ENVS 278: Applied Statistics for Environmental Research

Instructor: Dr. Chris Fletcher (chris.fletcher@uwaterloo.ca)

Lecture hours: 1:00-2:20pm TuTh, AL-116

Tutorial hours: all registered students should be enrolled in one tutorial class, held on Wednesdays.

Office hours: Wednesday 12:30-3:30pm in EV1-230 or by appointment via https://calendly.com/cgf

Introduction and Course Objectives

Statistics is the art and science of making sense with data; i.e. understanding the world around us based on evidence, while accounting for inherent uncertainties. Statistical methods are critical for quantitative environmental research across the full breadth of the physical and social sciences. This course builds on the knowledge gained in ENVS 178, examining further techniques for collecting, evaluating, and using data-based evidence in environmental research. It builds upon ENVS 178, with a focus on inferential statistics, including sampling distributions, confidence intervals, parametric and nonparametric hypothesis tests, and linear regression models. Students further develop skills in using statistical software for data analysis and modeling of environmental data, a necessary skill set for further pursuits in academic and professional life.

Prerequisite: ENVS 178

Learning Outcomes

At the end of this course, students will be able to

- Define and understand key statistical terminology and concepts;
- Select and apply suitable statistical tools for a variety of data analysis problems;
- Interpret and critically evaluate the results of statistical analyses;
- Use statistical software to perform selected data analysis tasks.

Learning Activities

This course employs a blend of learning activities and delivery methods: in class, tutorial, online and individual. Lecture time is used to introduce key concepts, and to work through and discuss examples to illustrate these concepts and enhance your understanding. Tutorials provide an opportunity to practice the application of statistical concepts and methods on sample questions, and to seek assistance from the Teaching Assistants (TAs) with homework problems. The online learning platform ‘LEARN’ will be used for discussions, quizzes, electronic assignment submission and to provide lecture material and informational messages to the students. The regression assignment will provide students with the opportunity to practice their statistical analysis skills on a real data set, and to gain experience using statistical modelling software. The required textbook provides additional material for self-study, for example through completion of homework problems, which is necessary to succeed in this course.

Required Text


- NOTE: Other Canadian editions are permitted, but chapter numbering, and some content, will be different to the second edition.

Last updated: Nov 16, 2018
• NOTE: Use of any United States editions is not recommended, because the exercises at the end of each chapter are different.
• Pearson Education Inc. offers additional online learning resources (MyStatLab); subscription to MyStatLab is not required for this course.

Lectures and Tutorials

*** Remember to bring paper, pencil and a pocket calculator to all lectures and tutorials. ***

Students should attend three classes per week: two lectures, and one tutorial session. Lectures motivate and introduce statistical concepts and methods, demonstrate their application, and discuss the potential and limitations of these methods.

A few words about why you should attend lectures:

• Attending class is good for your grade: students who attend regularly do better, on average, in the final exam. Attendance in lectures will be taken at random points throughout the term.
• The course content is incremental: one week’s material builds on the previous week’s. This makes it more difficult to catch up after missing a class or two, and so it makes good sense to attend all classes and tutorials to keep on top of the workload.
• This course has a reputation for being “difficult”, but I think that means it forces students out of their comfort zone. My firm belief is that all students have the ability to do well in this class if they commit to applying themselves regularly to the material. While ENVS278 requires a little more math than other courses in the Faculty, the math is Grade 9-10 level in Ontario high schools, and the instruction team is here to help you. If you come to class regularly you will gain confidence by seeing that solving statistical problems is actually not that “difficult” at all.

