ECOLOGY

Graduate Program Head

Program Code Campus(es)

Degrees Conferred

Jason Kaye ECLGY

University Park (Ph.D., M.S.) Doctor of Philosophy (Ph.D.) Master of Science (M.S.)

Dual-Title Ph.D. in Ecology and

Biogeochemistry

Dual-Title Ph.D. and M.S. in Ecology and International Agriculture and

Development

Dual-Title Ph.D. in Microbiome

Sciences

The Graduate Faculty View (https://

secure.gradsch.psu.edu/gpms/?
searchType=fac&prog=ECLGY)

This intercollege program emphasizes the properties of ecosystems by focusing on interactions of single organisms, populations, and communities with their environment. It is designed to give students an advanced understanding of ecological theory and hypothesis testing and is complementary to other environmental programs that emphasize the human role in ecosystems.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. The Program Chair is appointed by the dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (https://gradschool.psu.edu/graduate-admissions/how-to-apply/). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (https://gradschool.psu.edu/graduate-education-policies/).

GRE scores are not required for admission. Applicants should have a strong science background, including chemistry through organic chemistry, mathematics through calculus, physics, and biology. A limited number of such courses can be made up while the student is pursuing graduate studies.

Students with a background in another discipline that has potential value to original ecological work will be seriously considered. A junior/senior grade-point average of 3.00 or better (on a 4.00 scale) is required.

Students are strongly urged to choose their research interests and initiate communication with the relevant faculty member(s) before applying for admission. A student will not be admitted without the commitment of a faculty member to serve as the student's research adviser. Teaching and research assistantships are available mainly through the student's faculty adviser.

The following are required:

 three or more letters of recommendation regarding the student's academic and professional promise;

- a concise statement describing the student's goals both within the program and in professional life;
- 3. a curriculum vitae.

Specific inquiries about the Ecology Program may be directed to the program chair. Applications received by December 1 will have preferred consideration for assistantships and fellowships for fall semester admission.

Degree Requirements

Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (https://gradschool.psu.edu/graduate-education-policies/)

A minimum of 30 credits at the 400, 500, 600, or 800 level is required, with at least 18 credits at the 500 and 600 level, combined. A minimum of six (6) thesis research credits (ECLGY 600 or ECLGY 610) must be taken in Ecology.

In addition to Graduate Council requirements, the instructional program includes:

- · ECLGY 515 Advances in Ecology (3 cr.),
- two graduate courses in ecology selected from the following subdisciplines: Molecular, Physiological, Behavioral, and Evolutionary Ecology; Population and Community Ecology; Ecosystem, Landscape and Global Ecology. A list of courses that will satisfy this requirement is maintained by the graduate program office,
- · a graduate (500 or 800 level) statistics course,
- · two credits of colloquium (ECLGY 590),
- · a minimum of six thesis credits (ECLGY 600 or ECLGY 610),
- breadth courses selected by the student in consultation with the research adviser and research committee,
- and a thesis research project directed by the student's adviser. The
 thesis must be accepted by the advisers and/or committee members,
 the head of the graduate program, and the Graduate School, and the
 student must pass a thesis defense.

Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (https://gradschool.psu.edu/graduate-education-policies/)

In addition to Graduate Council requirements, the instructional program includes:

- · ECLGY 515 Advances in Ecology (3 cr.),
- ECLGY 510 Classical Ecology (2 cr.)
- two graduate courses in ecology selected from the following subdisciplines: Molecular, Physiological, Behavioral, and Evolutionary Ecology; Population and Community Ecology; Ecosystem, Landscape and Global Ecology. A list of courses that will satisfy this requirement is maintained by the graduate program office,
- · two graduate (500 or 800 level) statistics courses,
- two graded credits plus two audit credits (4 credits total) of colloquium (ECLGY 590),
- breadth courses selected by the student in consultation with the research adviser and Ph.D. committee,
- · one credit of Supervised Experience in College Teaching (ECLGY 602),

- · a minimum of 15 thesis credits (ECLGY 600 or ECLGY 610),
- and a dissertation research project directed by the student's adviser.

English competence will be assessed and reported at the time of the qualifying examination and formally attested before the comprehensive examination is scheduled. The qualifying examination includes written and oral portions.

