

ENVIRONMENTAL SCIENCES

The School of Environmental Sciences offers program of study leading to MSc, MES, and PhD degrees. Graduate Studies in the Environmental Sciences programs are designed to train people to work independently and imaginatively with a high level of technical skill and scientific acumen. It is expected that the graduates of the SES program will provide leadership in research and training in academic, government, and industrial sectors of society and who will participate in the formulation and implementation of constructive national and international science policy.

The PhD program has three fields of specialization:

1. Earth and Atmospheric Sciences;
 2. Ecosystem Science and Biodiversity; and
 3. Plant and Environmental Health.
- Earth and Atmospheric Sciences – Research areas include: soil biology and soil physics, environmental geology, geobiology, soil chemistry, geochemistry, micrometeorology and ecohydrology, soil health and land resource management
 - Ecosystem Science and Biodiversity – Research areas include: toxicology, pest management, management of agroecosystems, microbiology, forest systems, agroforestry, climate change biology, ecology, and entomology
 - Plant & Environmental Health – Research areas include: plant biology, plant pathology, epidemiology, soil-plant interactions, biotechnology, molecular biology, forest systems, agroforestry, and climate change biology

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MSc Program

The objective of the MSc program is to develop and train graduate students that possess a high level of knowledge about the field of environmental science, expertise in specific aspects of environmental science (their thesis research focus), training in laboratory and field techniques, and excellence in writing and oral communication. With these skills, MSc students will possess a strong foundation on which they can be highly successful in science-related positions in government, industry, and consulting, or carry out high quality research at the PhD level.

Admission Requirements

The School's admission standard for the MSc program is the same as the University and requires a four-year, honours science degree with a

minimum B- (70-72%) average during the final two years (4 semesters) of full time undergraduate study. Meeting the minimum requirement (B-) does not guarantee entrance; depending on other criteria (e.g., letters of reference, standardized test scores, academic background relevant to the area to which the applicant has applied, degree of work experience in related fields of study) students may be considered for admission with provisional status. Students on provisional status must obtain a "B" average (73%) with no individual grade lower than 70% in at least two graduate courses during their first two semesters of study to continue in the program. Provisional students will be funded at the same level as regular students.

Program Requirements

The MSc thesis program requires:

- At least 1.5 graduate course credits, including one mandatory 0.50 credit course (Research Seminar in Environmental Sciences).
- Completion and defense of a thesis on research carried out under the direct supervision of a core faculty member.

The thesis and the oral defense of the thesis are evaluated on a pass/fail basis. An acceptable MSc thesis consists of a defensible account of the student's research. The project is expected to represent a well-defined research problem, or hypothesis, and should be planned such that the clarity of the underlying rationale, the appropriateness of the technical approach, the research, and the critical evaluation of the results could normally be completed and the thesis defended within six semesters.

MES Program

The MES (coursework Master's) degree enables students to study the most recent theoretical and technical advances in the environmental sciences through multidisciplinary teaching and research. There are two options to the MES in Environmental Sciences: by coursework + research project and by coursework-only. The MES will promote critical thinking and enhance oral and written communication skills so that graduates can excel in industry, government and other sectors of civil society (e.g., environmental risk assessors/managers, political advisors on policy/law issues in government, senior positions in national and international agencies, etc.).

Admission Requirements

The School's admission standard for the MES program is the same as the University and requires a four-year, honours science degree with a minimum B- (70-72%) average during the final two years (4 semesters) of full time undergraduate study. Meeting the minimum requirement (B-) does not guarantee entrance; depending on other criteria (e.g., letters of reference, standardized test scores, academic background relevant to the area to which the applicant has applied, degree of work experience in related fields of study) students may be considered for admission with provisional status. Students on provisional status must obtain a "B" average (70%) in at least two graduate courses during their first semester of study to continue in the program.