Lecture Schedule

<table>
<thead>
<tr>
<th>Lecture Date</th>
<th>Lecture Topic</th>
<th>Textbook</th>
<th>Assessment Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Jan</td>
<td>Course Overview; Review of ENVS 178; Research Design 1</td>
<td>Review chapters from ENVS178</td>
<td>Course outline quiz (2%); Data Survey (1%)</td>
</tr>
<tr>
<td>10-Jan</td>
<td>Research Design 2</td>
<td>Ch. 10</td>
<td></td>
</tr>
<tr>
<td>15-Jan</td>
<td>Research Design 3</td>
<td>Ch. 11</td>
<td>Quiz 1 starts (due Monday)</td>
</tr>
<tr>
<td>17-Jan</td>
<td>Statistical Inference for proportions</td>
<td>Ch. 15-16</td>
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<tr>
<td>22-Jan</td>
<td>Comparing Proportions</td>
<td>Ch. 17-18</td>
<td>Quiz 2 starts (due Monday)</td>
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<tr>
<td>24-Jan</td>
<td>Comparing Two Proportions 1</td>
<td>Ch. 19</td>
<td></td>
</tr>
<tr>
<td>29-Jan</td>
<td>Comparing Two Proportions 2</td>
<td>Ch. 19</td>
<td>Quiz 3 starts (due Monday)</td>
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<tr>
<td>31-Jan</td>
<td>Test 1 (in class) (15%)</td>
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<tr>
<td>5-Feb</td>
<td>Inferences about Means</td>
<td>Ch. 20</td>
<td>Quiz 4 starts (due Monday)</td>
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<tr>
<td>7-Feb</td>
<td>Comparing Means 1</td>
<td>Ch. 21</td>
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</tr>
<tr>
<td>12-Feb</td>
<td>Comparing Means 2</td>
<td>Ch. 21-22</td>
<td>Quiz 5 starts (due Monday)</td>
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<tr>
<td>14-Feb</td>
<td>Comparing Means 3</td>
<td>Ch. 22</td>
<td>Midterm course survey</td>
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<tr>
<td>19-22 Feb</td>
<td>Reading week: No classes or tutorial</td>
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<td></td>
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<tr>
<td>26-Feb</td>
<td>Analysis of Variance 1</td>
<td>Ch. 25</td>
<td>Quiz 6 starts (due Monday)</td>
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<tr>
<td>28-Feb</td>
<td>Analysis of Variance 2</td>
<td>Ch. 25-26</td>
<td></td>
</tr>
<tr>
<td>5-Mar</td>
<td>Analysis of Variance 3</td>
<td>Ch. 26</td>
<td></td>
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<tr>
<td>7-Mar</td>
<td>Non-parametric Methods 1</td>
<td>Ch. 29</td>
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Tutorials

A few words about why you should attend tutorials, which:

- are considered a vital component of the teaching/learning process;
- provide an opportunity to practice the application of statistical concepts and methods and to seek answers to individual questions;
- are used to present the solutions of assignments and exercises, and to discuss common mistakes and challenges; active student participation is required to accomplish this;
- introduce the statistical software used in the data analysis project.
- have participation grades available for handing-in your attempts at statistical problems.

Tutorial class times and locations

<table>
<thead>
<tr>
<th>Section</th>
<th>Time</th>
<th>Location</th>
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<tbody>
<tr>
<td>TUT 101</td>
<td>2:30p-3:50p W</td>
<td>EV1 350</td>
</tr>
<tr>
<td>TUT 102</td>
<td>1:00p-2:20p W</td>
<td>EV1 350</td>
</tr>
<tr>
<td>TUT 103</td>
<td>11:30a-12:50p W</td>
<td>EV1 350</td>
</tr>
<tr>
<td>TUT 104</td>
<td>08:30a-9:50a W</td>
<td>EV1 350</td>
</tr>
</tbody>
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Assessment

Students will be evaluated based on:

- **1 Final Examination (35%)**: Details below.
- **2 In-class tests (15% each; total 30%)**: Details below
- **6 weekly quizzes (Q1-Q6; 2% each, best 5 of 6, total 10%)**: testing material covered in class/tutorials; interpretation of statistical software output; some short calculations; multiple-choice questions.
- **1 assignment on multiple linear regression (10%)**: perform a linear regression analysis using statistical software SPSS, and write-up the results in a short report. More detailed instructions (and a tutorial on how to use SPSS) to come later in the term.
- **Hand-in problems at tutorials (up to 10%)**: Students will earn 1% per tutorial class (up to a maximum of 10%) if they hand in their written attempt at a problem that is set during the class. The written attempt must be signed by the student, and handed to the TA when they ask for it toward the end of the class. Students may only submit their work for a grade at the tutorial in which they are registered. There are 12 tutorials scheduled for the term, so students can miss up to two tutorials in a term, and still receive the maximum 10% grade.
- **1 Course outline quiz (2%)**: To be completed during the first week of term. Multiple attempts are allowed; course content will be released on LEARN only after students receive a grade of more than 80%.
- **Discussion forum participation (2%)**: Students can earn a 2% participation grade by posting a new thread, or a reply, on the LEARN discussion forums at any time before 11:59pm on Monday Dec 3rd 2018 (1% per post, up to a maximum of 2%).
- **1 Class survey (1%)**: Students will earn an automatic 1% participation grade by completing the Class Survey Quiz on LEARN during Week 1. These data will be anonymized, and then used for class activities during the term.
• **BONUS for in-class attendance (up to 2%):** Attendance will be taken in class on three occasions during the term: the exact classes and times when the attendance is taken will be decided using a random number generator. Students will sign in using a quiz on LEARN. Students who sign in all three times will receive a bonus 2%, those signing in twice (i.e., you miss one class where attendance is taken), then the bonus is 1%, and those signing in only once (or never) will receive no bonus. Students who are not physically present in class to sign the sheet will not receive the bonus, and there will be no exceptions made for illness, or absence due to any other reason. A head count may be conducted during the taking of attendance, and we reserve the right not to award bonus marks in the event of a mismatch between the number of attendees and the number of signatures.

**Examinations and tests, calculators and crib sheets.**

Two compulsory non-cumulative tests (held in class) will gauge student progress on material covered up to and including the class before the test, and provide students with experience in completing multiple-choice and true-false questions similar to those in the final exam.

The compulsory final examination will cover all course materials (i.e. it is cumulative). It will include multiple-choice questions, true-false questions, short answer questions, and interpretation of graphical and numerical output from statistical software. The exam is split into three sections: Section 1 tests the material from midterm test 1, Section 2 tests material from midterm test 2, and Section 3 is on multiple linear regression. A practice final exam from a previous year will be made available on LEARN near the beginning of term.

Students are required to be present to write the exam. The date, time and location of the examination is not known at this time. The examination is scheduled by the Registrar’s Office and will be held within the University’s normal examination period. Students should not make travel arrangements until they have consulted the final examination time table. The University examination schedule is published by the Registrar during the fall term.

Students are permitted to bring one page (double-sided, US Letter size 8.5” x 11”, with no “flaps” or other material added) of hand-written study notes (aka a “crib sheet”) with them into each examination/test. Your crib sheet will be subject to inspection by exam proctors, and may be collected at the end of the test. Hand-written notes only: **photocopies and/or printouts are not permitted.**

Calculators are required for the tests and final exams but are not provided. Only calculators that are approved by the Math faculty are permitted in ENVS278 (see [https://uwaterloo.ca/math/current-undergraduates/regulations-and-procedures/calculator-regulation](https://uwaterloo.ca/math/current-undergraduates/regulations-and-procedures/calculator-regulation)). Calculators will be subject to inspection by exam proctors, and may be removed, or reset, if they do not meet the guidelines. I strongly recommend buying one of these calculators at the start of term (for $10 - $15 at Walmart), and bringing it to every class.

**What if I miss a quiz, test or examination?**

Life happens. Life is important. Sometimes we all need time away from school or work for a multitude of reasons: because we get sick, due to a family bereavement, or perhaps a friend or relative needs our support. I hope your term goes smoothly, and that you don’t need to take any time off. But if you do, for whatever reason, then you shouldn’t need to worry about school – it’s just not as important as those other things.

So, if you need to take time off during term, then please just take it. You don’t need to contact me (unless you want to), and I **don’t need to see any doctor’s notes, or other documentation.** If you need to miss a quiz, then just miss it: the lowest quiz grade (including zero) will be automatically dropped for all students. If you need to miss a midterm test, then just miss it: if you score higher in section 1 of the final exam than you did in test 1 (even if your grade was zero), your final exam grade will automatically not be changed.

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count for the 15% from test 1, and the same thing for section 2 of the final exam and test 2. The same rules apply to all students, regardless of whether you write the test, or not. Only one midterm grade can be overridden by the final exam: if you require additional accommodation, then please see the instructor at office hours.

