and lay it out for the instructor to inspect. The instructor will tell you whether a species is native or invasive. Keep track of the count of how many species of the two categories there are per plot.

Species per site (disturbance regime) or plot

In normal (non-Covid-19) years, the collected plant samples per plot per student would be dried and kept until further work on them in the lab, where as many as possible of these samples would be identified to species level. This would be done in assembling a growing exhibit of ID-ed reference plants on the blackboard in order for students to try to match hitherto unknown plants to the ID-ed references. Unfortunately, this approach is not possible under physical distancing. Instead, the collection of native and invasive plants per plot (previous paragraph) is just there to give each student an appreciation of how many species of both categories there are per plot, what the typical disturbance agents are in the field and what the breakdown is of native versus invasive species. Under Covid-19, no formal identification of the collected samples will happen. Instead, each student will get access to a species list, which is based on results of previous years and the personal knowledge of the professor what species are typically found in these types of habitats in the GTA. Each student will get access the excel table with the data collected across previous years on the course Quercus page.

Data analysis

The data analysis of this type of project cannot be done using the very basic knowledge of an average C-level bio student, thus an average student will need a lot of personal attention how this type of data needs to be analyzed. 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. In normal years, there would be a 2-hour in-person tutorial in UTSC's computer lab taught by the TA, dedicated to the instruction on how to run the statistical analysis for this project. Given the modified mode of the course delivery and the missing option to access a computer lab jointly and in person, there will be no statistical analysis in this year. Instead, we will rely on a simple graphical representation of the results.

In case you are a stats buff, here is what would happen in this part of the project under normal non-Covid circumstances. The analysis would entail the use of two-Way ANOVAs, testing for a correlation between level of disturbance (five plot types: predictor) and plant diversity per plot (dependent variable) and between level of disturbance and the number of native/invasive species (dependent variable). There would be 5-6 replicates per plot, one per student group which collected the samples in the field in each of the plots. The numbers of native and invasive species per plot type and per student group would be the dependent variables while plot type (disturbance regime) would be the predictor. After running the ANOVAs and seeing whether disturbance regime has a significant influence on the number of natives/invasives (with the P-value of the ANOVA ≤ 0.05), there would be a consecutive analysis ('post hoc') to see whether the pattern conforms to the intermediate disturbance hypothesis. Thus there the question would be: is the pattern of species diversity across decreasing disturbance intensity indeed hump-shaped? In order to test this statistically, post-hoc Tukey tests would be used (in the case of a significant ANOVA), to ask which of the plots significantly differ from other plots.

Figure needed in the report

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. But this is the reality of Covid-19...

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).

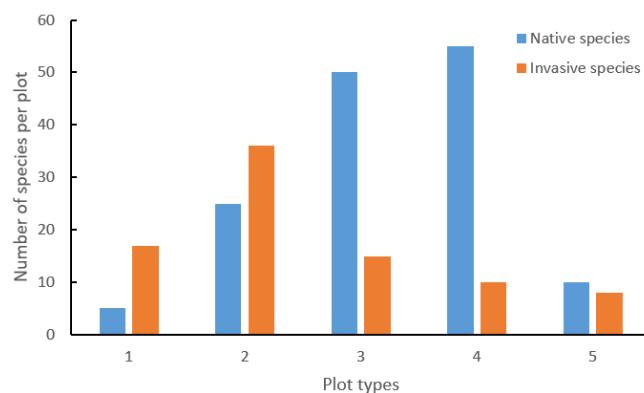


Fig. 2. Overview of what type of figure is expected from you in your paper for this project. Note that this figure is based on fake data and you will have to create the figure based on the data provided in the excel file of project 2 found on the Quercus course website. After making a standard bar graph, 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 21, 10 am – 3 pm, Highland creek ravine: Introduction, fieldwork (in person or virtual)

Sep 21, 11.59 pm: quiz (online)

Oct 22, 10 am: optional presubmission of complete draft of paper 2 to ivana.stehlik@utoronto.ca (online)