MES Program Requirements

Course Work and Major Research Project (MRP)

Candidates must complete a minimum of 4.0 credits:

Code	Title	Credits
ENVS*6500	Environmental Sciences Research Project	1.00
ENVS*6501	Integrating Science and Policy in Environmental Science	0.50

ENVS*6502	Seminar in Environmental Science	0.50
Two additional credits from Environmental Sciences courses		2.00

The research project may be completed at the University or as part of a placement with an approved non-academic agency. The project may include analysis of a data set (derived from lab, field, or computer simulation) related to the specialization chosen by the student including analyses and interpretations of relevant data (the student may or may not be involved in collecting the data), or major, critical literature review. The outcome of the research project will be a written report and a seminar presented to the department.

Course Work

Candidates must complete a minimum of 4.0 credits

Code	Title	Credits
ENVS*6501	Integrating Science and Policy in Environmental Science	0.50
ENVS*6502	Seminar in Environmental Science	0.50
Three additional credits from Environmental Sciences courses		3.00

Students in either option may select courses from other departments on campus but are advised that access may be restricted and permission may be required by course instructors. A maximum of 1.0 credits may be taken from senior undergraduate courses, with permission of the Graduate Coordinator.

PhD Program

The PhD is offered in the following fields:

1. earth and atmospheric sciences;
2. ecosystems science and biodiversity; and
3. plant and environmental health.

The objectives of the PhD program are to develop highly competent, independent, creative, and critical scientists. Doctoral students of the SES graduate program will provide leadership as scholars in academic institutions, as managers and officers in the industrial research and development sector, research and policy branches within the government sector and in other social institutions. Research in the PhD program is expected to be original and novel, contribute significantly to the relevant research field, and published in high-quality peer-reviewed journals.

Admission Requirements

Admission to the PhD program is generally restricted to students with a recognized MSc degree in a related field obtained with a minimum academic standing of "A-" ($\geq 80\%$) in their postgraduate studies. Students who meet the minimum University requirement (73-76%) but not the School requirement ($\geq 80\%$) may be considered depending on other criteria (e.g., letters of reference, standardized test scores, academic background relevant to the area to which the applicant has applied, degree of work experience in related field of study) for admission with provisional status. Students on provisional status must obtain an "A-" ($\geq 80\%$) and no individual mark below 80% average in at least two graduate courses during their first two semesters of study to continue in the program. Provisional students will be funded at the same level as regular students. In exceptional cases, students may enter the PhD program directly from a BSc (Hons) if they have the minimum requirements as defined by the Office of Studies, University of Guelph.

Program Requirements

The PhD program requires:

- Completion of one mandatory 0.50 credit course (Research Seminar in Environmental Sciences).
- Successful completion of a qualifying exam within five semesters of first registration in the program
- Successful defense of a thesis describing original research, carried out under the direct supervision of a core faculty member.

In the PhD program, the qualifying exam, thesis and the oral defense of the thesis are evaluated on a pass/fail basis. An acceptable PhD thesis consists of an authoritative report of the student's research. The project is expected to represent a well-defined research problem, or hypothesis, and should be planned such that the research could normally be completed and the thesis defended in nine semesters (12 semesters for those students transferring from the MSc program). The research described in the thesis must represent a significant contribution to knowledge in that field. Emphasis is therefore placed on the quality of the presentation, maturity in scholarship, breadth and depth of the work, and critical judgement. Successful completion of the PhD thesis occurs when the research is judged to be sufficiently meritorious to warrant publication in reputable, peer-reviewed journals in its field. PhD students are normally expected to have published, or have "in-press", one or more papers in peer-reviewed journals prior to the defense. In cases involving intellectual property, it is recognized that publication may not always be immediately possible. In such cases, a Pass will require that the committee is satisfied that, in their opinion, the work is of sufficient quality and originality that it would meet the standards for peer-reviewed publications.

Collaborative Specializations

International Development Studies

The School of Environmental Sciences participates in the MSc collaborative specialization in International Development Studies. Please consult the International Development Studies listing for a detailed description of this collaborative specialization.

One Health

The School of Environmental Sciences participates in the collaborative specialization in One Health. Master's and Doctoral students wishing to undertake thesis research or their major research paper/project with an emphasis on one health are eligible to apply to register concurrently in Environmental Sciences and the collaborative specialization. Students should consult the One Health (calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/one-health/) listing for more information.