Please note that due to the size of the class there are no extensions to quizzes, or alternative (make-up) dates to sit the tests. If you need to miss more than one quiz, or more than one test, then please contact the instructor. If you miss the final exam, or if you know in advance that you will miss the final exam, please contact the instructor at your earliest convenience.

Class policies, requirements and special considerations

- **Policy on cell phones:** There is no valid academic reason to be calling, messaging, watching videos or using social media during class. It is distracting to you, and it is distracting to the instructor, and to the others around you. Therefore, please keep cell phones in your bag/jacket on mute, not on your desk/tablet. The only exception is that, occasionally, the instructor will request that students use a web-enabled device (cell phone, tablet, laptop etc) to conduct in-class polls. Students often use their cell phone as a calculator, but this is not recommended because you will need an actual calculator during exams and tests (see above).

- **Backing up your data:** Students are fully responsible for maintaining backups of any files and data you have modified. Suitable options for backups include: networked drives; portable USB flash drives; external hard drives; laptops, or home desktop PCs; online “cloud” storage. No accommodation will be made for deadlines missed due to lost or corrupted data.

- **Policy on regrading assignments:** If you notice an error in the assessment of your work please follow these steps:
  - Wait 48 hours after the assignment was returned before contacting a member of the instruction team.
  - All requests for work to be regraded must be submitted to the instructor from your UWaterloo email account, in a message that fully describes the errors you believe were made. Verbal requests for regrades will not be accepted.
  - When writing your request, please follow the policy on student email (see below).
  - Be as specific as possible and list all relevant details, e.g., “my marks were summed incorrectly for questions 1–5”.
  - If another student’s work is used as an example or reason for an error in grading, both assignments will be subject to a regrade.
  - The entire assignment will be regraded, not just the errors indicated in the written request. The resulting grade may increase or decrease depending on the result of the regrading.

- **Policy on student email:** Most information students need is found in this course outline: please review it carefully before contacting the instructor or TAs. Discussion forums (for which participation grades are awarded) are available in LEARN and are the preferred means of answering procedural questions. Face-to-face contact time is available through office hours, during and after lectures, and in the tutorials and drop-in sessions. Students are strongly encouraged to attend office hours to discuss any issues related to the course, and email should only be used when none of these other
options is appropriate. The instructor and the TAs will not respond to emails if students have not first attempted to find an answer using these other means.

However, if your question or concern cannot wait until the next lecture or office hour then please remember these policies when sending email to the instructor or TAs:

- Always send emails from your University of Waterloo email account or from the email tool within UW LEARN.
- All emails should have the following subject line: “ENVS278: <<insert your subject here>>”
- The instructor should be copied on all course-related email communication with the TAs (TAs are under instructions not to respond to emails that do not cc the instructor).
- If your email includes an attachment, describe the contents of the attachment in the email.
- Be polite, respectful and professional.
- Proofread your email and use correct grammar and punctuation.
- Always use an appropriate greeting, and sign your full name.
- Allow the instructor or TA at least two business days to respond before sending the request again. Mark all urgent matters “URGENT” in the subject line.
- The instructor and TAs reserve the right to reply to you along with the entire class, if the question is deemed to be relevant to other students on the course. Alternatively, we may post the question and response in a discussion forum on LEARN. The questioner’s identifying personal information will be removed from such announcements.

- **Student collaboration:** All assignments and tests are to be completed individually by each student. These elements are expected to be the student’s original work and to reflect her/his own thinking. Student collaboration on Tutorial and In-class Exercises, however, is encouraged for improved learning.

- **Readability and clarity:** Students are expected to present well organized and properly written work. The instructor and TAs reserve the right not to grade work that does not conform to normal standards of academic writing and/or organization.

- **Assignment submission:** Quizzes Q1–Q6 are completed on LEARN, while the regression assignment is to be submitted as a Word or PDF document to the LEARN drop box. Assignments submitted in a different format or manner than that specified in the assignment instructions will not be graded. Emailed assignments will not be accepted under any circumstances.

- **Late work will not be graded:** all assignments are due on the date set by the instructor. Teaching assistants are NOT allowed to change the due dates. There are no late penalties: any work that is submitted after the stated deadline, without appropriate documentation, will not be graded.

