Agroecosystems Science Graduate Specialization

Scientists studying agroecosystems need the analytical tools to understand complex systems, and measure variation over large spatial extents and long time frames. A growing number of graduate school candidates are interested in approaching agricultural science from an agroecosystems perspective, stemming from interest in such topics as food systems, sustainability, adaptation of agriculture to climate change, and systems approaches to maintaining environmental quality. Agroecosystems function as a combination of people and the land. Therefore, research on agroecosystems is interdisciplinary and, consistent with the goals of the ESGP, requires ability to bridge the social and natural sciences. The Agroecosystems Management Program (AMP) is an interdisciplinary research program hosted by the Ohio Agricultural Research and Development Center. It was founded in the early 1990's by a group of faculty that spanned the physical, biological and social sciences. Based on their innovative approaches to research, education, and outreach associated with agroecosystems management, the program was endowed by the W. K. Kellogg Foundation in 1998, and the first Kellogg Chair in the US followed that appointment. This specialization will provide a pathway for ESGP students to become integrated more effectively into AMP's ongoing research and outreach efforts.

Examples of the cutting edge themes addressed by this specialization include:

Local food system development, food system assessment and sustainability – Over $2.5 million in federal and foundation grants have been received by AMP faculty in the past few years in the area of building local economies around food and agriculture.

Watershed ecology and participatory water quality management programs – the Sugar Creek Project has been enormously successful in attracting major research funding, a NSF GK12 training grant, and community-based approaches to creating new incentives for water quality improvement.

Renewable energy from agroecosystems – Research is needed to develop a rational approach to using open space found in agroecosystems for capturing wind and solar energy, and for converting biomass from agroecosystems to materials and energy in sustainable ways.

Sustainability science and policy – Based on the success of AMP, the W. K. Kellogg Foundation has established nine additional Kellogg Chairs throughout the US, and a new endowed network of these Chairs and other scholars from throughout the land grant system (INFAS, the Inter-institutional Network for Food, Agriculture and Sustainability) is currently developing a national research and research-driven policy agenda for sustainability in agriculture and food systems.

Relationship between the specialization and core requirements of ESGP

For all ESGP specializations, students must complete the requirements for both ESGP and the specialization. The purpose of specializations is to meet the needs of students with common, identifiable interests within the broad arena of environmental sciences and provide formal recognition for developing a particular area of expertise. The ESGP core courses are selected to be broadly applicable to any student in ESGP. Some, but certainly not all, of these courses may be relevant to a given specialization. We expect overlap but not exact correspondence between the ESGP core requirements, and how they are organized, and the specialization objectives and requirements.

Eligibility for the specialization in Agroecosystems Science in ESGP

Any student admitted to ESGP is eligible to pursue the specialization in Agroecosystems Science. Requirements for admission to the specialization course of study, therefore, are 1.) consent of the student's advisor, and 2.) completion of the specialization coursework requirements as outlined in this document. The Specialization in Agroecosystem Science Plan of Study form, signed by the student, advisor, and specialization subcommittee chair (appointed by the ESGP Director for each specialization) will be required to document completion of the requirements.

Objectives for the specialization in Agroecosystems Science

Objective 1
Students will develop a set of **Analytical Skills and Engineering** expertise that are needed to address the measurement and analysis of variation and change in agroecosystems, including their biological, physical, social and economic dimensions.

Objective 2
Students will develop an understanding of ecology, in terms of the relationship among species and between the biological and physical components of ecosystems, consistent with the core biology and physical sciences subject areas of ESGP. In particular, however, students in the specialization in Agroecosystems Science must demonstrate understanding of these ecological concepts through coursework that relates specifically to agriculture and food systems.

Objective 3
Students will develop an understanding of social, economic and political relationships that impact the functioning of agricultural ecosystems. This requirement will be met by requiring social science coursework that either relates specifically to agriculture and food systems or develops understanding and capabilities in the social sciences that are particularly important in addressing social, economic and policy issues in agriculture and food systems.

Specialization Subcommittee and Core Faculty Members
The specialization in Agroecosystems Science subcommittee of the ESGP Graduate Studies Committee currently consists of Casey Hoy (subcommittee chair, Entomology and Agroecosystems Management Program), John Cardina (Horticulture and Crop Sciences), Jay Martin (Food, Agricultural and Biological Engineering), and Richard Moore (School of Environment and Natural Resources).