Oct 25, 11.59 pm: submission of paper 2 to Quercus (online)

Nov 2, 1 PM: discussion of writing quality paper 2 (online)

Project 3

The effect of competition and touch on different plant functional types (germination experiment)

Background

Plants rely on their senses to adjust their growth morphology and to maximize their competitiveness in their world where they typically find themselves limited in terms of resources such as light, water or nutrients. An important way to assess above-ground competition is to sense light and touch. Plants use their phytochrome receptors to detect whether they are growing in the open or shaded by other plants. Phytochrome sensing is involved in the germination of seeds, the elongation of seedlings, or the size, shape and number of leaves. When seedlings detect shading by competing plants, they maximize their vertical growth to try to outgrow their competitors. Plants can also sense how strongly exposed they are to the mechanical force of wind or touch and if wind and/or touch happens on a regular basis, plants will again adjust their morphology to enforce their stems and adjust their vertical growth. Touch can happen by neighboring plants (depending on overall plant density and hence competition) or by herbivores. Because of resource limitation, extra investment into some organs or tissues (as a result of a sensory stimulus) results in a tradeoff for investment into other tissues or organs.

In this experiment, students will investigate the effect of different levels of competition on the above-ground plant morphology in early plant life-stages using three fundamentally different types of non-woody plants: herbs, legumes and grasses. Representatives of these three functional types will be grown at low, intermediate and high densities. In addition to the different densities, students will also test the influence of regular daily touch on above-ground growth. To test the effect of touch and the effect of different densities, this experiment will use a fully factorial design: one set of plants will be grown at low, intermediate and high densities and will never be touched (no-touch batch), while a second set of low, intermediate and high density plants will be touched by gently striking them with the hand twice a day (daily-touch batch). A third of the class will work with sunflower (functional type: herb), another third with chickpea (functional type: legume), and the last third with wheat or barley (TBA; functional type: grass). All student data will be pooled and hence each student will write up the results based on three species and the two treatments of touch and no-touch.



Fig. 1. Two replications of growth and competition experiments (sunflower). In both replications, plants are grown at high (H), medium (M) and low (L) densities. One set of plants (left) are never touched, while the second set of plants (right) are touched twice daily.

Background reading (connected to Quercus quizzes)

- Henry H.A.L. and Thomas, S.C. 2002. Interactive effects of lateral shade and wind on stem allometry, biomass allocation, and mechanical stability in *Abutilon theophrasti* (Malvaceae). American Journal of Botany 89: 1609-1615.
- Smith V.C. and Ennos A.R. 2003. The effect of air flow and stem flexure on the mechanical and hydraulic properties of the stems of sunflowers *Helianthus annuus* L. Journal of Experimental Botany 54: 845-849.

Materials

For students with access to UTSC, pick up a ‘care-package’ from Elena Gladilina in SW225 on TBA day. This package includes the appropriate number of plant seeds, containers in which to grow the plants, and enough soil for the six containers. For all other students, get your own supplies at a garden center, home-improvement store, or grocery store. Here are the instructions on what materials to get if you need to get the supplies on your own.

Plants. You will be told which species you will work with, which depends on whether you have access to the care packages or need to get your material all on your own in case you are an online-only student. In stores, it is easiest to get chickpeas, while sunflower and wheat/barley is harder to get. If buying chickpeas, look for dried and unprocessed chickpeas sold in plastic bags (not canned!), as can be bought in almost any grocery store. If buying sunflower seeds, same thing: go for untreated sunflower seeds, still contained in their shell (not roasted/toasted or peeled or seasoned). Such sunflower seeds can be bought in gardening stores, or home-hardware or home depot-type stores in their gardening sections. Dry and untreated wheat or barley seeds can be bought in health food stores (for example: as wheat ‘berries’). You will need 210 seeds for the actual experiment, but make sure to get at least twice as many, in case something goes wrong and you need to repeat the experiment. Any bag of chickpeas or wheat/barley seeds will probably contain many more seeds than these 420 seeds, but make sure you got enough sunflower seeds!