Toxicology

The School of Environmental Sciences participates in the masters/doctoral collaborative specialization in toxicology. The faculty members' research and teaching expertise includes aspects of toxicology; they may serve as advisors for MSc and PhD students. Please consult the Toxicology (calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/toxicology/) listing for a detailed description of the masters/doctoral collaborative specialization.

Courses

ENVS*6000 Physical Environment of Crops and Forests Fall Only [0.50]

Recent literature on temperature, humidity, radiation, wind, gases and particles in crop and forest environments; evapotranspiration and photosynthesis of plant communities; modification of microclimates; applied micrometeorology.

Offering(s): Offered in even-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6040 Molecular Basis of Plant-Microbe Interactions Fall Only [0.50]

A lecture and seminar course on recent advances in the study of plant-microbe interactions. Topics included are the biochemical, physiological and genetic aspects of plant defenses and the interaction of plants with pathogenic and mutualistic bacteria, fungi and viruses. Offered in conjunction with PBIO*4000. Extra work is required of graduate students.

Restriction(s): Credit may be obtained for only one of ENVS*6040 or PBIO*4000.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6050 Micrometeorology Winter Only [0.50]

Exchanges of mass, momentum and energy between the surface and the atmosphere will be studied in the context of larger-scale meteorology. Diffusion and turbulence in and above plant canopies will be examined from theoretical and practical perspectives. Topics include time-series analysis, micrometeorological measurement theory, and basic principles of atmospheric science.

Offering(s): Offered in even-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6060 Meteorological Instrumentation Winter Only [0.50]

Theoretical and practical aspects of electronic circuits, sensors, and equipment used in meteorological research.

Prerequisite(s): ENVS*4210

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6190 Environmental Microbial Technology Unspecified [0.50]

Current topics in selected areas of environmental microbial technology. An emphasis will be placed on the physiology and genetics of microorganisms useful in environmental biotechnology. The course involves extensive use of current journal articles. An undergraduate degree in microbiology or related discipline is recommended prior to registering in this course.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6242 Topics in Atmospheric Science Summer, Fall, and Winter [0.50]

Students will explore topics within atmospheric science such as climatology, animal biometeorology, air pollution meteorology, and hydrometeorology. Normally, an independent course of study will be developed with a faculty advisor and one or more students in the semester prior to enrollment. Occasionally, the course will be offered as a lecture/seminar in a particular area, to be advertised in the semester prior to offering. Typically, students will produce a major paper or scientific report.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6280 Soil Physics Winter Only [0.50]

The soil as a physical system with special regard to soil water movement and the diffusion and dispersion of chemical substances. Numerical techniques and computer solutions will be developed.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6300 Quantitative Pedology Fall Only [0.50]

Pedology considers the morphology, survey, geography, characterization and analysis, development, classification, and interpretation of soil.

This course focuses on the quantification of pedology, employing modern digital instrumentation, computational capacity and analytical strategies. Students explore how such multi-scale, spatial-temporal information is used in critical zone modeling. Students should have at least an introductory soil, ecology or physical geography course. Students with only an introductory level soil course are encouraged to audit ENVS*4390.

Restriction(s): Cannot take if credit received for ENVS*6250.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6340 Colloquium in Insect Systematics Winter Only [0.25]

Weekly discussions and seminars dealing with current topics in systematic entomology.

Offering(s): Offered in odd-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6350 Soil Organic Matter and Biochemistry Fall Only [0.50]

(1) Soil organic matter characterization, (2) dynamics of soil organic matter, (0.5) nutrient cycling.

Offering(s): Offered in odd-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6360 Soil and Water Chemistry Fall Only [0.50]

Thermodynamics of soil solutions; solution-solid phase equilibria; reaction kinetics; computer modelling of solute-mineral interactions.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6400 Soil Nitrogen Fertility and Crop Production Winter Only [0.50]

Emphasis will be placed on soil N transformations and processes, and N sources for crops; field experimentation methods; environmental issues.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6440 Field Sampling Strategies and Geostatistics Winter Only [0.50]

Concepts and practical aspects of collecting, synthesizing and interpreting data from spatially and temporally variable and/or correlated fields. Hands-on experience in describing spatial structure of large data sets (supplied by student or instructor) using available software.