Additional collaborating faculty include
Biological Sciences: Richard Dick, Charles Goebel, Susan Fisher, Parwinder Grewal, Brian McSpadden-Gardner, Alison Snow, Li Zhang

Physical Sciences and Engineering: Jay Martin, Steve Gordon, Karen Mancl, Fred Michel Social Sciences: Joe Heimlich, Elena Irwin, Tom Koontz, Brent Sohngen

Required and Optional Coursework
Coursework is organized according to the three specific objectives described above for the specialization in Agroecosystems Science. The required coursework in each of these areas is outlined below. Courses marked in **BOLD** may also satisfy core requirements of the ESGP. Depending upon the student's choices, a PhD student pursuing the specialization in Agroecosystems Science in ESGP could take as few as 25 required credit hours to achieve both the ESGP and specialization requirements (18 credit hours that satisfy both ESGP core and specialization requirements plus 2 ESGP seminar credits plus 5 credit hours in GIS and special topics that are unique to the specialization) or as many as 43 credit hours (18 credit hours that satisfy ESGP core requirements plus 23 credit hours of non-ESGP core courses for the specialization plus 2 ESGP seminar credits). Regardless, 37 to 55 of the student's 80 required credits will be electives selected by the student, advisor, and advisory committee.
Consistent with ESGP policy, courses taken to satisfy the requirements of a specialization in Agroecosystems Science during a student's MS will not count toward the requirements for an Agroecosystems Science specialization during the PhD, with the exception of GEOG 5220 Fundamentals of Geographic Information Systems, which will be required for either degree and once taken will count for either or both.

Objective 1: Analytical and Engineering Skills for Agroecosystem Analysis

Required of all students:

- GEOG 5220 - Fundamentals of Geographic Information Systems G 3

Choose at least 3 (MS) or 6 (Ph. D.) credits from the following:

- AEDECON 6120 - Applied Quantitative Methods II G 4
- AEDECON 7120 - Advanced Quantitative Methods II G 3
- AEDECON 7130 - Advanced Quantitative Methods III G 3
- CIVILEN 5420 - Remote Sensing of Environment G 3
- CIVILEN 5421 - Spatial Analysis Techniques for Civil Engineering G 3
- ENVENG 7217 - Applied Mathematical Ecology G 4
- **ENR 5225 - Ecosystem Modeling G 3 (ESGP Core: Biological Science)**
- FABENG 3510 - Introduction to Biological Engineering U G 4
- **FABENG 5320 - Agroecosystems G 3 (ESGP Core: Physical Science)**
- **FABENG 5180 - Ecological Engineering and Science G 4 (ESGP Core: Physical Science)**

Objective 2: Biological and Physical Sciences Related to Agricultural Ecology

Choose at least 3 (MS) or 6 (Ph. D.) credits of the following:

- **EEOB 5470 - Community and Ecosystem Ecology G 3 (ESGP Core: Biological Science)**
- **HCS 5602 - The Ecology of Agriculture G 3 (ESGP Core: Biological Science)**
- **ENR 5263 - Biology of Soil Ecosystems G 3 (ESGP Core: Biological Science)**
- **EARTHSC 5651 – Hydrogeology G 4 (ESGP Core: Physical Science)**
- ENR 7700 - Watershed Ecology and Restoration G 3

Objective 3: Social Sciences and Policy Important in Agroecosystem Function and Change

Choose at least 3 (MS) or 6 (Ph. D.) credits of the following:

- **AEDECON 5330 - Benefit-Cost Analysis G 3 (ESGP Core: Social Science)**
- AEDECON 7320 - Advanced Resource Economics G 2
- AEDECON 7410 - Advanced Regional Economics G 2
- **CRPLAN 6410 - Planning for Sustainable Development G 3 (ESGP Core: Social Science)**
- **ENR 8350 - Ecosystem Management Policy G 3 (ESGP Core: Social Science)**
- ENR 8400 - Human Dimensions of Ecosystems Management G 2
- **RURLSOC 5530 - Sociology of Agriculture and Food Systems G 3 (ESGP Core: Social Science)**
- RURLSOC 7600 - Concepts and Theories in Rural Sociology G 3
- **RURLSOC 7560 - Environmental Sociology G 3 (ESGP Core: Social Science)**

Special topics

Seminars, studios and group studies courses are offered regularly by faculty participating in the Agroecosystems Management Program, allowing students to focus on key topics in Agroecosystems Science, work in interdisciplinary teams, and partner with stakeholders on real-life case studies. At least 2 credit hours are required in special topics courses related to the specialization in Agroecosystem Science for both the MS and Ph. D. degrees (e.g. Entomol 7890, ENR 8890.03, EEOB 8896.04, etc). These courses will be approved for credit by the specialization subcommittee.