Soil. Any potting soil will do! Soil is mostly sold in large bags, which is too much for our experimental purposes, unless you are an avid gardener and will use the rest of the soil anyway. You can repurpose soil from either the cheapest-possible potted plant sold in a garden store or even a corner store, or from an already existing, but not loved or dead plant in your home. In both cases, make sure the source pot is large enough and hence contains enough soil for the six experimental containers. A pot with an upper diameter of 5 to 6 inches will probably do in terms of the necessary amount of soil. Separate the living or dead plant tissue from the soil including, as completely as possible, its roots. Divide the soil into six equal parts.

Growth containers. As illustrated in figure 1, plants will be grown in plastic food containers. You need six identical containers! They should be of intermediate size, approximating 5 X 10 cm (it is OK if the containers are a little larger, but they need to be identical).

Growth location

Set up all six of your containers in a spot which gets direct sunlight at least during part of the day, preferably nearest to a south-facing window (on a window sill, or onto chairs moved in front of the window). East- or west-facing windows are good too. North-facing windows are least favorable, but better than no window (in a basement apartment...). Crucial: all six containers should, as much as possible, receive the same amount of light!

Experimental setup

Two days before the official start of the experiment, count out 210 seeds and pre-soak them for 36 hours. This will break their dormancy and speed up germination. To do this, place two layers of a paper towel on a plate, add the seeds on top of the paper, add another paper towel layer on top of the seeds, and soak all with water. On the second day, count out six piles of seeds: 5, 5, 20, 20, 80, 80. Plant these six groups of seeds into your six containers (containing 2 cm of moist, but non-soggy soil), by distributing them as evenly as possible in their allotted container. Add 1 cm of moist soil on top of the seeds. For the ease of the experimental daily-touch treatment, mark your six containers as NT-L (no-touch low density), NT-M (no-touch medium density), NT-H (no-touch high density), DT-L (daily-touch low density), DT-M (daily-touch medium density), and DT-H (daily-touch high density). Spatially divide the NT from DT containers (Fig. 1). Now wait and observe as the seeds germinate. Throughout the duration of the experiment, keep the soil moist, but not water-logged, to avoid mold buildup.

Experimental treatment of the daily-touch batch

Once the seeds have started germinating, apply the experimental treatment to the daily-touch batch. This entails a twice-daily (morning and evening) gentle petting with your open fingers across the top of the plants for approximately 2 min each time (Fig. 1). Apply this treatment to each seedling, as soon as it has expanded its cotyledons (two for sunflower and chickpea and one for wheat/barley). There is no need to wait until ALL seeds of the daily-touch individuals have germinated and thus are ready. Rather, apply the treatment to all seedlings once they have expanded their cotyledons. Make sure to never touch the no-touch plants! Continue with this treatment for the entire duration of the experiment.

Duration of growth experiment and final data collection

Run the experiment for 3 weeks. At the end of the growth period, do your measurements. In preparation of the measurements, cut each individual plant at the soil surface level, making sure not to sever any leaves from individuals. For the low-density containers, measure each plant (five out of five). For the medium and high density treatments, choose 20 individuals at random from different locations within the pot. For each single plant, measure four parameters (according to figure 2):

- (1) Maximum plant length from the soil level to the end of the longest leaf in the case of wheat/barley or to the middle of the plant in the case of chickpea and sunflower
 - (2) Stem diameter at soil level
 - (3) Length of the longest leaf
 - (4) Number of leaves

Assemble measured data into a table following the sample layout shown in Table 1 and send it in to the TA for assembly of class data set.

Data analysis

The data analysis of this project would be the same as in the project dealing with the intermediate disturbance hypothesis. But again, because of the difficulty associated with computer lab use under Covid-19, we will rely on a simple graphical representation of the results.

