Geography and Environmental Systems (GES)

Eugene P. (Sandy) Parker, Chair
Andrew J. Miller, Graduate Program Director

Associate Professors
BENNETT, SARI J., Ph.D., University of Illinois, Economic geography, geographic education
ELLIS, ERLE, Ph.D., Cornell University, Biogeochemistry, landscape ecology, managed ecosystems
HALVERSON, JEFFREY B., Ph.D., University of Virginia, Mid-Atlantic meteorology and climatology, hurricanes and severe storms
MILLER, ANDREW J., Ph.D., The Johns Hopkins University; Hydrology, geomorphology, water resources
PARKER, EUGENE P., Ph.D., University of Colorado, Environmental history and conservation, cultural ecology

Assistant Professors
BAKER, MATTHEW, Ph.D., University of Michigan, Ann Arbor, Watershed ecology, riparian ecosystems, ecosystem/landscape ecology, watershed hydrology and biogeochemistry
BIEHLER, DAWN, Ph.D., University of Wisconsin, Madison, Health geography, urban environmental history, environmental justice
LEWIS, LAURA R., Ph.D., University of California, Davis, Biogeography, agroecology, crop evolution
NEFF, ROBERT, Ph.D., Pennsylvania State University, Human dimensions of global change, urban geography, environmental and social justice
SWAN, CHRISTOPHER M., Ph.D., University of Maryland, College Park, Community ecology, aquatic ecosystems
TANG, JUNMEI, Ph.D., University of Texas, San Marcos, Geographic Information Science, Remote sensing, urban landscape ecology, resource management, environmental modeling

Adjunct and Affiliate Research Professors
BULMER, MARK K.H., Ph.D., University of London, Geophysical flows and natural hazards, remote sensing of earth and terrestrial planets, hazard mitigation and disaster response
CAMPBELL, Petya K.E., Ph.D., University of New Hampshire, Remote sensing of vegetation, vegetation biophysical parameters and spectral response
GROFFMAN, Peter, Ph.D., University of Georgia, Environmental regulation of microbes, ecosystem function and nutrient cycling, water and air quality, soil carbon storage
HUEMMRICH, Karl F., University of Maryland, College Park, Remote sensing of ecosystem structure and function
PICKETT, STEWARD T.A., Ph.D., University of Illinois, Urban ecosystems, function of landscape boundaries, plant community succession
POUYAT, RICHARD V., Ph.D., Rutgers University, Urban/suburban effects on soil carbon and nitrogen dynamics, ecosystem response to environmental stressors
TOKAY, ALI, Ph.D., University of Illinois, Cloud and precipitation physics, severe storms

Degrees offered:

M.S., Ph.D.

The Department offers graduate programs leading to the M.S. degree and Ph.D. degree. Both non-thesis and thesis M.S. degree options are available. The department also offers qualified UMBC undergraduates an accelerated Bachelors/Masters program culminating in the M.S. degree in Geography and Environmental Systems.

2. Program Description

The Department of Geography and Environmental Systems is at the interface between natural science, social science, public policy, engineering and information technology, with faculty who have background and collaborative relationships in both research and teaching related to all of these areas. The spatial perspective central to Geography as a discipline provides an analytical framework that bridges disciplinary boundaries and utilizes the tools of Geographic Information Science to assist in our understanding of complex patterns in the natural and human environment. Collaborative relationships with other academic programs on campus include Public Policy, Economics, the School of Aging Studies, Civil and Environmental Engineering, Mathematics and Statistics, Biological Sciences, and Physics.

The environment is a key focus area of education and research on the UMBC campus. In addition to a core group of interested faculty from the natural sciences, social sciences and engineering, the campus hosts the field headquarters of the Baltimore Ecosystem Study, an NSF and U.S. Forest Service-supported Urban Long-Term Ecological Research Site; the Joint Center for Earth Systems Technology (JCET) and Goddard Earth Sciences and Technology Center (GEST), both of which are components of a NASA/UMBC consortium focusing on earth systems science and the application of remote sensing technology to monitoring of the earth's atmosphere and surface; the Center for Urban Environmental Research and Education (CUERE), focusing on the environmental, social and economic consequences of landscape transformation associated with urban and suburban development; and the U.S. Geological Survey Water Science Center for the MD-DE-DC region, which is located in the campus Research Park with a staff of 60+ personnel. Our department is an active participant in the NSF-funded IGERT (Integrative Graduate Education, Research and Training) program on Water in the Urban Environment, and students interested in our Ph.D. program and in the general themes of the IGERT program are eligible to apply for IGERT traineeships. In addition UMBC is a partner, along with several other University of Maryland institutions as well as other research universities and federal agencies, in the Chesapeake Watershed Cooperative Ecosystem Studies Unit (CESU), part of a national CESU network. The concentration of environment-related research activity on campus provides a rich and diverse set of opportunities for prospective graduate students entering our program.