Total ESGP core course options for the specialization:

Biological Sciences - 4; Physical Sciences and Engineering - 3; Social Sciences - 5

Climate Change Science and Policy Graduate Specialization

Global climate change is among the most pressing issues we face today, with broad science and policy implications. Climate change is likely to have a large number of critical impacts including on water resources, agriculture, energy production, public health, poverty and development, biodiversity, and natural ecosystems and the services they provide. Research scientists studying climate change science and policy need the analytical tools to understand the causes and consequences of climate change, as well as the communication skills to effective advise policymakers and stakeholders. A growing number of graduate school candidates are interested in approaching global climate change from an integrated systems perspective, stemming from interest in such topics as sustainability of coupled human-natural systems, agroecology and food security, the linkages between water and climate (including polar and mountain ice), complexity and systems theory, and risk analysis. Research on climate change at both the scientific and policy-making level inherently requires an interdisciplinary approach that bridges the gap between social and natural sciences, and is consistent with climate change as a specialization within ESGP. The climate science designation is broadly interdisciplinary and many disciplines contribute to the specialization across multiple colleges.

Examples for the cutting-edge themes addressed by this specialization?

Examples of cutting edge themes addressed by the climate change specialization program include: the global water cycle including causes and consequences of sea level rise, and sustainability of water resources; the global energy economy, including conventional and alternative energy sources, technology, and policy; and rapid climate change including changes in the mean and variation in temperature and precipitation and their effects on managed and natural ecosystems, including biodiversity and agroecosystems.

Relationship between the specialization and core requirements of ESGP

For all ESGP specializations, students must complete the requirements for both ESGP and the specialization. The purpose of specializations is to meet the needs of students with common, identifiable interests within the broad arena of environmental sciences and provide formal recognition for developing a particular area of expertise. The ESGP core courses are selected to be broadly applicable to any student in ESGP. Some, but certainly not all, of these courses may be relevant to a given specialization. We expect overlap but not exact correspondence between the ESGP core requirements, and how they are organized, and the specialization objectives and requirements.

How does this specialization promote an interdisciplinary cluster?

The study of global climate change requires integration of numerous physical, biological, and social sciences. Topics addressed by OSU scientists include, but are not limited to, melting of mountain ice, adaptation of agricultural practices to changing temperature and precipitation patterns, effects of climate change on ecological interactions in managed and natural ecosystems, carbon sequestration in agricultural and forested ecosystems, dynamics of glacial and polar ice sheets, sea level rise and storm surge, atmospheric aerosol and ocean surface chemistry, and economic implications of climate change policy. Interdisciplinary centers at Ohio State such as the Byrd Polar Research Center and the Carbon Management and Sequestration Center are internationally recognized centers of climate change research. The addition of the proposed ESGP specialization would complement this interdisciplinary research with enhanced opportunities for integrative teaching and trainee mentorship.

Eligibility for the specialization in Climate Change Science and Policy in ESGP

Any student admitted to ESGP is eligible to pursue the Specialization in Climate Change Science and Policy. Requirements for admission to the specialization course of study are 1) consent of the student's advisor, and 2)

completion of the specialization coursework requirements as outlined in this document. The Specialization in Climate Change Science and Policy Plan of Study form, signed by the student, advisor, and specialization subcommittee chair (appointed by the ESGP Director for each specialization) will be required to document completion of the requirements.

Objectives for the Specialization

1. Provide students with a working understanding of natural science behind the physical drivers of climate change including anthropogenic and natural contributions to long-term and recent climate change, regional impacts on temperature and precipitation patterns, as well as the scientific basis of future climate projections.
2. Provide students with a working understanding of ecological and environmental impacts of global climate change (and associated feedbacks) including effects on ice fields, sea level and water resources, and responses of aquatic, marine, and terrestrial ecosystems (including global food production).
3. Provide students with a working understanding of global climate change policy initiatives and implications and cost:benefit analyses including economic impacts, public health, the energy economy, food security, and climate change mitigation and adaptation strategies.

The specialization objectives are designed to align closely with the three existing ESGP curriculum focus areas: Biological Sciences, Physical Science and Engineering, and Social Sciences and Policy.

Specialization Subcommittee and Core Faculty Members

The specialization in Climate Change Science and Policy subcommittee of the ESGP Graduate Studies Committee currently consists of Dan Herms (subcommittee chair, Entomology), J. Mac Crawford (Environmental Health Sciences, Public Health), Peter Curtis (Evolution, Ecology and Organismal Biology), Rattan Lal (School of Environment and Natural Resources), Jialin Lin (Geography), Bryan Mark (Geography), Richard Moore (School of Environment and Natural Resources), and Brent Sohngen (Agricultural, Environmental and Developmental Economics).

Additional collaborating faculty may include the 20 other ESGP faculty with a research interest in climate change (see Appendix).

Required and Optional Coursework

Students must comply with all ESGP and graduate school requirements, including the ESGP core area course requirements, which may overlap with the specialization courses.