The Ph.D. committee is selected by the student and adviser and approved by the Program Chair and the Graduate School. The Ph.D. Committee must meet all Graduate Council Requirements (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation/). In addition, members of the Ecology faculty must comprise at least half of the committee. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements. The committee will administer the comprehensive examination and final oral examination.

Doctoral students must pass a qualifying examination, a comprehensive examination, and a final oral examination (the dissertation defense). To earn the Ph.D. degree, doctoral students must also write a dissertation that is accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Options

Four options for specialization are offered, for both the M.S. and the $\mbox{Ph.D.}$:

- 1. Conservation Biology
- 2. Microbial Ecology
- 3. Quantitative Ecology
- 4. Physiological Ecology

Students are not required to select an option. Each option entails extra course requirements plus a thesis directed by an ecology faculty member in the option.

When courses that fulfill option requirements appear on the list of approved subdiscipline courses, these courses may also be counted towards the subdiscipline graduate courses required for the Ecology major.

Conservation Biology

The Conservation Biology option is concerned with problems of maintaining the rapidly disappearing diversity of organisms and their habitats, and the global reservoir of genetic diversity that these organisms represent.

Code	Title	Credits

Required Courses

Select two required courses from the following list:

ANTH 559	Human Ecology
BIOL 428	Population Genetics
GEOG 414	Principles and Applications in Landscape Ecology
WFS 430	Conservation Biology

In addition, two courses (at least 6 credits) are required from this list of Conservation Biology courses:

ANTH 560	Ecology, Evolution, and Human Behavior
BIOL 414	Taxonomy of Seed Plants
BIOL 422	Advanced Genetics

BIOL 427	Evolution
BIOL 448	Ecology of Plant Reproduction
ENT 432	Insect Biodiversity and Evolution
ENT 457	Principles of Integrated Pest Management
FOR 508	Forest Ecology
FOR 530	Conservation Genetics
GEOG 411	Forest Geography
GEOG 587	Conservation GIS
WFS 462	Amphibians and Reptiles

Microbial Ecology

The Microbial Ecology option addresses the structure, function, and interactions of microbial populations and communities, both within plants and animal hosts and in diverse environmental samples (soils, sediments, water).

Code Title	Credits
------------	---------

Required Courses

Select two requir	ed courses from the following list:	
MICRB 401	Microbial Physiology and Structure	
MICRB 416	Microbial Biotechnology	
SOILS 512	Environmental Soil Microbiology	
PPEM 440	Introduction to Microbiome Analysis	

In addition, two courses (at least 6 credits) are required from this list of Microbial Ecology courses:

01	or Microbial Ecology Courses.			
	BIOL/PPEM 425	Biology of Fungi		
	BMB/MICRB 450	Microbial/Molecular Genetics		
	CE 479	Environmental Microbiology for Engineers		
	FDSC 526	Microbial Physiology of Foodborne Organisms		
	GEOSC 409W	Geomicrobiology		
	GEOSC 502	Evolution of the Biosphere		
	MCIBS 593	Molecular Biology Laboratory		
	PPATH 533	Molecular Genetics of Plant-Pathogen Interactions		
	PPEM 454	Virus Ecology		
	PPEM 456	Applied Microbial Ecology		
	SOILS/CE 536	Topics in Biogeochemistry		
	or GEOSC 53	Topics in Biogeochemistry		

Quantitative Ecology

The Quantitative Ecology option includes mathematical and statistical modeling and applications of statistics to experimental design and data analysis.

Code	Title	C	redits

Required Courses

Select two required courses from the following list:		
	BIOL 465	Network analysis of biological systems
	BIOL 519	Ecological and Environmental Problem Solving
	WFS 560	Population Estimation and Modeling
	WFS 585	Applied Spatial Ecology
-	1.15.5	

In addition, two courses (at least 6 credits) are required from this list of Quantitative Ecology courses:

BIOL/STAT	Statistical Analysis of Genomics Data
555	

3

FOR 455	Remote Sensing and Spatial Data Handling
GEOG 464	Advanced Spatial Analysis
GEOG 465	Advanced Geographic Information Systems Modeling
GEOSC 450	Risk Analysis in the Earth Sciences
MATH 450	Mathematical Modeling
STAT 416	Stochastic Modeling
STAT 464	Applied Nonparametric Statistics
STAT 505	Applied Multivariate Statistical Analysis
STAT 508	Applied Data Mining & Statistical Learning
STAT 510	Applied Time Series Analysis
STAT 511	Regression Analysis and Modeling
STAT 512	Design and Analysis of Experiments
STAT 513	Theory of Statistics I
STAT 514	Theory of Statistics II
STAT 515	Stochastic Processes and Monte Carlo Methods
STAT 517	Probability Theory
STAT 551	Linear Models I
STAT 565	Multivariate Analysis

Physiological Ecology

The Physiological Ecology option is concerned primarily with the function and performance of organisms in their environment.

and performance of organisms in their environment.		
Code	Title	Credits
Required Course	s	
Select two requir	red courses from the following list:	
BIOL 406	Symbiosis	
BIOL 446	Physiological Ecology	
HORT 445	Plant Ecology	
PLBIO 514	Modern Techniques and Concepts in Plant Ecophysiology	
In addition, two courses (at least 6 credits) are required from of Physiological Ecology courses:		list

, ,	3,
AGRO 410W	Physiology of Agricultural Crops
AGRO 518	Responses of Crop Plants to Environmental Stress
BIOL 415	Ecotoxicology
BIOL 441	Plant Physiology
ENT 539	Chemical Ecology of Insects
PLBIO 512	Plant Resource Acquisition and Utilization
PLBIO 513	Integrative Plant Communication and Growth
PLBIO 515	Modern Techniques and Concepts in Plant Cell Biology
PLBIO 516	Modern Techniques and Concepts in Plant Molecular Biology

Dual-Titles

Dual-Title Ph.D. in Ecology and Biogeochemistry

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-titles/).

Graduate students with research and educational interests in biogeochemistry may apply to the Biogeochemistry dual-title degree

program. Students must apply and be admitted to the graduate program in Ecology and The Graduate School before they can apply for admission to the dual-title degree program. After admission to the Ecology program, students must apply for admission to and meet the admissions requirements of the Biogeochemistry dual-title program. Refer to the Admission Requirements section of the Biogeochemistry Bulletin page (http://bulletins.psu.edu/graduate/programs/majors/biogeochemistry/). Once a student has been admitted to the dual-title degree in Biogeochemistry, they must pass a qualifying examination that incorporates knowledge of the discipline of biogeochemistry.

It is preferred that students take a joint Ecology / Biogeochemistry qualifying examination incorporating knowledge of both the ecology and biogeochemistry disciplines. When a joint qualifying examination is administered, the qualifying examination committee will be composed of Graduate Faculty from Ecology and must include at least one Graduate Faculty member from the Biogeochemistry program.

Ecology graduate students who have already passed their qualifying examination will take a second qualifying examination focused solely on the discipline of biogeochemistry. When the Biogeochemistry qualifying examination is administered separately, faculty members who hold appointments in the Biogeochemistry Graduate Faculty may serve in administering the Biogeochemistry qualifying exam.

In either case, all qualifying examinations must be complete no later than the end of the fourth semester (not counting summer semesters) of entry into the Ecology program.

To qualify for the Biogeochemistry dual-title degree, students must satisfy the degree requirements for the Ph.D. in Ecology, listed in the Degree Requirements section. In addition, students must complete the degree requirements for the dual-title in Biogeochemistry, listed on the Biogeochemistry Bulletin page (http://bulletins.psu.edu/graduate/programs/majors/biogeochemistry/). Some courses may satisfy both the Ecology program requirements and those of the Biogeochemistry dual-title program.

In addition to the general Graduate Council requirements for Ph.D. committees (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation/), the Ph.D. committee of an Ecology and Biogeochemistry dual-title Ph.D. student must include at least one member of the Biogeochemistry Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Biogeochemistry, the member of the committee representing Biogeochemistry must be appointed as co-chair. The Biogeochemistry representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Ecology and Biogeochemistry. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Dual-Title M.S. and Ph.D. in Ecology and International Agriculture and Development

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (https://

gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/qcac-208-dual-titles/).

