UNIVERSITY OF SASKATCHEWAN

BIOL 875: Ecotoxicology Theory and Practice

Instructor	Dr. Christy Morrissey Office: Rm 243, Biology Ph: 966- 4433 Email: christy.morrissey@usask.ca
Course delivery	Graduate Tutorials: 2 hours per week Wednesdays Undergrad Lectures (if required; see prerequisites):3 hours per week MWF 10:30-11:20
Location	Remote for 2022
Office hours	By appointment (email)
Prerequisites	At least 1 undergraduate or graduate course in Ecotoxicology or permission from instructor – attendance of BIOL 475 undergraduate lectures may satisfy this prerequisite.
Enrollment Limit	12

Course Description

This course examines how principles and theories in ecology can better inform ecotoxicology problems at multiple levels of biological organization (individuals to ecosystems). Much of the science of this relatively young discipline has traditionally lacked a conceptual basis and major recent advances are being drawn from ecological theories, models and approaches to strengthen the field. Students will examine current advanced topics and contemporary approaches that add ecological relevance and predictive strength to both field and laboratory ecotoxicology studies.

Learning Outcomes

Upon completion of this course, students will be able to:

1. Understand the theories of how life history traits affect contaminant exposure and explain how contaminants act at multiple levels of biological organization (individuals, populations, communities and ecosystems)
2. Critique and apply the various approaches, tools and ecological theories relevant to advanced topics in ecotoxicology
3. Apply newly learned theory and approaches to their own ecotoxicology research
4. Demonstrate advanced level critical thinking, judgement, analytical, oral and written communication skills through independent writing, discussion and collaborative work

Class Schedule and Format

Each week, the 875 class normally meets for ~2 hours to examine and critique novel and current approaches and theories of ecotoxicology in addition to specific skill development required for designing, reviewing and conducting advanced ecotoxicological research. Typically, one week will involve group discussion of a set of assigned readings that review the topic and critique specific case studies where authors have or have not incorporated the application of ecological theory. The second week of the topic will take the form of structured in class activities and computer exercises. It is expected that students come prepared for all sessions having completed the readings ahead of time and bring laptops to complete the exercises.

The BIOL 875 course is structured to run in parallel with the lecture portion only of BIOL 475: Ecological Toxicology. The undergraduate lectures (3 hrs/wk) provide a foundation in the important principles and hierarchy of Ecotoxicology with topics on contaminant fate and transport, influence of life history traits and contaminant effects on multiple levels of biological organization. The undergraduate lecture material is required only for discipline-specific students without a background in Ecotoxicology as it will establish the basis for advanced interdisciplinary topics covered throughout the graduate course. Students who have taken BIOL 475 or equivalent course in Ecotoxicology at the undergraduate or graduate level will have met the pre-requisite and are not required to attend undergraduate lectures. No course credit will be given for BIOL 475 and you do not need to register for that course.

Course schedule (beginning second week of term- see table page 5)

Week 2: Being a grad student in 2 worlds: need for integrating ecology and environmental toxicology.

Readings:

Schmitt-Jansen et al. 2008. An ecological perspective in aquatic ecotoxicology: approaches and challenges. Basic and Applied Ecology 9: 337–345

Relyea, R. and Hoverman, J. 2006. Assessing the ecology in ecotoxicology: a review and synthesis in freshwater systems. Ecology Letters 9:1157-1171

Ruden, C et al. 2017.Assessing the relevance of ecotoxicological studies for regulatory decision making. Integrated Environmental Assessment and Management. https://doi.org/10.1002/ieam.1846

Reading Activity: Identify common themes between the Ecology and Toxicology disciplines (see table 1 Clements and Rohr 2009).

Week 3 and 4: Coping with natural variability: dynamics of individual species sensitivity

Readings:

Cairns, J Jr. 1986 The myth of the most sensitive species. Bioscience 36: 670-672

Barata, C. et al. 2002. Determining genetic variability in the distribution of sensitivities to toxic stress among and within field populations of *Daphnia magna*. Environ. Sci. Technol., 36 (2002), pp. 3045-3049.

Tjalling, J. 2013. All individuals are not created equal; accounting for interindividual variation in fitting life-history responses to toxicants. ES&T 47: 1664-69.