Program Specialties

Areas of concentration available to students include (1) Environmental Systems, including water resources and earth-surface processes, ecosystem science, and atmospheric processes; (2) Human

Geography, with an emphasis on coupled human-natural systems including the impacts of human activities on the environment, the socioeconomic consequences of environmental degradation, and environmental policy; and (3) Geographic Information Science and Remote Sensing, focusing on training students in the application of geospatial analysis to improve understanding of changing spatial patterns in the natural and human environment. As indicated above, research on the urban environment is a particular strength among the opportunities available through this program. The areas of concentration identified above are not separate programs and do not have separate application requirements; students may elect to pursue a program of study that draws from multiple areas to suit their particular needs.

Objectives

A hallmark of our program is its broadly integrative nature. Our goal is to train students at the M.S. and Ph.D. level who are capable of meeting the challenge identified in the following quote from the National Science Foundation Advisory Committee for Environmental Research and Education (2003):

> *New interdisciplinary programs and connections need to be fostered among traditional departments of science and engineering, including those in the social sciences (p. 8). Environmental scientists and engineers increasingly consider the interplay of physical, biological, and social factors and are required to use advanced observational, database, and networking technologies. As a consequence, there is a growing need for scientists, engineers, managers, and technicians who have the ability to work on multidisciplinary and cross-cultural teams; to use sophisticated new instrumentation, information systems, and models; and to interpret research results for decisionmakers and the general public. Fresh and innovative approaches to education are needed to train individuals to undertake interdisciplinary, collaborative, and synthesis activities. (p. 41)*

Our graduates will be able to collaborate as members of multidisciplinary teams who can carry a research plan through to completion and also communicate effectively with policymakers and the general public about the significance of their work. They will acquire the skills needed to make use of new instrumentation, data-handling, and methodological capabilities to study and understand the environment. Ph.D. recipients will be well-prepared for careers as research and teaching faculty, as agency scientists, policy analysts, or decision makers, or in environmental consulting. M.S. recipients likewise will be eligible for positions in either the public or private sector and will be trained to take up a variety of career opportunities in such areas as natural resource management, urban planning, transportation planning, environmental policy, environmental science, water resources or watershed management, natural hazards planning and response, GIS and remote sensing, global change research, atmospheric science, landscape ecology, and ecosystem resource management.

Program Admission

Admissions decisions are made once each year for Fall admission. The application deadline is **February 1**. Students wishing to enter the Ph.D. or the M.S. programs in Geography and Environmental Systems (GES) have to meet the minimum standards for admission to the University of Maryland Graduate School, Baltimore. Candidates for admission must have earned a bachelor's degree at an accredited U.S. university or an equivalent degree from a comparable foreign institution, with a minimum GPA of 3.0 overall and 3.3 for the major. All

applicants should submit scores for the Graduate Record Examination (Aptitude Test). Scores on the Test of English as a Foreign Language (TOEFL) must be submitted by applicants whose native language is not English and who do not have a degree from a U.S. postsecondary institution. Decisions on admission are made by the department's Graduate Admissions Committee and are based on the applicant's transcripts, letters of recommendation, the personal statement of goals and objectives, and GRE scores. All original application documents should be sent as a package directly to the Graduate School, not the graduate program.

Because of the diversity of subject matter and research interests covered in our program, there is no specific academic major required as a prerequisite for admission. However, in addition to deciding which students to admit to the program, the Graduate Admissions Committee will identify any background or prerequisite courses that admitted students might need to complete based on their expressed research interests. That information will be included in the admissions letter and students will be encouraged to contact their prospective advisor to discuss how those needs can be addressed. Students also will be strongly encouraged to contact their advisor after accepting an offer to discuss their course load for the first semester.

Full-time enrollment is the standard for both the M.S. and Ph.D. graduate programs. Some courses are offered in late afternoon or in the evening but the majority of courses are offered during daytime hours and the department cannot guarantee the availability of a full suite of graduate courses for students who are able to attend only in the evening. Prospective applicants who wish to enroll on a part-time basis will need to discuss their interests in advance with a faculty advisor to determine whether such an arrangement is feasible.