In order to earn a Climate Change Science and Policy specialization, students must take courses from the three specialization objectives, which roughly align with the ESGP core areas.

- MS students: Take a total of three credits from each of the three objectives below.
- PhD students: Take a total of six credits from each of the three objectives below.
- Both: In addition to the courses above, take at least two credits of special topics.*

*Special topics: Seminars, studios and group studies courses are offered regularly by faculty participating in the Climate Change Science and Policy Specialization, allowing students to focus on key topics in Climate Change Science and Policy, work in interdisciplinary teams, and partner with stakeholders on real-life case studies. At least two credit hours are required in climate change-related special topics courses for both the MS and Ph. D. degrees, to be approved via the Specialization in Climate Change Science and Policy Plan of Study form.

ESGP core course options among the Specialization courses:

These courses may count both toward the ESGP degree as well as the Climate Change Science and Policy specialization

- Biological Sciences: 1
- Physical Sciences and Engineering: 3
- Social Sciences: 2

Consistent with ESGP policy, courses taken to satisfy the requirements of a Specialization in Climate Change Science and Policy during a student's MS will not count toward the requirements for a specialization in Climate Change Science and Policy during the PhD.

Program Objective 1

Provide students with a working understanding of natural science behind the physical drivers of climate change including anthropogenic and natural contributions to long-term and recent climate change, including regional impacts on temperature and precipitation patterns, as well as the scientific basis of future climate projections.

ATMOSSC 5901 G 3
Climate System Modeling: Basics and Applications
An examination of climate system modeling, including their component atmospheric, oceanic, sea ice and land surface models, and their coupling, and their applications. Prereq or concur: 2940, 230, Geog 5900, or 520; or permission of instructor. Not open to students with credit for 629.

GEOG 5900 G 3 ESGP Core: Physical Science
Climatology
The elements and the controls of climate; types of climate and their distribution; climates and their effects on the economic and other activities of humans. Prereq: Not open to students with credit for 520 or AtmosSc 2940 (230).

GEOG 8902 G 3
Applied Climatology
Analysis of climatic and environmental change on various time scales; human impact on climate; theory and application of long-range and climate forecasting. Prereq: 5941 (623.01) or permission of instructor. Not open to students with credit for 823.

EARTHSC 5627 G 3
Global Biogeochemical Cycles
Examination of processes influencing the cycling of major elements in the environment: anthropogenic alteration of these cycles (e.g. nutrient addition, acid rain, greenhouse gases). Prereq: EarthSc 5621 (EarthSci 621) or GeolSci 621, or permission of instructor. Not open to students with credit for EarthSci 627 or GeolSci 627.

EARTHSC 6750 G 4
Paleoclimatology
Examination of climate records in ice, lake, and marine cores, tree rings, corals and historical records for a global perspective of Quaternary climate change. Prereq: Grad standing or permission of instructor. Not open to students with credit for EarthSci 750 or GeolSci 750.

ATMOSSC 5950 G 3
Atmospheric Thermodynamics
An analysis of the fundamentals of atmospheric thermodynamics and their application to meteorological problems. Prereq: Math 1152 (153). Not open to students with credit for 631.

CHEM 6550 G 3 ESGP Core: Physical Science
Atmospheric Chemistry
Chemistry of the lower atmosphere, including air pollution and climate change, chemistry and kinetics of atmospheric oxidants, heterogeneous chemical mechanisms, tropospheric and stratospheric gas and particulate

phases relative to ozone depletion. 231 or 251 recommended. Prereq: 1220 (123), 1620, 1920H, or equiv, and 4200, 4300, or equiv. Not open to students with credit for 641.

Program Objective 2

Provide students with a working understanding of ecological and environmental impacts of global climate change (and their feedbacks) including effects on ice fields, sea level and water resources, and responses of aquatic, marine, and terrestrial ecosystems (including agroecosystems and food production).

EARTHSC 5203/ PUBHLTH 5203 G 3
Geo-environment and Human Health
Examine geo-environmental processes that are contributing to human health degradation and the resultant societal impacts. Prereq: EarthSc 2245 (EarthSci 245), or GE or GEC data anly course or equivalent; Soph standing and above, or permission of instructor.

PUBHEHS 5320 G 3
Climate Change and Human Health
Recognize current controversies about climate change, summarize the evidence about climate change on human health, and identify major human diseases associated with climate change. Prereq: Not open to students with credit for 794.

EARTHSC 5663 G 4
Global Change and Sustainability in the Earth System
Analysis of Earth systems, global environmental change and options for sustainability. Prereq: Sr or Grad standing, or permission of instructor. Not open to students with credit for EarthSci 663 or GeolSci 663.