Morrissey, C. et al. 2015. Neonicotinoid contamination of global surface waters and associated risk to aquatic invertebrates: a review. Environ International 74:291-303.

Homework: Caddis – compiling and interpreting data to create species sensitivity distribution (SSD) curves for group of species and toxicant of interest (see http://www.epa.gov/caddis/da_software_ssdmacro.html)

***Assignment 1:** Knowing your study species or community- Research the relevant life history traits of your chosen study spp or the community dynamics of multiple spp. Plot a SSD curve for the group of species and contaminant of choice and interpret your findings.

Week 5 and 6: Extrapolation from individuals to populations. Why behaviour and demographic theory are needed to conserve populations.

Readings:

Kramer, V.J. et al. 2011. Adverse outcome pathways and ecological risk assessment: bridging to population level effects. Environmental Toxicology and Chemistry 30: 64-76.

Peterson, E. et al. Integrative behavioral ecotoxicology: bringing together fields to establish new insight to behavioral ecology, toxicology and conservation. 2017. Current Zoology 63(2): 185–194.

Zala and Penn. 2004. Abnormal behaviours induced by chemical pollution: a review of the evidence and challenges. Animal behavior 68: 649-664.

Eng et al. 2019. A neonicotinoid insecticide reduces fueling and delays migration in songbirds. Science Vol. 365 (6458): 1177-1180

Activity: Independent population modeling exercise using dataset provided: Download PopTools software Excel add in. **Attend Lab 5 (Feb. 16)**

Week 7 and 8: The influence of multiple stressors and application of trait based approaches to understand effects on populations and communities.

Readings:

Verberk, W.C.E.P. 2013. Delivering on a promise: integrating species traits to transform descriptive community ecology into a predictive science. Freshwater Science 32: 531-547

Rubach MN, Baird DJ, Boerwinkel MC, Maund SJ, Roessink I, Van der Brink PJ. 2012. Species traits as predictors for intrinsic sensitivity of aquatic invertebrates to the insecticide chlorpyrifos. Ecotoxicology 21: 2088-2101

Williams, N., Crone, E., Roulston, T., Minckley, R., Packer, L., Potts, S. 2010. Ecological and life-history traits predict bee species responses to environmental disturbances. Biol Conserv. 143: 2280-2291.

***Assignment 2:** Research the origin and application of Trait based approaches in addressing community level changes (based on the Ecology and/or Ecotoxicology literature). Write an essay to describe how trait based approaches could be applied to your own research system. Review the ecotoxicology literature and provide trait data for your group of species and topic to better position your arguments.

Week 9: Indirect effects and trophic relationships: concepts, approaches and applications to ecotoxicology problems

Readings:

Clements, WH and Rohr, JR 2009. Community responses to contaminants: using basic ecological principles to predict ecotoxicological effects. Environ Toxicol Chemistry 28: 789-1800

Relyea, R. Amphibians are not ready for Roundup®. In Wildlife Ecotoxicology: Forensic Approaches. Ch.9. pp. 267-300

Activity: How can indirect effects be used in regulatory world? What are the challenges for quantifying risk based on indirect vs direct effects.

Week 10 and 11: The big picture: exploring the importance of macroecology and ecosystem service approaches to ecotoxicology.

Readings:

Beketov, MA.; Liess, M. 2012. Ecotoxicology and macroecology – Time for integration. Environmental Pollution 162: 247-254

Burton, G. A., et al. (2012), Making ecosystem reality checks the status quo. Environmental Toxicology and Chemistry, 31: 459–468.

Stanley et al. 2015. Neonicotinoid pesticide exposure impairs crop pollination services provided by bumblebees. Nature 528 (7583): 548-550

***Assignment 3:** Make an ecosystem reality checklist for your own research program. Justify what elements in your lab and field study that needs to be considered to ensure your design and conclusions are "ecologically relevant".

Week 12: Evolution in ecotoxicology- what would Darwin have to say about persistence and resistance?