Offering(s): Offered in even-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6450 Multivariate Environmental Data Analysis Winter Only [0.50]

This course will examine the application of statistical techniques to analyzing multivariate environmental data. Methods will include Ordination (e.g., Principal Components Analysis, NDMS), Multivariate Regression (e.g., Partial Least Squares Regression), and Structural Equation Modelling. Emphasis will be placed on peer and collaborative learning through discussion, and comparative application of analyses to multivariate environmental data. Students should have at least one undergraduate course in statistics.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6452 Special Topics in Ecosystem Science and Biodiversity Summer, Fall, and Winter [0.50]

Students will explore topics within ecosystem science such as terrestrial ecology, forest science, aquatic systems and environmental biology. Normally, an independent course of study will be developed with a faculty advisor and one or more students in the semester prior to enrollment. Occasionally, the course will be offered as a lecture/seminar in a particular area, to be advertised in the semester prior to offering. Typically, students will produce a major paper or scientific report.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6460 Environmental Remediation Winter Only [0.50]

This course will discuss environmental remediation topics including, but not limited to, using plants, microorganisms and substrates (e.g., soil and engineered materials) to improve air, water and soil quality. For example, this course will explore the current sciences and technologies of living walls to improve indoor air quality, green roofs to manage storm water and air pollutants, and constructed wetlands to treat wastewater. Environmental remediation is, by nature, multidisciplinary, involving chemistry, physics, biology, engineering, landscape design, etc.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6470 The Science and Management of Multiple Stressors in the Great Lakes Fall Only [0.50]

In this two-week lecture-field course, students will learn about historical and current environmental issues affecting the Great Lakes basin from the perspective of multiple stressors and their cumulative impacts. The importance of linking science and policy, and the role important of governments, are emphasized.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6500 Environmental Sciences Research Project Unspecified [1.00]

A concise, critical review of an area of study related to the field chosen by the student including analyses and interpretation of relevant data. The project will be written in the form of a scientific paper and presented to the department as a seminar.

Restriction(s): Restricted to Master of Environmental Science students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6501 Integrating Science and Policy in Environmental Science Fall Only [0.50]

A case-study approach, based on current and historical issues, and involving presentations from faculty, professionals and students, will be used to develop an advanced understanding of current issues in the environmental sciences, including examination of the underlying science and management of the issues, and the effectiveness of associated policies.

Restriction(s): Restricted to Master of Environmental Science students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6502 Seminar in Environmental Science Winter Only [0.50]

This course will provide an interactive and critical forum for students to participate in an advanced discussion and debate on current environmental issues, and to learn about the practical skill set(s) required by various employment sectors in solving these issues.

Restriction(s): Restricted to Master of Environmental Science students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6503 Biogeochemistry of Wetlands Landscapes Landscapes Fall Only [0.50]

This course is focused on the role of wetlands in maintaining healthy ecosystems and in controlling contaminant fluxes to water. Lectures complement field and laboratory assessments of wetlands to understand element biogeochemical cycles in these transitional environments. The course includes field trips to Ontario wetlands.

Prerequisite(s): BIOL*1020 BIOL*1070 CHEM*1040 CHEM*1070 and PHYS*1070 or PHYS*1080

Restriction(s): Restricted to Environmental Sciences students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6505 Soil Survey and Interpretation Summer Only [0.50]

Students will learn concepts, techniques and analysis related to the characterization of soil in the landscape. Focus will be given to soils encountered in southern Ontario. Course involves multiple field excursions to examine the distribution of soils in this region.

Restriction(s): Restricted to Environmental Sciences students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6506 Forest Ecosystem Patterns and Processes Summer Only [0.50]

Students will learn concepts, techniques and analysis related to the ecological characterization of forests. Focus will be on southern and mid-central Ontario forests and will involve periodic excursions to various locations for the purpose of demonstrating theoretical principles, sampling techniques, in-field measurements, and collecting samples for in-lab assessment.

Restriction(s): Restricted to Environmental Sciences students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6520 Pollinator Biology Fall Only [0.50]

The biology of pollinators will be discussed in lectures and seminars stressing fundamental and applied aspects. The honey bee will be used as the model system.