ENR 8710 G 2 ESGP Core: Physical Science
Soils and Climate Change
Soil processes, abrupt climate change, trace gases and their properties, global C cycle, gaseous emissions, C-neutral fuels, carbon sequestration, Kyoto Treaty, trading of C credits. Sp Sem. Prereq: Grad standing. Not open to students with credit for 871.

EARTHSC 5650 G 4
Glaciology
The fundamental processes controlling ice flow, glacier mass balance and the interaction of glaciers and ice sheets with the solid earth, ocean and atmosphere. Observational and computational methods are also addressed. Prereq: EarthSci 4450 (EarthSci 450) or permission of instructor. Not open to students with credit for EarthSci 650 or GeolSci 650.

EEOB 5470 G 3 ESGP Core: Biological Sciences
Community and Ecosystem Ecology
A quantitative and descriptive approach to the establishment, development, succession, and dynamics of communities and their interrelations with historic, climatic, soil, and biotic factors. Prereq: 3410, or Grad standing. Not open to students with credit for 700 or 720.

Program Objective 3

Provide students with a working understanding of global climate change policy initiatives and implications, cost:benefit analyses including economic impacts, public health, the energy economy, food security, and climate change mitigation and adaptation strategies.

AEDECON 4320/ INTSTDS 4320 U 3
Energy, the Environment, and the Economy
Examines the economics of implications of climate change and climate change policies for society including discussion of major state, federal, and international legislation. Prereq: 2001 (200) or Econ 2001 (200). Not open to students with credit for 565 or IntStds 4320 (565).

ENR 7380 G 3 ESGP Core: Social Science
Climate and Society
Examines links between climatic changes and human societies and examines social influences on our current

state of knowledge, impacts, and potential responses. Au Sem. Prereq: Grad standing, or permission of instructor. Not open to students with credit for 738.

PUBAFRS 7500 G 3

Energy Policy and the Environment

Provides an historical and broad policy perspective on energy policy, energy resources and use, environmental protection, energy regulation, renewable resource economics, CO2 emission reduction strategies, and other issues. Prereq: Not open to students with credit for 880.06.

GEOG 5802 G 3

Globalization and Environment

Transnational dimensions of changes to the natural environment; ways that global economic activity, international institutions, and global environmentalism contribute to environmental problems and solutions. Prereq: Not open to students with credit for 635.

AEDECON 5330 G 3 ESGP Core: Social Science

Benefit-Cost Analysis

Benefit-cost analysis theory and methods and their application to projects pertaining to public infrastructure, agriculture, the environment, natural resources, and human health. Prereq: 4310 (531) or 4001 (500), or Econ 4001 (501). Not open to students with credit for 631.

ENR 7400 G 2

Communicating Environmental Risk

Introduction to the design and implementation of public-focused risk communication as it relates to environmental, agricultural and public health contexts. Sp Sem. Prereq: Grad standing, or permission of instructor.

PUBAFRS 7504 G 3

Science and Technology Policy

Surveys various aspects of science and technology policy such as scope, rationales, actors, politics of decisions, types of policies and priorities. Prereq: Not open to students with credit for 880.05.

ENR 5600 G 3

Sustainable Agriculture and Food Systems

A critical examination of sustainable agriculture including links between food and climate change, and food and water security. Examines the environmental and social costs and consequences between food production with an emphasis on the development of sustainable agriculture. Prereq: Grad standing, or permission of instructor.

Appendix

Potential Specialization Faculty

The ESGP faculty listed below are members of the university's Environmental Sciences Network (esn.osu.edu) who have indicated a research interest in climate change. They should be invited to participate in the Climate Change Science and Policy specialization upon approval of the specialization by OAA.

- Heather Allen
- Douglas Alsdorf
- James Bauer
- Gil Bohrer
- Anne Carey
- Cinnamon Carlarne
- J. Mac Crawford
- Peter Curtis
- Richard Dick
- Warren Dick
- P. Charles Goebel
- Dan Herms
- Kristin Jaeger

- Rattan Lal
- Jiyoung Lee
- Yebo Li
- Jialin Lin
- Desheng Liu
- Berry Lyons
- Bryan Mark
- Elizabeth Marschall
- Richard Moore
- Ellen Mosley-Thompson
- Lauren Pintor
- Gajan Sivandran
- Brent Sohngen
- Doug Southgate
- Eric Toman

Water Issues Graduate Specialization

Access to abundant clean water and potential modifications of the hydrologic cycle under future climate change scenarios are major global problems that will be exacerbated with projected human population increases. Scientists studying water science need the analytical tools to understand complex systems and to measure and analyze variation over large spatial extents and long time frames. A growing number of graduate school candidates are interested in approaching water issues from an integrated systems perspective, stemming from interest in such diverse perspectives as water quantity, water quality and remediation, aquatic ecosystems, public health, ecotoxicity, and sea level change. Decisions regarding water rights are likely to be among the most contentious of the coming decades, and decisions regarding water quality will have increasing importance in environmental and human health. Therefore, research on Earth's water is interdisciplinary, requires ability to bridge the social and natural sciences and engineering, and is consistent with water issues as a specialization within ESGP.