Readings:

Monosson, E. 2012. Evolution of the toxic response: How might ecotoxicology benefit by considering evolution? Integrated Environmental Assessment and Management 8: 379-380

Whitehead, A. et al. 2012. Common mechanism underlies repeated evolution of extreme pollution tolerance. Proc Royal Soc B: 279: 427-433

Hamilton et al. 2017. Adaptive capabilities and fitness consequences associated with pollution exposure in fish. Phil. Trans. R. Soc. B http://doi.org/10.1098/rstb.2016.0042

Activity: How common is contaminant induced resistance? What factors are necessary to drive resistance?

BIOL 875 schedule and lecture schedule. [1]Undergraduate lecture topics are shown for reference. Attendance is *not required if exemption granted by instructor*.

Week	898 Theme	Readings 875	BIO 475 Lecture topics [1]
Week 1		see syllabus for detailed list	Intro and history of Ecotox; Role of Ecology in Ecotoxicology; Review of major principles in toxicology; Contaminant sources
Week 2	Integrating Ecology and Toxicology		Contaminant transport and fate in Ecosystems; Exposure and uptake;
Week 3	Individual Variation and Life History traits		Bioaccumulation/Bioavailability; Trophic transfer and Biomagnification; Food webs
Week 4	Continued		Scale and the Individual organism; Lethal and Sublethal Effects; Stress, Growth and Energy allocation; Behaviour;
Week 5	Population demographic models and theory		Intro to Population ecotoxicology; Epidemiology, Effects on population size and dynamics;
Week 6	Continued		Population models; Population demographics;
Week 7	Multiple stressors, trait based approaches to community ecotox		Spatial distributions of contamination; Consequences for Metapopulations;
Week 8	Continued		Intro to Community Ecotoxicology, Abiotic/Biotic factors regulating communities; Measuring community effects,
Week 9	Indirect effect case studies		Indirect effects; Disturbance and recovery from pollution; Intro ecosystem ecotoxicology
Week 10	Macroecology and ecosystem approaches		Contaminant effects on ecosystems; Landscape ecotoxicology
Week 11	Continued		Current issues in Ecotoxicology: Chemical mixtures, Multiple stressors; Climate change and contaminants
Week 12	Contaminant induced evolutionary change		Ecotoxicology in the Regulatory context;
Week 13	**Grad Student teaching lectures**		**Grad Student teaching lectures**
Date TBC	**FINAL TAKE HOME EXAM**		

Required Resources

Readings

No textbook required. Readings from primary literature provided in syllabus. Each class will have assigned homework/readings and you are expected to read in preparation for class. I will provide a set of guidance questions that will assist you to digest the material in a constructive and critical manner, to identify the main points, to contrast ideas from multiple sources, and to develop critical thinking about the topic. Students should come prepared to class and each student will be randomly asked to present on a selected paper. Keep a record of your thoughts in the Learning Log.

Supplementary reading can be drawn from Newman: Ecotoxicology: A Comprehensive Treatment (recommended) or Fundamentals of Ecotoxicology (undergraduate required). A list of suggested chapter readings can be provided upon request.

Textbooks are available from the Natural Science library on reserve or the University of Saskatchewan Bookstore: www.usask.ca/consumer_services/bookstore/textbooks

Other Required Materials

Laptop computer is required to download reading material and to complete certain assignments. They should be brought to class on dates indicated by the instructor. Downloading of free software packages will be required in advance of the class. A separate journal (notebook) is recommended to keep a "Learning Log" notes on the course. This can also be in electronic form (e.g. OneNote, Evernote).

Electronic Resources

Caddis (USEPA) http://www.epa.gov/caddis/index.html
ECOTOX (USEPA) http://cfpub.epa.gov/ecotox/
ISI Web of Science http://library.usask.ca/find/node.php?nid=137352

Downloads

PopTools http://www.poptools.org/
R http://www.r-project.org/ (optional)
Cadstat (package for R) (optional)

Grading Scheme

Assignments (3 - weighted equally)	45 %
Learning Log – Readings/Activity	20 %
Final take home exam	35 %
Total	100%

Assessments

A detailed rubric with expectations for each assignment will be developed and shared with students at the time of assigning.

Assignments 1-3

Value: 45% of final grade (approx. 15% each)
Due Date: See Course Schedule
Type: The assignments are designed to complement and extend the in class activities through research and computer exercises.