Offering(s): Offered in odd-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6530 Pollinator Conservation Winter Only [0.50]

In this course students will explore the ecology of pollination with an emphasis on the factors affecting declines in pollinating insects as well as potential mitigation strategies to ensure long-term stability of food production and maintenance of biodiverse wild plant communities. Offered in conjunction with ENVS*4070. Extra work is required of graduate students.

Restriction(s): Credit may be obtained for only one of ENVS*6530 or ENVS*4070.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6540 Integrated Pest Management: Insects Winter Only [0.50]

Concepts associated with integrated pest management of insect pests of various plant hosts will be introduced to students in an interactive lecture and laboratory format. Experiential learning and skill development, associated with economic entomology, will also be emphasized. Offered in conjunction with ENVS*4100. Extra work is required of graduate students.

Offering(s): Offered annually

Restriction(s): Credit may be obtained for only one of ENVS*6540 and ENVS*4100

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6550 Bioactivity and Metabolism of Insecticides Winter Only [0.50]

The basis of insecticide bioactivity will be examined, with emphasis on mode of action, structure-activity relationships and analytical methods. Students will choose a specific insecticide or class of insecticides as their primary topic of study for the semester. Students will participate in seminars, prepare a conference poster and complete a research paper.

Offering(s): Offered in even-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6560 Forest Ecosystem Dynamics Fall Only [0.50]

An exploration of energy flow and distribution in forest ecosystems. Both components will be examined in the context of biomass and productivity, perturbations and resilience. Some aspects of modelling will be covered.

Offering(s): Offered in odd-numbered years.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6582 Special Topics in Soil Science Summer, Fall, and Winter [0.50]

Students will explore topics within soil science such as soil physics, pedology, soil chemistry and microbiology. Normally, an independent course of study will be developed with a faculty advisor and one or more students in the semester prior to enrollment. Occasionally, the course will be offered as a lecture/seminar in a particular area, to be advertised in the semester prior to offering. Typically, students will produce a major paper or scientific report.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6720 Geology of Groundwater Systems Winter Only [0.50]

This course will examine the geological characteristics and processes that influence groundwater flow systems and contaminant transport and fate in different geological settings. The course will include seminar discussions of readings, guest speakers from industry and government agencies as well as hands-on exercises in class.

Offering(s): Offered in alternate years

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6730 Special Topics in Environmental Earth Science Summer, Fall, and Winter [0.50]

Students will explore topics within environmental earth science such as glacial geology, environmental geophysics and hydrogeology. Normally, an independent course of study will be developed with a faculty advisor and one or more students in the semester prior to enrollment. Occasionally, the course will be offered as a lecture/seminar in a particular area, to be advertised in the semester prior to offering. Typically, students will produce a major paper or scientific report.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6740 Environmental Organic Chemistry Winter Only [0.50]

This course explores the chemical processes that influence organic compounds in the environment. Topics discussed include: the transformation of anthropogenic organic contaminants, the form and function of natural organic matter, and analytical methods including compound specific stable isotope analysis and environmental nuclear magnetic resonance. Offered in conjunction with ENVS*4370. Extra work is required of graduate students.

Restriction(s): Credit may be obtained for only one of ENVS*6740 or ENVS*4370. Restricted to Environmental Sciences students.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6882 Special Topics in Plant and Environmental Health Summer, Fall, and Winter [0.50]

Students will explore topics within plant and environmental health such as integrated pest management, apiculture and environmental microbiology. Normally, an independent course of study will be developed with a faculty advisor and one or more students in the semester prior to enrollment. Occasionally, the course will be offered as a lecture/seminar in a particular area, to be advertised in the semester prior to offering. Typically, students will produce a major paper or scientific report.

Restriction(s): Instructor consent required.

Department(s): School of Environmental Sciences

Location(s): Guelph

ENVS*6900 Research Seminar in Environmental Sciences Fall and Winter Reg Required [0.50]

This course provides information and training in scientific presentations for thesis-based Environmental Sciences (ENVS) programs. Students will prepare a written research proposal and make an oral presentation of their proposed studies. Students are expected to complete this course in their second or third semester of study.

Restriction(s): Restricted to Environmental Sciences MSc and PhD students.

Department(s): School of Environmental Sciences

Location(s): Guelph