For stats-buffs, here is more explanation on the statistical treatment as would have been done in a normal year. The total plant length (and stem diameter and leaf length and number of leaves) would be the response variable, while density, treatment (no-touch versus daily touch) and species identity (chickpea, sunflower, and wheat/barley) are predictors. The analysis would thus again entail the use of two-way ANOVAs, testing for a correlation between the response variables and the predictors. After running the ANOVA and in the case that size measurements are significantly influenced by the experimental treatments (a significant P-value in the ANOVA; $P \leq 0.05$), post-hoc Tukey tests would have to be run to see what the nature of the significant results is (for example: are plants in dense plots larger or smaller than plants grown in more space?).

Table 1. Overview on how your data should be formatted in excel. C: chickpea; S: sunflower; B/W: barley or wheat. No-touch treatment should be indicated by 0, while daily-touch treatment by a 1. All plant measurements should be provided in mm. Note that your table should have 210 entries, one for each of the seedlings, assuming all seeds germinated and all seedlings survived until harvest.

Nihar	C	H	0	20	2	10	15
...
Nihar	C	H	1	21	3	10	15
...

Figures needed in the report

You will need three sets of figures, one set for each of the three species or functional types. Create the figures using the following (fake) examples (Fig. 1).

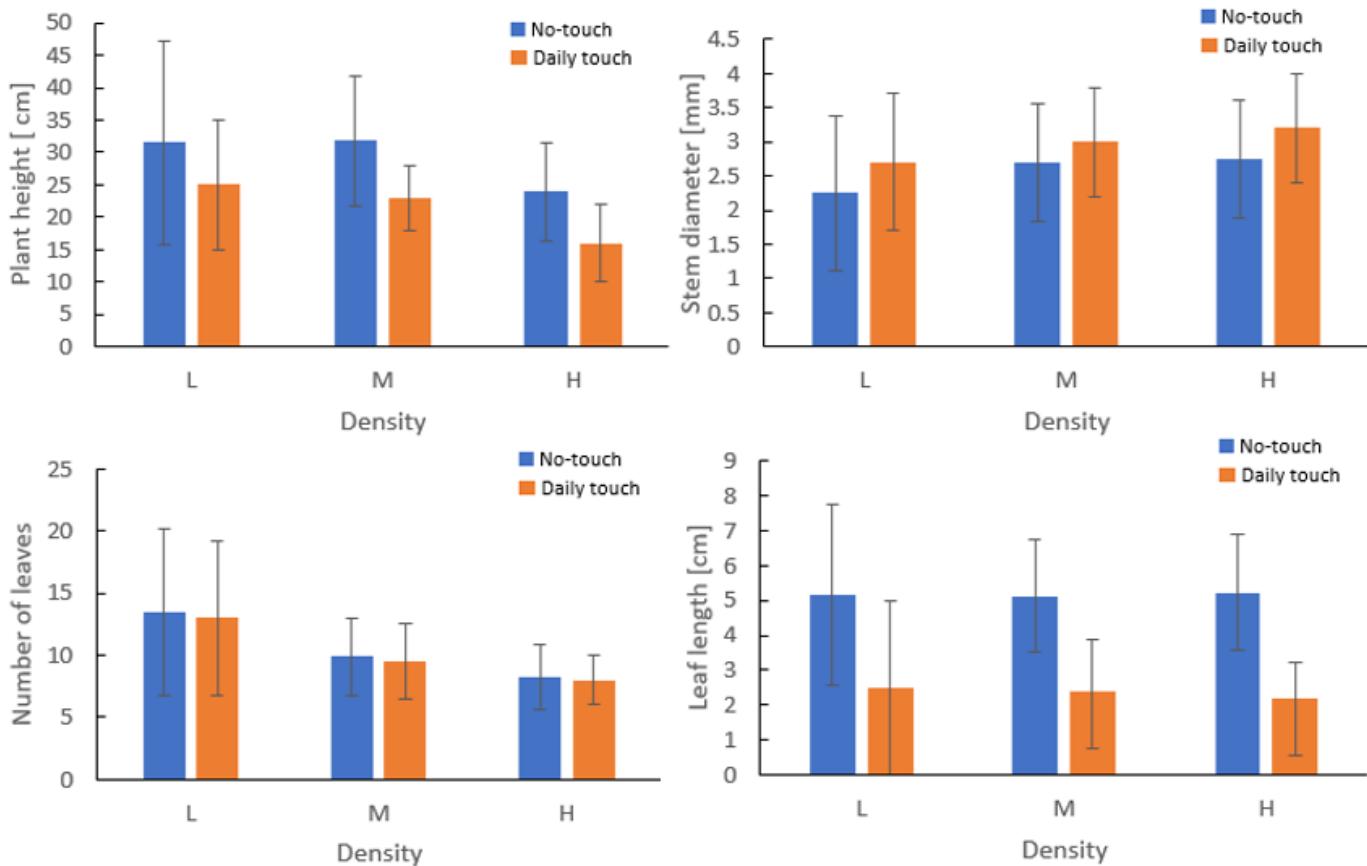


Fig. 1. Overview of what type of figure is expected from you in your paper for this project. Note that this figure is based on fake data and you will have to create the figure based on the data provided in the excel file of project 3 found on the Quercus course website. You will have to produce three versions of this sample figure, one for each one of the three species. 