Accelerated Masters program admission

The Accelerated M.S. program is designed for current UMBC students who would like to begin their graduate education while completing the Bachelor's degree in their senior year. Students can complete up to three graduate courses in their senior year while paying tuition at the undergraduate rate. Application requirements are the same as for the regular graduate degree; GRE scores for students applying for the Accelerated M.S. can be submitted through Feb. 15. Three letters of recommendation are required, with no more than two from GES faculty.

Students who wish to pursue this option need to be close enough to completion of Bachelor's degree requirements that they can accommodate up to three graduate courses in their last two semesters above and beyond courses needed to complete the Bachelor's degree. Because students' applications are being submitted earlier than is normally the case and the academic record is shorter, strong evidence of academic ability and motivation will be especially important in the admissions process.

Degree Requirements

Once enrolled, students will work with a faculty advisor to select courses and a program of study that meets their particular needs. The selection of courses includes core courses, other departmental requirements, electives, and research credits. Minimum credit totals and specific course requirements are listed below for each degree option. Additional courses needed either as

prerequisites for graduate study or to prepare the student for the research area identified, may be required after consultation with the student's graduate advisor.

We anticipate that Masters students will complete their degree within 4 semesters and that Ph.D. students will typically complete the degree requirements within 8 to 10 semesters of matriculation, depending in part on previous coursework and relevant experience. Prospective Ph.D. students who have not completed a Masters degree prior to arriving at UMBC can expect to take more coursework and will typically need more time to complete the program than students who have already completed a Masters degree. A faculty committee will evaluate progress toward the degree and will be responsible for determining whether the thesis proposal is acceptable (in the case of students pursuing the M.S. thesis option) and for administering an oral defense of the thesis after it is complete. Thesis-option Masters students will defend their thesis proposal by the beginning of their third semester; Ph.D. students will take a comprehensive qualifying exam between the end of their fourth and fifth semesters and will defend their dissertation proposal by the end of their next semester after passing the comprehensive exam. The committee also will administer an oral defense of the dissertation after it is completed.

M.S. Requirements (30 hours)

We offer both a Thesis and a non-Thesis option for the Master's degree; either option will require at least 30 credits. A Thesis Option Masters requires six hours of research credit (GES 799) leading to successful completion and defense of the M.S. thesis. A non-Thesis Option Masters requires a minimum of 18 credits taken in courses numbered 600 or higher. The graduation requirement for the non-Thesis M.S. option includes two research papers, either or both of which may be expanded from course-related project work.

Core courses (7 credits):

- GES 601 Introduction to Geography and Environmental Systems (3)
- GES 602 Research Methods in Geography and Environmental Systems (3)
- GES 689 Department Seminar (1 credit, to be taken in Fall of the first year; students will be expected to attend in subsequent semesters but will not be required to register for credit)

Required courses (7 credits):

- STAT 614 Environmental Statistics (3)
- GES 686 Introduction to Geographic Information Systems (4)

Electives: 10 credits (Thesis option), 16 credits (non-Thesis option)

Electives will be chosen in consultation with the faculty advisor and committee. One of these electives will be selected from among the following areas: Social Science Methods, Remote Sensing, Computational Methods and Modeling, and Environmental Science Field and Laboratory Methods. Eligible courses available each year will be determined by the faculty and the list will be disseminated to faculty advisors and graduate students

Research credits

- GES 799 - 6 credits (Thesis option)

Ph.D. Requirements (40 credits minimum)

Core Courses (7 credits)

- GES 601 Intro to Geography and Environmental Systems (3)
- GES 602 Research Methods in Geography and Environmental Systems (3)
- GES 689 Department Seminar (1 credit, to be taken in the first semester; students will be expected to attend in subsequent semesters but will not be required to register for credit)

Required Courses (7 credits)

- GES 686 Introduction to Geographic Information Systems (4) or equivalent
- STAT 614 – Environmental Statistics (3)

(Graduate-level STAT and GIS requirements can be waived if a student has already taken equivalent; this will require faculty evaluation.)

Electives (14 credits)
Electives will be chosen in consultation with the faculty advisor and committee. One of these electives will be selected from among the following areas: Social Science Methods, Remote Sensing, Computational Methods and Modeling, and Environmental Science Field and Laboratory Methods. Eligible courses available each year will be determined by the faculty and the list will be disseminated to faculty advisors and graduate students

Additional electives will be chosen based on the specific subject areas needed to prepare for success in conducting doctoral research. Courses offered by Geography and Environmental Systems or by other departments can be used as electives where they meet a particular need.