What are some of the cutting-edge themes addressed by this specialization?

- Water in global change
- Water quantity, hydrologic forecasting and remote sensing
- Water quality, the role of water in biogeochemical cycles
- Consequences of human activities to aquatic ecosystem services
- Consequences of aquatic ecosystem conditions to public health
- Water rights in coupled human-natural systems
- Water contaminant fate and ecotoxicity
- Collaborative watershed planning
- Transboundary water governance

Relationship between the specialization and core requirements of ESGP

For all ESGP specializations, students must complete the requirements for both ESGP and the specialization. The purpose of specializations is to meet the needs of students with common, identifiable interests within the broad arena of environmental sciences and provide formal recognition for developing a particular area of expertise. The ESGP core courses are selected to be broadly applicable to any student in ESGP. Some, but certainly not all, of these courses may be relevant to a given specialization. We expect overlap but not exact correspondence between the ESGP core requirements, and how they are organized, and the specialization objectives and requirements.

How does this specialization promote an interdisciplinary cluster?

In its 2009 report, the Task Force on the Environmental Sciences at Ohio State identified water both as a current strength at the university as well as a frontier research area. Indeed, the researcher directory of OSU's Environmental Sciences Network includes over 100 faculty members who identify water as a key interest. However, few researchers are involved in formal large-scale collaborations across the university. Creating a framework for interdisciplinary graduate training in this area would facilitate synergy among the decentralized research units at Ohio State. In addition to meeting needs within ESGP, an interdisciplinary focus on water issues addresses university-wide research directions, including all university Discovery Themes, as well as research themes articulated in college-specific planning documents.

Does this proposed transcript designation involve core subject matter from other disciplines?

The ESGP Water Issues specialization addresses a need for a more broadly interdisciplinary coursework reflective of the actual research into water issues. While contributing departments make some provisions for a focus on water issues (e.g. the School of Earth Sciences' Division of Water, Climate and the Environment), these foci are primarily discipline-oriented. By drawing broadly from the natural sciences, engineering, and

social sciences, the coursework both fosters cross-disciplinary thinking in students and facilitates "cross-pollination" among departments.

Eligibility for the specialization in Water Issues in ESGP

Any student admitted to ESGP is eligible to pursue the specialization in Water Issues. Requirements for admission to the specialization course of study, therefore, are 1) consent of the student's advisor, and 2) completion of the specialization coursework requirements as outlined in this document. The Specialization in Water Issues Plan of Study form, signed by the student, advisor, and specialization subcommittee chair (appointed by the ESGP Director for each specialization) will be required to document completion of the requirements.

Objectives for specialization in water issues

Upon completion of the requirements for the ESGP water issues specialization, students will be able to do the following.

Biological Sciences

- Analyze ecological relationships among biological agents in both natural and coupled human-natural water systems
- List major environmental determinants of aquatic population and community status, ecosystem function, and biological diversity
- Predict the key biological responses of aquatic systems under changing climate, patterns in land-use, and aquatic pollution

Physical Sciences and Engineering

- Describe the nature, distribution and cycling of Earth's water and its critical role in regulating Earth system processes including climate and changing biogeochemical cycles.
- Apply modern research tools to understand and quantify sources, transport, and fate of water contaminants
- Analyze water treatment alternatives based on technical (e.g., physical, chemical, and biological), social, and economic knowledge

Social Sciences & Policy

- Identify key components of social systems that affect and are affected by water resources and water management
- Analyze human components of coupled human-natural water systems
- Suggest how natural science knowledge might be made more usable to policy makers and other decision makers
- Identify political and institutional challenges to trans-boundary water governance and collaborative watershed planning

Specialization Subcommittee and core faculty members

The specialization in Water Issues subcommittee of the ESGP Graduate Studies Committee currently consists of Berry Lyons (subcommittee chair, Earth Sciences), Tomas Koontz (Environment and Natural Resources), John Lenhart (Civil, Environmental and Geodetic Engineering), Jiyoung Lee (Environmental Health Sciences, Public Health), Bryan Mark (Geography), Elizabeth Marschall (Evolution, Ecology and Organismal Biology), Richard Moore (Environment and Natural Resources), and Mark Moritz (Anthropology).

Additional collaborating faculty may include the 51 other ESGP faculty with a research interest in water (see Appendix).