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. Add units in [brackets] to Y axes. Add standard error (SE) bars to each average. Note that the error bars bars will be different for each individual bar! If you do not know how to do that, watch the 1-min youtube tutorial: https://www.youtube.com/watch?v=OGutc_I0JjE. I suggest to create each of the four (actually twelve) figures individually in excel and format them according these outlined instructions. Then use print-screen or a snipping tool to copy an individual figure on your screen in excel. Paste each picture into an empty PPT file and arrange it there. Add figure legend there (No-touch and Daily touch plus colored squares; I am sure this step could be done in excel, but I am not sure how...). Once your overall figure in PPT looks good, use again print-screen or snipping tool to copy the overall picture and then add it into your paper (this is the 'sneaky' way your prof made the above figure...).

Calendar of events for this project (compare time table)

By Sep 28, for completely online students: get all materials needed to do this project

Oct 5, 1 pm: introduction (online)

Oct 5: count and presoak seeds for 36 hours (individual student work at home)

Oct 5, 11.59 pm: quiz (online)

Oct 7: plant seeds (individual student work at home)

Oct 14, 1 – 5 pm*: check-in with prof on progress (online)

Oct 26: harvest and measure plants (individual student work at home)

By Oct 27, 11.59 pm: submit correctly formatted data to TA (online)

By Nov 13, 10 am: access class data set (online), assemble excel data set for paper (individual student work at home)

Nov. 17, 1-3 pm: optional help session with TA on the creation of the graph (online)

Nov 22, 11.59 pm: submission to paper to Quercus (online)