Graduate students with research and educational interests in international agriculture and development may apply to the International Agriculture and Development (INTAD) dual-title degree program. Students must apply and be admitted to the graduate program in Ecology and The Graduate School before they can apply for admission to the INTAD dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of INTAD dual-title program. Refer to the Admission Requirements section of the INTAD Bulletin page (https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/).

Degree Requirements for dual-title M.S.

To qualify for the INTAD dual-title degree, students must satisfy the requirements of the Ecology M.S. program. In addition, they must satisfy the INTAD program requirements for the dual-title M.S. degree. Refer to the M.S. Degree Requirements section of the INTAD Bulletin page (https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/). Some courses may satisfy both the Ecology program requirements and those of the INTAD dual-title program.

The Ecology program requires students pursuing a M.S. degree to produce a master's thesis. Therefore, in addition to the 12 credits specified in the degree requirements, dual-title students must write the thesis on a topic that reflects their education and interest in both Ecology and INTAD. At least 6 thesis research credits (ECLGY 600 or ECLGY 610) must be taken in Ecology.

All members of the student's committee for the dual-title M.S. degree will be members of the Graduate Faculty. The committee must include at least one Graduate Faculty member from INTAD. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role.

Degree Requirements for the Dual-Title Ph.D.

To qualify for the INTAD dual-title degree, students must satisfy the requirements of the Ecology Ph.D. program. In addition, they must satisfy the INTAD program requirements for the dual-title Ph.D. degree. Refer to the Ph.D. Degree Requirements section of the INTAD Bulletin page (https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/). Some courses may satisfy both the Ecology program requirements and those of the INTAD dual-title program.

Qualifying Examination

It is preferred that students in the dual-title program take a single qualifying examination, containing elements of both Ecology and INTAD. However, in cases when students matriculate into a dual-title after they have already completed the Ecology qualifying exam, a second qualifying exam may be taken for the dual title, according to policy GCAC-604 (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-604-qualifying-exam/) and the guidelines of the dual-title degree program. Whether taken as a combined exam in ECLGY and INTAD or a second, separate exam for INTAD, the qualifying examination committee for the dual-title Ph.D. degree must include at least one Graduate Faculty member from the INTAD program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role.

Committee Composition

In addition to the general Graduate Council requirements for Ph.D. committees (https://gradschool.psu.edu/graduate-education-policies/

gcac/gcac-600/gcac-602-phd-committee-formation/), the Ph.D. committee of an Ecology and INTAD dual-title Ph.D. student must include at least one member of the INTAD Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in INTAD, the member of the committee representing INTAD must be appointed as co-chair.

Comprehensive Exam

At the end of their course work, students must pass a comprehensive examination that follows the guidelines established by the Ecology program and reflects both the Ecology program and the INTAD dual-title degree curriculum. International agriculture must be one of the key areas of the exam and the INTAD representative on the student's Ph.D. committee must have input into the development of and participate in the evaluation of the comprehensive examination.

Dissertation and Dissertation Defense

Doctoral students enrolled in the dual-title degree program are required to write and orally defend a dissertation on a topic that reflects their original research and education in both Ecology and INTAD. The dissertation should contribute to the body of knowledge in international agriculture. A public oral presentation of the dissertation is required. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School, and the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree.

DUAL-TITLE PH.D. IN ECOLOGY AND microbiome Sciences

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-titles/).

Ecology Ph.D. students with research and educational interests in Microbiome Sciences may apply for admission to the Microbiome Sciences Dual-Title Degree Program. Students must first apply and be admitted to the Ecology graduate and The Graduate School before applying for admission to the dual-title program. To apply, a student should send to the MBIOM Graduate Program Advisor (microbiomesciDT@psu.edu) a written personal statement that explains their interest in Microbiome Sciences; the career goals they hope to work toward by attaining the dual-title degree; and describe actual or potential research objectives that integrate microbiome sciences. This statement should be signed by their major adviser or dissertation adviser, if assigned. Students should also send the MBIOM Graduate Program Advisor their undergraduate and graduate transcripts for review by the MBIOM Faculty-in-Charge, who will notify the Graduate School and student about the enrollment decision.

The result of the ECLGY qualifying examination serves to qualify the student's entrance to the MBIOM dual-title program The application for the dual-title degree program may be completed after the qualifying examination in the major program, as long as the application takes place before the end of the fourth semester.