Required and Optional Coursework

Specialization requirements:

1. Work with an ESGP advisor from the Water Issues faculty list
2. Complete specialization course requirements
3. Conduct research project in Water Issues topic

Course requirements:

Choose at least 3 (MS) or 6 (Ph. D.) credits from the following:

ENR 5280 Stream Ecology U & G 4
ENR 5345 Methods in Aquatic Ecology U 4
ENR 5355 Aquaculture U & G 3
ENR 7700 Watershed Ecology and Restoration G 3
CIVILEN 5230 Transport Phenomena in Water Resources Engineering U&G 3
CIVILEN 5420 Remote Sensing of Environment U 3
ENVENG 5120 Advanced Environmental Biotechnology G 3
CIVILEN 6230 Numerical Models in Water Resources Engineering G 3
EARTHSC 5206 Advanced Oceanography U&G 3
EARTHSC 5655 Land Surface Hydrology U 3
EARTHSC 5751 Quantitative Ground-Water Flow Modeling U&G 4
EARTHSC 5752 Contaminants in Aqueous Systems G 4
ENVENG 6210 Environmental Engineering Unit Operations G 3
FABENG 5730 Design of Agricultural Water Management Systems U&G 3
FABENG 5750 Stream Geomorphology and Watershed Hydrology U&G 3

Biological Sciences in Water Issues:

Choose at least 3 (MS) or 6 (Ph. D.) credits of the following:

EEOB 5420 Aquatic Ecosystems- Ecology of Inland Waters U&G 1.5 – 4
EEOB 6210 Ecotoxicology G 2-4
ENR 5250.01 + ENR 5250.02 Wetland Ecology and Restoration + Field Laboratory U&G 3
PUBHEHS 7360 Water Contamination: Sources and Health Impact G 3

Physical Sciences in Water Issues:

Choose at least 3 (MS) or 6 (Ph. D.) credits of the following:

CIVILEN 5130 Applied Hydrology U 3
EARTHSC 5621 Introduction to Geochemistry U&G 3
EARTHSC 5651 Hydrogeology U 4
EARTHSCI 5718 Aquatic Geochemistry G 3
ENR 5273 Environmental Fate and Impact of Contaminants in Soil and Water U&G 3
ENVENG 6100 Environmental Engineering Analytical Methods G 3
ENVENG 5430 G 3 Principles of Risk Assessment G 3
FABENG 5550 G 3 Sustainable Waste Management G 3

Social Sciences and Policy in Water Issues:

Choose at least 3 (MS) or 6 (Ph. D.) credits of the following:
ENR 5451 Water Law U&G 3
ENR 8350 Ecosystem Management Policy G 3
LAW 8309 Environmental Law L 2-4

Seminar:

Three (3) credits:
ESGP 7899 – Current Issues in Environmental Science G 1
ENR 8890.02 Ecological Restoration Seminar

Biological Sciences

EEOB 5420 U&G 1.5 – 4 ESGP Core: Biological Science
Aquatic Ecosystems- Ecology of Inland Waters
A study of the physical, chemical, and biological factors influencing the biological productivity of inland waters, and of techniques and equipment used in evaluating them. Also available summer session at Stone Lab. Prereq: 3410, or Grad standing, or permission of instructor. Not open to students with credit for 647 and 655.

ENR 5250.01 + ENR 5250.02 U&G 3 ESGP Core: Biological Science
Wetland Ecology and Restoration + Field Laboratory
Wetland hydorlogy, biogeochemistry, vegetation, biotic adaptations. Ecosystem services, classification, and management of wetlands. Fundamental concepts of ecological engineering applied to wetland creation and restoration and river restoration. Prereq: EEOB 503.01 or Grad standing. Not open to students with credit for 725 or 726. Laboratory on wetland hydrology, vegetation, water quality, soils, and aquatic biota. Prereq: Concur: 5250.01. Not open to students with credit for 725 or 726.

EEOB 6210 G 2-4
Ecotoxicology
Technical examination of the environmental fate and toxicity of organic xenobiotics, inorganics, and metals; emphasis on chemistry of interactions with physical environment, fugacity models, risk assessment, and predictive toxicology. Prereq: 3410, or Chem 2510 and 2520 or equiv, or Grad standing, or permission of instructor. Not open to students with credit for Entomol 762.

PUBHEHS 7360 G 3 ESGP Core: Biological Science
Water Contamination: Sources and Health Impact
Topics focus on understanding the sources, the transport mechanisms and the fate of microbial and chemical contaminants in water, human exposure risks, tracking methods, linking to other environmental matrices and the public health impacts. Prereq: Not open to students with credit for 729.