*with personally arranged timeslots per student

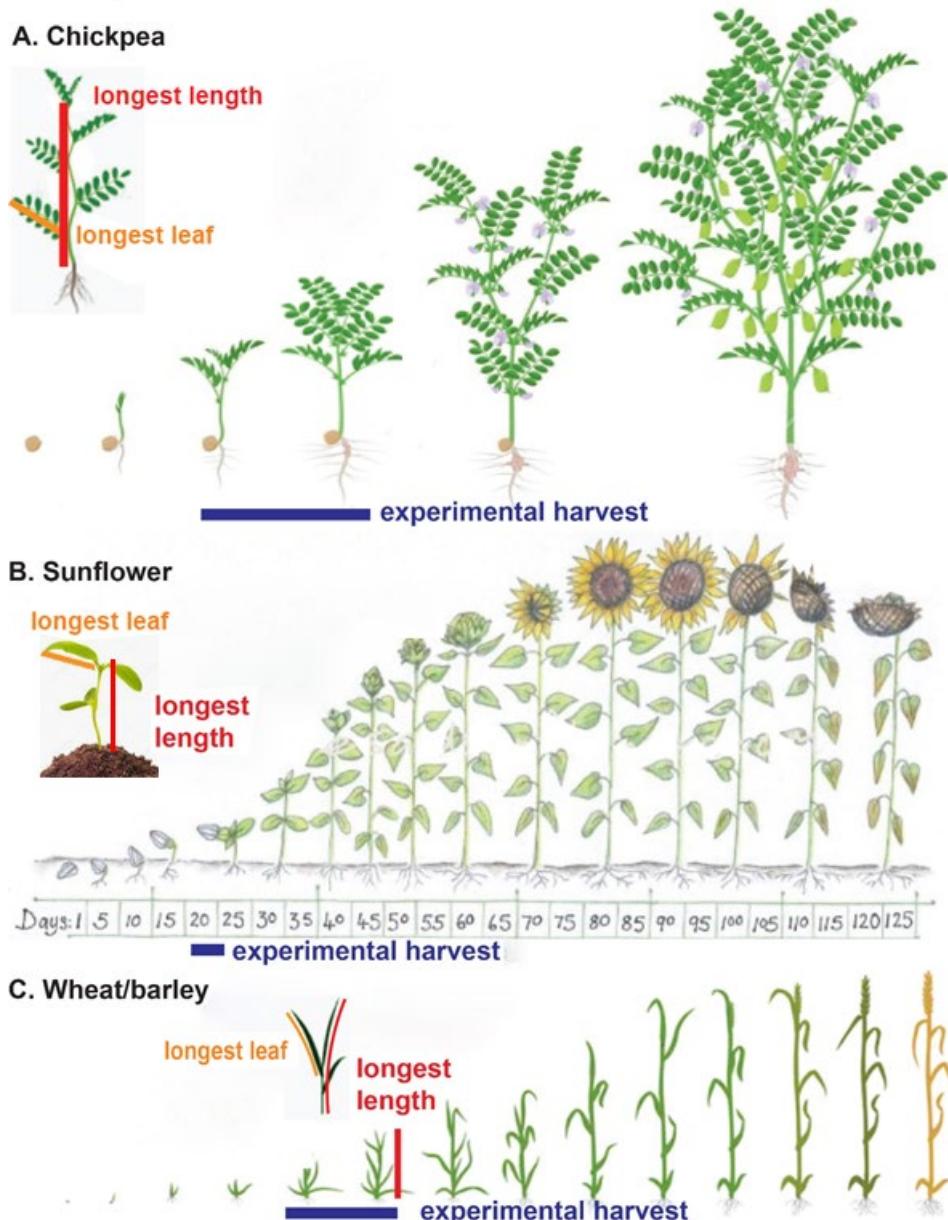


Fig. 2. Life cycles of chickpea (A), sunflower (B) and wheat/barley (C) and how to measure the growth parameters (please note that the measurement of the stem diameter should be down at the soil level of the stem).

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 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 colour 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.

Background reading (connected to Quercus quiz)

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.

Data collection

Locations and timing of data collection

This project has two dedicated Mondays to collect data. On the first 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 Mondays, 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. LD: low (human) density; HD: high (human) density.

Student name	Location [LD; HD]	Flight distance [m]
Sharanja	LD	4.30
Sharanja	LD	6.25
...
Sharanja	HD	8.35
Sharanja	HD	9.55
....

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 2, 12.30 pm: instruction (online)

Nov 2, 11.59 pm: quiz (online)

By Nov 5: decide where you will hunt squirrels (high and low human density areas)

Nov 6, 1 - 5 pm*: check-in with prof on fieldwork plans (online)

Nov. 9: fieldwork (high human density area)

Nov 13, 1 – 5 pm*: check-in with prof on progress of fieldwork (online)

Nov 16: fieldwork (individual student work, outdoors)

Nov 20, 1 – 5 pm*: final check-in with prof on fieldwork (online)

Nov 21, 11.59 pm: submit data to TA (online)

Nov 23, 1 pm: instruction on how to make a poster (online)

Nov 30: work on poster (individual student work at home)

Dec 7, 11.59 pm: submit poster to Quercus (online)

*possibly with personal timeslots per student, TBA