To obtain this dual-title, students must satisfy the degree requirements for the Ph.D. in Ecology, listed in the ECLGY Degree Requirements section. In addition, students must complete the degree requirements for the MBIOM dual-title, listed on the Microbiome Sciences Bulletin page (http://bulletins.psu.edu/graduate/programs/majors/biogeochemistry/). Students must complete a total of 15 credits including 2 credits of ECLGY 550 (https://bulletins.psu.edu/search/?P=ECLGY%20550) and

5

at least 13 credits chosen in consultation with the adviser from an approved list of courses, with at least 3 credits in each of the following areas: Microbial Sciences, Ecology and Evolution, and Bioinformatics and Research Tools.. Eight of the 15 total credits must be taken at the 500-level. No more than six of the 15 total credits can be offered by the ECLGY program.

In addition to the general Graduate Council requirements for Ph.D. committees (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation/), the Ph.D. committee of an Ecology and Microbiome Sciences dual-title Ph.D. student must include at least one member of the Microbiome Sciences Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Microbiome Sciences the member of the committee representing Microbiome Sciences must be appointed as co-chair. The Microbiome Sciences representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Ecology and Microbiome Sciences. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Minor

A graduate minor is available in any approved graduate major or dualtitle program. The default requirements for a graduate minor are stated in Graduate Council policies listed under GCAC-600 Research Degree Policies (https://gradschool.psu.edu/graduate-education-policies/) and GCAC-700 Professional Degree Policies (https://gradschool.psu.edu/ graduate-education-policies/), depending on the type of degree the student is pursuing:

- GCAC-611 Minor Research Doctorate (https://gradschool.psu.edu/ graduate-education-policies/gcac/gcac-600/gcac-611-minorresearch-doctorate/)
- GCAC-641 Minor Research Master's (https://gradschool.psu.edu/ graduate-education-policies/gcac/gcac-600/gcac-641-minorresearch-masters/)
- GCAC-709 Minor Professional Doctorate (https:// gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/ gcac-709-professional-doctoral-minor/)
- GCAC-741 Minor Professional Master's (https://gradschool.psu.edu/ graduate-education-policies/gcac/gcac-700/gcac-741-masters-minorprofessional/)

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (https://gradschool.psu.edu/graduate-funding/) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (https://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/) set by The Graduate School.

Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Ecology (ECLGY) Course List (https://bulletins.psu.edu/university-course-descriptions/graduate/eclgy/)

Learning outcomes

Master of Science (M.S.)

- Know: demonstrate knowledge of core principles and primary literature in their specialty area including comprehension of methods, results, and data analysis in the specialty area.
- Apply/Create: demonstrate ability to design and carry out a major research project in the discipline, including synthesis of previous work in the field, and assembling findings into a written work.
- Think: demonstrate ability to critically analyze work by others in their specialty area.
- Communicate: demonstrate ability to convey scientific ideas and results in clear, concise and original writing as well as in formal oral presentations.
- 5. **Professional Practice:** demonstrate comprehension of and commitment to ethical standards in the discipline.

Doctor of Philosophy (Ph.D.)

- Know: demonstrate knowledge of core principles and primary literature in their specialty area including comprehension of methods, results, and data analysis in the specialty area.
- Apply/Create: demonstrate ability to design and carry out a major research project in the discipline, including synthesis of previous work in the field, and assembling new findings into a written work that advances understanding in the field.
- 3. Think: demonstrate ability to critically analyze work by others in their specialty area.
- Communicate: demonstrate ability to convey scientific ideas and results in clear, concise and original writing as well as in formal oral presentations.
- 5. **Professional Practice:** demonstrate comprehension of and commitment to ethical standards in the discipline.
- Teach: demonstrate the ability to teach key concepts of the discipline to students.

Contact

CampusUniversity ParkGraduate Program HeadJason Philip KayeDirector of Graduate Studies (DGS)Jared Gregory Ali

or Professor-in-Charge (PIC)

Program Contact Jean Pierce

101 Life Sciences Bldg University Park PA 16802

jep32@psu.edu (814) 867-0371

Program Website View (https://www.huck.psu.edu/

graduate-programs/ecology/)