Dissertation (12 Credits)

- GES 899 – Dissertation Research

Facilities and Special Resources

The Department is well-equipped with laboratories for GIS, cartography, ecology and biogeography; and research space supporting research in sustainability, historical urban ecology, landscape ecology and advanced GIScience. The ecology lab maintains resources to perform research particularly in aquatic ecosystems, including equipment to delineate aquatic habitats, stereomicroscopes, a spectrophotometer, temperature-controlled environmental units, and supplies to study aquatic communities both in the lab and the field. Field sites are located close to campus at Patapsco State Park. The biogeography lab is equipped to measure genetic diversity at the morphological and molecular levels in addition to analysis of survey results. Field sites to conduct common garden experiments or measurements are also available.

The Department also owns several current meters for streamflow measurement and has access to total stations for surveying as well as other field equipment for collecting and analyzing sediments and soils. Facilities and equipment in support of hydrologic research and for other

types of environmental sampling, analysis and modeling are available on campus at the Technology Research Center (TRC), where faculty projects involving collaboration with the Baltimore Ecosystem Study (BES) and the Center for Urban Environmental Research and Education (CUERE) are located. CUERE has newly refurbished GIS laboratories and computing facilities in support of the IGERT "Water in the Urban Environment" graduate training program. BES and CUERE, working together with the U.S. Geological Survey MD-DE-DC Water Science Center, operate field monitoring and sampling networks in the Baltimore metropolitan area and collaborative opportunities are available for graduate students working on problems of mutual interest. The U.S. Forest Service has several full-time scientific staff on campus who play an active role in these projects. Through these collaborations as well as collaborations with researchers in UMBC's NASA-funded Joint Center for Earth Systems Technology (JCET) and Goddard Earth Sciences and Technology (GEST) Center, graduate students will also have access to high-resolution GIS data, LiDAR topographic data and remote sensing images characterizing the regional landscape, global earth systems and the built environment. Regional partnerships with state and local agencies involved in environmental monitoring, planning and regulation offer additional resources in support of graduate research.

Financial Assistance

A limited number of graduate teaching and research assistantships are available through the department. Externally funded research conducted by the program's faculty provides opportunities for graduate students to be employed on research projects. Most assistantships will be awarded to students who are seeking the Ph.D. degree. Funding decisions will be made separately from admissions decisions and applicants will generally be informed about both admissions and availability of departmental support in the same letter. Check the Geography and Environmental Systems website for further information on internal and external fellowships as well as various funding opportunities which may arise (www.umbc.edu/ges/). You can also consult the Graduate School page on Funding Opportunities (http://www.umbc.edu/gradschool/funding/opps.html) or the Financial Aid and Scholarship web page (http://www.umbc.edu/financialaid/) for additional information about special scholarship opportunities as well as financial aid.

Student Learning Outcomes and Assessment

It is imperative that students be clearly informed of knowledge, skills, and competencies that they are expected to exhibit upon successful program completion, and understand the major exams and assessments they will be expected to pass in order to complete their degree. We plan to address this need through several documents (such as the admissions letter and annual written reports), meetings, evaluations and examinations throughout the students' graduate programs.

The admissions process will require that students submit a transcript, GRE scores, letters of recommendation, a curriculum vitae or resume, and a personal statement. In addition to deciding which students to admit to the program, the admissions committee will identify any background or prerequisite courses that admitted students might need to complete based on expressed research interests. That information will be included in the admissions letter and students will be encouraged to contact their prospective advisor to discuss how those needs can be addressed. Students also will be strongly encouraged to contact their advisor after accepting an offer to discuss their course load for the first semester.

Once the students have arrived on campus, the process becomes more formal. During an orientation seesion, students will be provided with materials describing all requirements, evaluations, and expectations for successful completion of their program. Students also will have a formal meeting with their advisor to plan their curriculum and decide on specific courses to be taken. These advising decisions will be discussed among the graduate faculty at a special meeting, to ensure that students face comparable expectations.

As the students' programs progress, the emphasis of this process is increasingly on evaluation of student performance. Grades are one way to communicate faculty expectations and perceptions of student progress, but are not sufficient to communicate all faculty expectations, nor student achievement, at the graduate level. Therefore, at the end of every academic year, all students will be evaluated during a special meeting of the graduate faculty. The purpose of this evaluation is to ensure that students make sufficient progress in their overall program. Their progress will be measured in faculty evaluations based on course work, research activities (such as assistantships or other projects), and any other scholarly activities relevant to their preparation for their thesis (if pursuing the thesis option) at the Masters level or comprehensive exam and dissertation at the Ph.D. level. A summary of this evaluation will be provided to the student in writing and placed in their file.