Physical Sciences And Engineering

CIVILEN 5130 U 3
Applied Hydrology
Engineering application of the principles of hydrology focusing on precipitation processes and data analysis, water budget analysis, evaporation and evapotranspiration processes, infiltration and rainfall-runoff relationships, hydrograph properties and unit hydrograph analysis, flood frequency analysis and flood routing. Prereq: 3160 (516) or EnvEng 516. Not open to students with credit for 613 or EnvEng 613.

EARTHSC 5621 U&G 3 ESGP Core: Physical Science
Introduction to Geochemistry
Introduction to the chemistry of the solid Earth and hydrosphere describing the processes controlling the distribution of elements. Prereq: Chem 1220 or above; Sr standing in EarthSc (EarthSci) or related field; or permission of instructor. Not open to students with credit for 621 or GeolSci 621.

EARTHSC 5651 U 4 ESGP Core: Physical Science
Hydrogeology
Geologic and hydrologic factors controlling the occurrence, movement, storage, and chemical quality of surface water and ground water; exploration, evaluation, development and management of water resources. Prereq: EarthSc 1121 (EarthSci 121) or GeolSci 121; and Math 1152 (153) or above. Not open to students with credit for EarthSci 651 or GeolSci 651.

EARTHSCI 5718 G 3
ESGP Core: Physical Science Aquatic Geochemistry
Examination of the processes that control chemical equilibria in natural waters: acid/base reactions, metal complexation/speciation and oxidation-reduction processes. Intended for students in EarthSci, CivilEn, and the Grad EnvSci program. Prereq: Chem 1220 (122) or above; and Math 1151 (152) or above; or equivalents. Not open to students with credit for EarthSci 718 or GeolSci 718.

ENR 5273 U&G 3 ESGP Core: Physical Science
Environmental Fate and Impact of Contaminants in Soil and Water
An overview of contaminant sources, transport through soil and water, and environmental fate and impact to human and ecosystem receptors. Sp Sem. Prereq: Grad standing or two semesters of chemistry. Not open to students with credit for 675.
ENVENG 6100 G 3 ESGP Core: Physical Science
Environmental Engineering Analytical Methods
Application of analytical methods to calculate, measure and interpret chemical characteristics of water, soil, and air. Prereq: Chem 1220 (122) or 1250 (125), or Grad standing. Not open to students with credit for 2100 (610) or CivilEn 610.
ENVENG 5430 G 3 ESGP Core: Physical Science
Principles of Risk Assessment
Basic methodologies for quantitative risk assessment and applications to a variety of contaminants and pathways. Prereq: 3200 (511), or Grad standing in Engineering, EarthSc, or ENR, or permission of instructor. Not open to students with credit for 720 or PubHEHS 7365 (831). Cross-listed in PubHEHS 7365.
FABENG 5550 G 3 ESGP Core: Physical Science
Sustainable Waste Management
A comprehensive examination of waste generation, treatment and reuse including the impacts of pollution on the environment and human health. The focus will be on agricultural residues, manure, domestic wastewater, and municipal solid waste streams. Prereq: Sr or Grad standing in Engineering. Not open to students with credit for 650 or 652.

Social Sciences and Policy

ENR 5451 U&G 3 ESGP Core: Social Science
Water Law
Review and advanced analysis of Ohio, interstate, and federal institutions and policies which influence the use and management of water resources. Sp Sem. Prereq: 4000 (400), or Sr standing or Grad standing, or permission of instructor. Not open to students with credit for 651.
ENR 8350 G 3 ESGP Core: Social Science
Ecosystem Management Policy
Theory and practice of integrating natural and social science for managing watersheds, forests, and regions. Evolution of policies to address human-ecological systems. Service learning "lab". Au Sem. Prereq: Grad standing. Not open to students with credit for 835.
LAW 8309 L 2-4 ESGP Core: Social Science
Environmental Law

Appendix

Potential Specialization Faculty

The ESGP faculty listed below are members of the university's Environmental Sciences Network (esn.osu.edu) who have indicated a research interest in water. They should be invited to participate in the Water Issues specialization upon approval of the specialization by OAA.

Water Issues Faculty

- Rattan Lal SENR
- Mark Moritz Arts and Sci
- Kelly Wrighton Arts and Sci
- Gil Bohrer Engineering
- Nick Basta SENR Y
- Larry Brown CFAES
- Jiyoung Lee Public Health
- Joel Barker Arts and Sci
- Allison MacKay Engineering
- Roman Lanno Arts and Sci
- Casey Hoy CFAES

- Shaurya Prakash Engineering
- Paula Mouser Engineering
- Susan Olesik Arts and Sci
- Virginia Rich Arts and Sci
- Andy May Engineering
- Linda Weavers Engineering
- Dale White Engineering
- Ozeas Costa Arts and Sci
- Heather Allen Arts and Sci
- Mazeika Sullivan SENR
- Michael Durand SES