Description: Students must complete analysis of data provided, present and interpret the findings and submit a concise written report. No formal format for each report is required but direction will be offered for each assignment. The due dates are provided.

Learning Log

Value: 20% of final grade
Date: Last week of class
Type: Written journal
Description: Keep a journal of entries on the notes from your lectures, your assigned readings and your response to the guidance questions or questions posed under the week's "Activities". The learning log can be done in any format but should have the dates for all entries and contain a record of evidence to demonstrate you have completed the readings and attended lectures.

Final Written Exam (take home)

Value: 35% of final grade
Date: TBD- during final exam period
Type: Written research essay on topic provided by instructor

Description: Students will write a take home exam that consists of an essay written over 7 days. The exam will be structured as a written critique of a published paper provided by the instructor based on the material learned in the course. The final exam paper will have a word limit of 2500 words plus references. This will test your ability to integrate material learned across the course, draw from relevant literature (assigned), and express your thoughts in a clear and concise format.

Required Materials

Textbooks

No textbook required. Readings from primary literature are provided in the syllabus.

Other Required Materials

Laptop computer is required to download reading material and to complete certain assignments. They should be brought to class on dates indicated by the instructor. Downloading of free software packages will be required in advance of the class.

Electronic Resources

Caddis (USEPA) http://www.epa.gov/caddis/index.html
ECOTOX (USEPA) http://cfpub.epa.gov/ecotox/
ISI Web of Science http://library.usask.ca/find/node.php?nid=137352

Downloads

PopTools http://www.poptools.org/
R http://www.r-project.org/ (optional)
Cadstat (package for R) (optional)

Key Dates

The following table summarizes key due dates for assignments.

Week	Module	Evaluation Due Date
3-4	Assignment 1	Due 2 weeks from assigned date Jan 26; **due Feb 9**
7-8	Assignment 2	Due 2 weeks from assigned date Feb.23; **due Mar 9**
10-11	Assignment 3	Due 2 weeks from assigned date Mar 23; **due Apr 6**
13	Learning Log	April 8
	Final written exam	TBD

Submitting Assignments

All assignments should be handed in via Blackboard in PAWS before midnight on the due date. No assignment will be accepted more than 3 days past the due date without prior arrangement. A 10% penalty per day applies.

Criteria That Must Be Met to Pass

Students must submit all the assignments and exams to pass the course.

Attendance and Participation Expectations

Attendance and participation are expected for the weekly grad course meetings. Attendance of undergraduate BIOL 475 lectures is required to meet the pre-requisite unless waived by the instructor. Participation is key to your learning and you are encouraged to keep a learning log. If you are unable to attend a class due to illness or emergency, you should notify me by email and make arrangements to make up the material.

Student Feedback

I welcome student feedback throughout the course. There will be formal opportunities at the start and end of the course to offer feedback and suggestions on course design, material and delivery and topics may be modified to fit the needs of the students.

Final Examination Scheduling

The final exam scheduling is to be determined. The final exam will be delivered at a mutually agreed date after all other coursework is complete. Students are encouraged to review all examination policies and procedures:http://www.usask.ca/calendar/exams&grades/examregs/

University of Saskatchewan Grading System (for graduate courses)

The following describes the relationship between literal descriptors and percentage scores for courses in the College of Graduate Studies and Research:

90-100 Exceptional

A superior performance with consistent strong evidence of

- a comprehensive, incisive grasp of subject matter;
- an ability to make insightful, critical evaluation of information;
- an exceptional capacity for original, creative and/or logical thinking;
- an exceptional ability to organize, to analyze, to synthesize, to integrate ideas, and to express thoughts fluently;
- an exceptional ability to analyze and solve difficult problems related to subject matter.

80-89 Very Good to Excellent

A very good to excellent performance with strong evidence of

- a comprehensive grasp of subject matter;
- an ability to make sound critical evaluation of information;
- a very good to excellent capacity for original, creative and/or logical thinking;
- a very good to excellent ability to organize, to analyze, to synthesize, to integrate ideas, and to express thoughts fluently;
- a very good to excellent ability to analyze and solve difficult problems related to subject matter.