The Ph.D. comprehensive exam will consist of two parts: a written exam, and an oral defense of the answers. In addition, Ph.D. and thesis-option Masters students will be required to defend their dissertation or thesis proposal to ensure that the work makes an appropriate contribution to their field and is feasible within each student's time and fiscal constraints. Masters students will defend their thesis proposal by the beginning of their third semester; Ph.D. students will defend their dissertation proposal between 2 months and the end of the next semester after passing their comprehensive exam.

COURSE LISTING

GES 601 – Introduction to Geography and Environmental Systems [3]
This course is a graduate-level introduction to the principles underlying geographic and environmental systems. Guiding theories of human geography, physical geography and environmental science will be introduced through detailed examination of cross-cutting multidisciplinary issues including natural hazards and human vulnerability, the management of water resources and fossil fuels, and global environmental changes such as the recent atmospheric-oceanic warming trend and land-use/land-cover change. Within these topics, specific theories guiding geographic and environmental research will be covered in depth, including spatial analysis, critical geographic theory, postmodern social theories, and political ecology. Important theories governing the functioning of environmental systems will be presented. This includes the cycling of mass and energy between Earth's various spheres and the theory of Earth as a dynamic system seeking equillibrium in the face of multiple perturbations both natural and anthropogenic.

GES 602 – Research Methods [3]
This course is designed to provide GES graduate students with a clear understanding of past and present methodology associated with spatial, temporal, and dynamic research in geography and environmental systems. The primary focus of the course will be on the development of research questions and how to utilize various types of analyses to answer these questions and further fields of inquiry. Several methodologies will be covered during the course of the semester and applied to specific research questions generated by students in the course.

GES 605 – Applied Landscape Ecology
This course applies the tools of landscape ecology, including GIS, remote sensing, aerial photography and landscape classification, to explore the spatial patterning of ecological processes across landscapes at different scales. Hands-on lab and field exercises will develop understanding and skills necessary for students to plan and conduct their own investigations of landscape pattern, process, and change in local and regional landscapes in collaboration with the instructor. Prerequisites: GEOG 305 and 386 or permission of instructor. NOTE: The course includes 4 full day Saturday field trips, scheduling to be arranged. Students enrolling for graduate credit are required to design and execute an original research project relating to their Thesis or Dissertation work.

GES 606 Aquatic Ecology [4]
Students enrolled in this course will gain a thorough knowledge of the local aquatic biota and their habitats. Emphasis in this lab/field-based course will be placed on the interaction between physical, chemical and biological processes occurring in aquatic ecosystems. Students will learn how to collect, analyze, and interpret ecological information by working in teams to conduct a research project.

GES 608 - Field Ecology [4]
Students enrolled in this course will gain an appreciation for the modern scope of scientific inquiry in the field of ecology. A major goal is for the students to become familiar with how organisms interact with each other and their natural environment by understanding the structure

and function of different types of local ecosystems. Students will learn field collection techniques, as well as how to organize, analyze, present and interpret ecological information. This class includes both lecture and laboratory sessions.

GES 610 – Atmospheric Science [3]
This course provides a rigorous survey of advanced concepts in atmospheric science including: Thermodynamics, radiative transfer, chemistry, cloud microphysics, dynamics, mid-latitude weather systems, boundary layer and climate processes. The emphasis is on developing a conceptual understanding of the various physical processes at work in the atmosphere and their linkage with other planetary systems such as the hydrosphere, cryosphere and biosphere. The course will provide a synthesis of underlying principles for the graduate student who desires a concise, modern understanding of how the atmosphere functions within the larger Earth system. The course is also suitable for those wishing to pursue more advanced work in physical geography and/or specialized topics in meteorology such as PHYS 621/622, 721/722, and 731/732. Prerequisites: Introductory Calculus and College-Level Physics.

GES 611 – Fluvial Geomorphology [3]
This course focuses on watershed processes associated with the evolution of river systems and with sculpture of the earth's surface by running water. Topics covered include the principles of flow in river channels; erosion and sedimentation; dynamics of sediment transport; morphometry of drainage networks; depositional and erosional features associated with the development of river channels and floodplains; the geometry and statistical properties of channel cross-section, longitudinal profile and planform patterns; the dynamics of channel and floodplain response to environmental change; spatial and temporal variability of fluvial processes and landforms; and anthropogenic modification of the fluvial system. Prior coursework in geomorphology or hydrology preferred but waived for graduate students with other strong science background. Introductory physics and calculus required.