**Academic Policies**

- **Co-op interviews and class attendance:** Co-op students are encouraged to try and choose interview time slots that result in the least amount of disruption to class schedules. When this is challenging, or not possible, a student may miss a portion of a class meeting for an interview. Instructors are asked for leniency in these situations; but, a co-op interview does not relieve the student of any requirements associated with that class meeting. When a co-op interview conflicts with an in-class evaluation mechanism (e.g., test, quiz, presentation, critique), class attendance takes precedence and the onus is on the student to reschedule the interview. CECA provides an interview conflict procedure to manage these situations. Students will be required to provide copies of their interview schedules (they may be printed from JobMine/WaterlooWorks) should there be a need to verify class absence due to co-op interviews.

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• **Academic Integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [www.uwaterloo.ca/academicintegrity](http://www.uwaterloo.ca/academicintegrity) Students who are unsure what constitutes an academic offence are requested to visit the on-line tutorial at [http://www.lib.uwaterloo.ca/ait/](http://www.lib.uwaterloo.ca/ait/).

• **Discipline:** A student is expected to know what constitutes academic integrity, to avoid committing academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline, [www.adm.uwaterloo.ca/infosec/Policies/policy71.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm). For typical penalties, check Guidelines for Assessment of Penalties, [www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm](http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm)

• **Note for students with disabilities:** AccessAbility services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with [https://uwaterloo.ca/accessability-services/](https://uwaterloo.ca/accessability-services/) at the beginning of each term.

• **Research Ethics:** The University of Waterloo requires all research conducted by its students, staff, and faculty which involves humans as participants to undergo prior ethics review and clearance through the Director, Office of Human Research and Animal Care (Office). The ethics review and clearance processes are intended to ensure that projects comply with the Office’s Guidelines for Research with Human Participants (Guidelines) as well as those of provincial and federal agencies, and that the safety, rights and welfare of participants are adequately protected. The Guidelines inform researchers about ethical issues and procedures which are of concern when conducting research with humans (e.g. confidentiality, risks and benefits, informed consent process, etc.). If the development of your research proposal consists of research that involves humans as participants, the please contact the course instructor for guidance and see [http://iris.uwaterloo.ca/ethics/](http://iris.uwaterloo.ca/ethics/)

• **Religious Observances:** Student needs to inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

• **Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4, [www.adm.uwaterloo.ca/infosec/Policies/policy70.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm). When in doubt please contact your Undergraduate Advisor for details.

• **Appeals:** A decision made or penalty imposed under Policy 70 - Student Petitions and Grievances (other than a petition) or Policy 71 – (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) [www.adm.uwaterloo.ca/infosec/Policies/policy72.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm)

• **Turnitin:** Text matching software (Turnitin) will be used to screen assignments in this course. Turnitin is used to verify that all materials and sources in assignments are documented. Students submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course. For guidance on how to interpret the Turnitin Similarity Report, which will be available through LEARN, see: [https://guides.turnitin.com/01_Manuals_and_Guides/Student_Guides/Feedback_Studi](https://guides.turnitin.com/01_Manuals_and_Guides/Student_Guides/Feedback_Studi)

• **LEARN:** Users can login to LEARN via: [http://learn.uwaterloo.ca/](http://learn.uwaterloo.ca/); use your WatIAM/Quest username and password. Documentation is available at: [http://av.uwaterloo.ca/uwace/training_documentation/index.html](http://av.uwaterloo.ca/uwace/training_documentation/index.html)

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• **Recording lectures:** Use of recording devices during lectures is only allowed with explicit permission of the instructor of the course. If allowed, video recordings may only include images of the instructor and not fellow
classmates. Posting of videos or links to the video to any website, including but not limited to social media sites such as: Facebook, twitter, etc., is strictly prohibited.

• **Intellectual Property:** Students should be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as: Lecture content, spoken and written (and any audio/video recording thereof); Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides); Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student’s educational experience. However, sharing this intellectual property without the intellectual property owner’s permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository).

Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online. The intellectual property rights owner deserves to know (and may have already given their consent).