70-79 Satisfactory to Good

A satisfactory to good performance with evidence of

- a substantial knowledge of subject matter;
- a satisfactory to good understanding of the relevant issues and satisfactory to good familiarity with the relevant literature and technology;
- a satisfactory to good capacity for logical thinking;
- some capacity for original and creative thinking;
- a satisfactory to good ability to organize, to analyze, and to examine the subject matter in a critical and constructive manner;
- a satisfactory to good ability to analyze and solve moderately difficult problems.

60-69 Poor

A generally weak performance, but with some evidence of

- a basic grasp of the subject matter;
- some understanding of the basic issues;
- some familiarity with the relevant literature and techniques;
- some ability to develop solutions to moderately difficult problems related to the subject matter;
- some ability to examine the material in a critical and analytical manner.

<60 Failure
An unacceptable performance.

Program Requirements

- Percentage scores of at least 70% are required for a minimal pass performance for this course for a Ph.D. student;
- Percentage scores of at least 60% are required for a minimal pass performance for this course for a masters student
- However, to pass the MSEM program overall, the student's Cumulative Weighted Average must be at least 70%;
- Students should seek information on other program requirements in the Course & Program Catalogue and in their own home academic unit publications.

Integrity Defined (from the Office of the University Secretary)

The University of Saskatchewan is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Student Conduct & Appeals section of the University Secretary Website and avoid any behavior that could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

All students should read and be familiar with the Regulations on Academic Student Misconduct (https://secretariat.usask.ca/documents/student-conduct-appeals/StudentAcademicMisconduct.pdf) as well as the Standard of Student Conduct in Non-Academic Matters and Procedures for Resolution of Complaints and Appeals (http://www.usask.ca/secretariat/student-conduct-appeals/StudentNon-AcademicMisconduct.pdf)

For more information on what academic integrity means for students see the Student Conduct & Appeals section of the University Secretary Website at:
http://www.usask.ca/secretariat/student-conduct-appeals/index.php

Access and Equity Services (AES)

Students who have disabilities (learning, medical, physical, or mental health) are strongly encouraged to register with Access and Equity Services (AES) if they have not already done so. Students who suspect they may have disabilities should contact AES for advice and referrals. In order to access AES programs and supports, students must follow AES policy and procedures. For more information, check www.students.usask.ca/aes, or contact AES at 306-966-7273 or

aes@usask.ca.

Students registered with AES may request alternative arrangements for mid-term and final examinations.
Students must arrange such accommodations through AES by the stated deadlines. Instructors shall provide the examinations for students who are being accommodated by the deadlines established by AES.

Student Supports

Student Learning Services
Student Learning Services (SLS) offers assistance to U of S undergrad and graduate students. For information on specific services, please see the SLS web site http://library.usask.ca/studentlearning/.

Writing support
The Writing Centre offers up to 10 hours of free writing support for students as well as workshops and other materials. This is not an editorial service. For more information see https://library.usask.ca/studentlearning/writing-help/

Student and Enrolment Services Division
The Student and Enrolment Services Division (SESD) focuses on providing developmental and support services and programs to students and the university community. For more information, see the students' web site http://students.usask.ca.

Financial Support
Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact Student Central (https://students.usask.ca/student-central.php).

Aboriginal Students Centre
The Aboriginal Students Centre (ASC) is dedicated to supporting Aboriginal student academic and personal success. The centre offers personal, social, cultural and some academic supports to Métis, First Nations, and Inuit students. The centre is also dedicated to intercultural education, brining Aboriginal and non-Aboriginal students together to learn from, with and about one another in a respectful, inclusive and safe environment. Students are encouraged to visit the ASC's Facebook page (https://www.facebook.com/aboriginalstudentscentre/) to learn more.
International Student and Study Abroad Centre
The International Student and Study Abroad Centre (ISSAC) supports student success in their international education experiences at the U of S and abroad. ISSAC is here to assist all international undergraduate, graduate, exchange and English as a Second Language students and their families in their transition to the U of S and Saskatoon. ISSAC offers advising and support on all matters that affect international students and their families and on all matters related to studying abroad. Please visit students.usask.ca for more information.