GES 612: Biogeochemical Cycles and the Global Environment [3]
This course explores the chemistry and cycling of elements across the Earth's surface and atmosphere, with special emphasis on human-induced changes in biogeochemistry that are driving global warming, ocean acidification, acid rain, ozone depletion, water pollution, and nutrient saturation of freshwater, estuarine and coastal environments. Basic biogeochemical processes will be introduced and then integrated to explain the global cycles of water, carbon, nitrogen, phosphorus and sulfur and how these are changed by human activities. Students enrolling for graduate credit are required to design an original research project relating to their Thesis or Dissertation work. Prerequisites: GES 110, 111 or 120, CHEM 102, and GES 308 or BIOL 301, or permission of instructor.

GES 613 - Advanced Biogeography Seminar [3]
This course will focus on specific topics relevant to the field of biogeography and will include such topics as: phylogeographpy, paleobiogeography, invasive species, island biogeography, diversification and biodiversity, linguistic biogeography and so on. The areas covered in any semester will vary according to recent developments in the field and based on the interests of the students and faculty. The course will include lecture material, relevant scientific papers for discussion, and written and oral presentations by students of reports on selected topics.

When appropriate, there will also be field trips to area organizations and agencies as well as parks and reserves to illustrate examples of processes and methods studied and utilized by biogeographers.

GES 615 - Climate Change [3]
The course will present the historical evolution of Earth's atmosphere and its response as a dynamic system to both internal and external forcings, including anthropogenic influences. This will include examination of the unique manner in which Earth's atmosphere evolved compared to other planetary atmospheres, and the linkages between climate and other Earth spheres (biosphere, hydrosphere, cryosphere, geosphere). The various timescales of climate change ranging from millions of years to decades will be discussed. Theories that involve changes in orbital parameters, solar output, plate tectonics, ocean thermohaline circulations, planetary impactors, volcanic emissions, the El Nino-Southern Oscillation (ENSO) and human emissions of carbon dioxide will be investigated in detail. Students will gain insight into the workings of General Circulation Models (GCMs) and run their own climate simulations using the EdGCM model developed jointly between NASA and Columbia University. The course will include a lab component where students will run a climate model. Prerequisite: GES 601**.**

GES 616 – Physical Hydrology [4]
Provides an introduction to quantifying the components of the hydrologic cycle – precipitation, evaporation, transpiration, infiltration, runoff, stream flow, and groundwater flow. Emphasis is on quantifying flow and storage in watersheds, including temporal and spatial patterns. Appropriate field and laboratory tests used to measure hydrologic processes and mechanistic and statistical models for data evaluation and interpretation are presented. Prerequisites: Calculus; probability and statistics.

GES 618 - Agricultural Evolution [3]
This course will pursue in depth the field of agricultural evolution of both plant and animal species. Topics that will be covered in this course include: centers of origin, models of domestication, artificial selection, the domestication syndrome, agricultural development, human ecology of agriculture, germplasm management in traditional and conventional farming systems, and germplasm conservation. The course will involve the critical reading and discussion of the relevant research literature and the preparation of one or more papers on specific issues or topics. On occasion, there will also be field trips to visit farms and research institutions to further illustrate the course themes. This course will be relevant to students pursuing research on agricultural evolution, international agricultural development, plant and animal breeding, cultural ecology, human ecology, invasive species, and conservation.

GES 621 – Water in the Urban Environment [3]
This course is designed for first-year graduate students who have been awarded Integrative Graduate Education, Research and Training (IGERT) fellowships on the theme of “Water in the Urban Environment” and is intended to provide an overview of topics related to the broad themes of the program. The syllabus will focus on the environmental, engineering, economic, and policy aspects of water management in urban areas and will address the impacts of urban development on hydrology, geomorphology, water quality and aquatic ecology. The course is team-taught by faculty from Geography and Environmental Systems, Civil and Environmental

Engineering, Economics, and Public Policy. There will be several field trips outside of regularly scheduled class time. Prerequisite: permission of instructor.

GES 622 – Research Design for the Urban Environment [3]
This is a core course in the IGERT "Water in the Urban Environment" program. Topics include the following: What are valid and feasible research questions for different kinds of projects? What are the assumptions, conceptual models and research approaches associated with different disciplinary perspectives? What are the key requirements for successful interdisciplinary research? What themes and trends will be important in the near future in interdisciplinary environmental research focusing on urban environment and water resources? Students will work individually and as members of interdisciplinary teams to present case studies, analyze journal articles and grant proposals, educate other students about their own disciplinary perspective, terminology, and methods, and develop research plans in response to an example RFP addressing an urban water-related problem. Each team will prepare written documents and will present and defend its work to the faculty and other IGERT students.

GES 623: Modeling and Spatial Statistics with Applications to the Urban Environment [3]
The goal of this course is to provide students with knowledge of mathematical models for the urban environment from various disciplinary perspectives, and how such models might be coupled to address urban water problems. Simple models from the fields of environmental contaminant transport, economics and ecology will be used as examples. Material covered will include time series analysis and geostatistical anaylsis of spatially distributed data in the physical, biological, and social sciences. The course will highlight challenges of the interdisciplinary perspective, including (1) space and time scales of concern to different disciplines; (2) issues with uncertainty in data and models; and (3) examples of models that are available to the different disciplines. The course will include hands-on exercises and the challenge for students to combine models from different disciplines.

GES 629 – Graduate Seminar in Geography of Disease and Health [3]
This course will engage students in advanced study of environmental and geographical perspectives on health and disease, focusing particularly on the ways health knowledge interacts with society, space, and politics. The course focuses on environmental justice, political ecology of disease, public health policy, pollution law, and historical change in landscapes and medical paradigms, The primary focus is on the US context, but with some attention to international and global health issues.

GES 632 - Seminar in Natural Resources and Environmental Conservation [3]
The course is designed to provide students with the opportunity to undertake advanced study of particular natural resource/environmental problems and conflicts. The course also is intended to encourage students to identify and/or design strategies for resource/environmental conservation. A major goal of the course is to map future resource landscapes through the systematic analysis of contemporary natural resources and environments. In recent years the seminar has taken up such topics as world water resource supplies, global biodiversity, and conflicts over wilderness designation in the western United States.

GES 634 - Wildlife Law and the Endangered Species Act [3]
The 1973 Endangered Species Act(ESA) is arguably the most controversial of U.S. environmental laws. The course combines science, policy and legal history, philosophy and contemporary politics in an integrative approach to understand and analyze the natural resource problem of threatened and endangered species in the U.S. The course covers the evolution of wildlife law from feudal Europe to the present, conflicts over state vs. federal powers, the emergence of wildlife and natural history literature, changing attitudes towards wildlife in the 20th century, and the concept of extinction.

GES 642 – Seminar in Metropolitan Baltimore [3]
Advanced study of the social and economic geography of Baltimore City and surrounding counties. Course will include data analysis and field research.

GES 650 – Seminar in Social Geography [3]
Advanced study of the spatial dimensions of selected social problems and policies. Students will make use of GIS and several collateral software platforms to produce a research paper on a topic of social significance.

GES 651 – Seminar in Urban Sustainability [3]
Students will be exposed to cutting-edge literature in Urban Sustainability, and conduct an original research project integrating the concept of sustainability with human and physical geographies of urban places. Possible topics include urban development and energy consumption, land-use change, or the influence of climate change on environmental issues facing urban places. Research projects focused on environmental justice and equitable urban form are encouraged, but not required. Readings and in-class discussion will support the topical foci of student projects and develop students' research, writing, and presentation skills.

GES 661 - Social Dimensions of Sustainability [3]
One of the greatest barriers to truly interdisciplinary human-environment research in recent years has been the lack of environmental research fully incorporating the rich theoretical literatures from human geography and other social sciences addressing social dynamics. However, a newly evolving body of sustainability literature grounded in existing literatures from the critical social science has begun to emerge. This cutting-edge body of theoretical works and empirical research attempts to elucidate the complex social processes driving environmental degradation, environmental change, and differential vulnerabilities through the lens of critical social theory. This new approach marks a departure from the more familiar multidisciplinary research in sustainability that came before, and marks the beginnings of a new interdisciplinary approach to sustainability science. Students will be exposed to this cutting-edge literature in sustainability science, and will be required to critically engage it through in-class discussions and written assignments. Finally, students will apply this literature to their own research through a formal written paper. Prerequisite: GES 601 (No concurrent enrollment)

GES 662 - Spatial Analysis of Coupled Human-Environmental Systems [3]
This course will focus on the use of GIS in analyzing social and environmental systems that constitute complex human-environmental systems. Specific dimensions of environmental and

social sustainability such as land use, transportation, economic development, environmental justice, etc., will then be explored in detail. Spatial analysis skills focused on environmental processes and social contexts will be developed through in-class exercises. These exercises and discussions are designed to enhance the students' understandings of the planning process and of the complexities of applying the concept of sustainability in the real world. The course will end with a student-defined research project. Projects with an urban focus are encouraged, but not required. Prerequisite: GES 386 or 686

GES 670: Advanced Seminar in Geographic Information Systems
This course provides a geographic foundation vital to effective spatial systems development and an introduction to common geospatial tools including ESRI's ArcGIS and Google Earth. Fundamental GIS concepts and technologies are reviewed, applicable core concepts from geography and cartography, elements of GIS systems management, GIS organizations and industry standards efforts.

GES 671: Spatial Database and System Design [3]
Students are introduced to the process of spatial database development from data modeling to database implementation in an enterprise environment. Students also learn about database diagramming techniques (e.g., UML), spatial data formats and storage options, database query languages (e.g., SQL), and installation of spatial database software.

GES 673: Geoprocessing and Spatial Analysis [3]
This course covers the manipulation and analysis of geospatial data, and focuses on automated approaches to geographic feature overlay, feature selection and analysis, topology processing, raster processing, and data conversion. This course also addresses the role of geoprocessing and spatial analysis in the definition, management. and analysis of information used to form decisions.

GES 681 – Remote Sensing of Environment [3]
This course is an introduction to image analysis and interpretation for mapping/monitoring the earth’s surficial environments from multispectral satellite images. Lectures will cover advanced topics in theories and principles of environmental remote sensing. Laboratory exercises will provide hands-on experience in the use of computers and software for image analysis, interpretation, and classification applied to multispectral satellite image data. Environmental applications include wetland delineation, forest mapping, and land use land cover, and urban sprawl analysis. Prerequisite: permission of instructor.

GES 683 – Advanced Topics in Remote Sensing [3]
Students enrolled in this course will gain a thorough knowledge of the advanced concepts, methods, and applications of remote sensing. Examples of research topics that may be covered include bio-physical parameter extraction, conventional image classification, spatial statistical methods, linear spectral unmixing, change detection, and spatial-temporal modeling. Students will learn how to collect, analyze, and interpret information by working on remote sensing images in teams to conduct a research project.

GES 685: Field Methods in Geography and Environmental Systems: Environmental Mapping of Local Landscapes [3]
Students in this course gain hands-on experience with field methods for landscape ecology, including sampling, mapping and spatial analysis of soils, vegetation, soil organisms, stream hydrology, and land use patterns in local landscapes using GIS, GPS, imagery, and other techniques. The class will meet one session each week and six full-day Saturday sessions: scheduling to be arranged. Students will work in teams and prepare final projects that will be presented as scientific posters and on the web. Students enrolling for graduate credit are required to design an original research project relating to their Thesis or Dissertation work. Prerequisites: GES 386 (GIS) , and at least one 300-level physical geography course, or permission of instructor.

GES 686 – Introduction to Geographic Information Systems [4]
This course covers the basic concepts and principles of Geographic Information Systems, data models, data structures, applications, and technical issues. Lab will focus on how these basic principles are implemented in a GIS. These include an entire sequence of building spatial databases: data capture, editing, adding attributes, building topology, registering layers to real-world coordinates, making map compositions, data conversion, and basic analysis available in a vector-based GIS. Prerequisite: Permission of instructor.

GES 687 – Advanced Applications of Geographic Information Systems [3]
This is an advanced GIS course covering advanced applications of Geographic Information Systems (GIS), and is intended for students who have already acquired an introductory knowledge of the field. The course places a strong emphasis on building hands-on skills as well as advanced theoretical knowledge in spatial analysis. The topics includes the theory and methods based on prior knowledge, skills, and interests of students in the following areas: geospatial ontologies, spatial pattern analysis, advanced raster processing, spatial interpolation and geostatistics, database design and systems, dynamic GIS modeling, and computational geometry and mathematical techniques used in GIS. Prerequisite: Permission of instructor.

GES 688 –Seminar in Geography and Environmental Systems [1]
This is a 1-credit seminar that may be offered by department faculty on any topic of special interest. Students will met with the faculty member once each week to discuss key concepts and methods as presented in the scholarly literature. May be repeated for credit and may be offered in multiple sections concurrently.

GES 689 – Department Seminar [1]
Invited speakers will make presentations on current research topics. All graduate students are required to enroll in Department Seminar for credit as described in the curriculum requirements for the M.S. and Ph.D. degrees. May be repeated for credit.

GES 690 – Special Topics [3]
This course is reserved for topics that are not otherwise covered in the set of courses listed in the graduate catalogue. May be repeated for credit (as long as the topic is different) and may be offered in multiple sections concurrently.

GES 790 – Special Topics [3]

GES 799 – Master's Thesis Research

GES 898 – Pre-candidacy Doctoral Research [1-3]
This research course is designated for Ph.D, students who need to enroll in research credits but who have not yet advanced formally to candidacy.

GES 899 – Doctoral Dissertation Research [6]