



# COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

## Graduate Programs

- **Animal and Food Sciences (M.S., Ph.D.)**
- **Bioresources Engineering**
- **Entomology and Applied Ecology (M.S., Ph.D.)**
- **Food and Resource Economics (M.S.)**
- **Operations Research (M.S., Ph.D.)**
- **Plant and Soil Sciences (M.S., Ph.D.)**
- **Public Horticulture (M.S.)  
(Longwood Graduate Program)**

The College of Agriculture and Natural Resources offers graduate-level education through all of its academic departments: Animal and Food Sciences, Bioresources Engineering, Entomology and Applied Ecology, Food and Resource Economics, and Plant and Soil Sciences. All departments offer programs leading to the Master of Science degree; additionally, programs leading to the Doctor of Philosophy degree are offered in animal science and in plant and soil sciences. The college manages an M.S. degree program cooperatively with Longwood Gardens in the area of Public Horticulture Administration. Two departments, Bioresources Engineering and Food and Resource Economics, participate in the interdisciplinary Operations Research Program, through which students may earn the M.S. or Ph.D. The college is interested in attracting highly qualified students with a desire to enter into research. Professors in the college are formally responsible for research projects in the Delaware Agricultural Experiment Station, and students often move into a facet of an established research project.

Close association with the departmental research program affords unusual opportunities to broaden a student's perspective of the research process. Each department has several areas of concentration within the discipline. The Department of Bioresources Engineering provides concentrations in soil and water resources, structures and environment, power and machinery, or food process engineering. The Department of Food and Resource Economics offers concentrations in quantitative economics, international agricultural trade, economic development, resource economics, and marketing and policy. The Department of Entomology and Applied Ecology offers graduate research opportunities in both applied and basic research in most areas including field entomology, biological control, physiology, ecology and plant-insect interactions.

The Department of Animal and Food Sciences has three graduate degree offerings: the Ph.D. in Animal Science, the M.S. in Animal Science and the M.S. in Food Science. For the Ph.D., a student may specialize in nutrition, physiology, pathology, molecular biology/

biotechnology, or food science. A student in the M.S. program in Animal Science may specialize in animal management in addition to any of the disciplines listed for the Ph.D. The M.S. program in Food Science emphasizes food safety with a focus on food processing and packaging.

In Plant and Soil Sciences, areas of concentration include plant breeding, tissue culture, molecular biology, pathology, plant improvement, physiology and horticulture. In Soil Science the areas are soil chemistry, biochemistry, microbiology and management. A specialized M.S. program, the University of Delaware/Longwood program in Public Horticulture is a 2-year Master's degree program requiring a thesis.

The College of Agriculture and Natural Resources houses modern research laboratories and state-of-the-art equipment for graduate study in Worrlow Hall, Townsend Hall, the Charles C. Allen, Jr. Laboratory, the Fischer Greenhouse and other buildings located on the Delaware Experiment Station. Field plots, a 35-acre woodlot, an insectary, environmental growth chambers, and animal research facilities are available for graduate research. An excellent library and computing site are located in the college.

### ANIMAL AND FOOD SCIENCES

Telephone: (302) 831-2524

The Department of Animal and Food Sciences offers three graduate degree programs: The Master of Science (M.S.) degree in Animal Science, the M.S. degree in Food Science and the Doctor of Philosophy (Ph.D.) degree in Animal Science. Research programs are offered in avian and dairy nutrition, rumen microbiology, avian physiology, virology, bacteriology, immunology, pathology, molecular biology and endocrinology. The department maintains dairy cattle, sheep, and poultry for graduate instruction and research. Modern,

well-equipped laboratories and animal facilities are available for conducting research. Students have access to mainframe and microcomputers for data collection, analysis and presentation. The College of Agriculture and Natural Resources houses a computing site and an excellent library.

### RESEARCH FACILITIES

**W**ell-equipped laboratories are located in Worrlow Hall, the Allen Biotechnology Laboratory, the Delaware Agricultural Experiment Station Farm, and adjacent buildings. Equipment available for graduate student research includes an amino acid analyzer, preparative ultracentrifuges, an atomic absorption spectrophotometer, a blood gas analyzer, UV-Vis spectrophotometers, photomicroscopes, fluorescent microscopes, a tissue processor, a rotary microtome, gas chromatographs, liquid scintillation counters, a gamma counter, continuous culture fermentors, environmental chambers, a respiratory calorimeter, an oxygen bomb calorimeter, HPLC, FPLC, PCR thermocyclers, ELISA plate diluters and readers, an X-omat autoprocessor, and electrophoresis and DNA sequencing equipment.

An excellent food microbiological research and teaching laboratory is equipped for batch and continuous fermentations, anaerobic microbiology, and bioengineering investigations.

Laboratory space and specialized food processing equipment are available for heat sterilization, freeze-drying and other preservation studies on foods. Laboratory and pilot scale packaging equipment, which includes a vacuum-sealing machine with controlled atmosphere capabilities and computer facilities, are also available.

The Allen Biotechnology Laboratory, completed in 1997, is a state of the art, biosafety level 2 and 3 facility for research and graduate instruction in the areas of highly pathogenic and exotic (foreign) avian disease agents and recombinant poultry microorganisms. Additional animal facilities for nutrition, physiology, and infectious disease research are available on the Delaware Agricultural Experiment Station Farm.

### REQUIREMENTS FOR ADMISSION

**A**n applicant for graduate study in Animal and Food Sciences should have an appropriate background from the Baccalaureate degree, with a minimum cumulative grade point average of 2.75, and a 3.00 average in his/her major. Undergraduate preparation for most areas of study should include general and organic chemistry, biology/microbiology, biochemistry, physics, and calculus. For students lacking appropriate preparatory course work, additional courses applicable to certain areas of study may be required prior to admission. A Graduate Record Examination combined score (quantitative + verbal sections) of 1075 on the general exam is desirable. Exceptions may be made for students with special backgrounds, abilities, and interests. All students must provide three letters of recommendation from former professors, a completed Graduate Studies Application form, and a completed assistantship form if applying for financial aid. Foreign students must demonstrate competence in the use of the English language by a TOEFL score of 575 or greater and provide evidence of sufficient financial support for the course of the degree program. Foreign students applying for a teaching assistantship must have a TOEFL score of 600 or greater. Applicants may be requested to visit the department for a personal interview before a final decision concerning admission is made. Admission to the graduate program is dependent upon availability of an appropriate faculty advisor in the student's area of study.

### FINANCIAL AID

**P**lease refer to the chapter "Graduate Fellowships and Assistantships" in this catalog.

### REQUIREMENTS FOR THE DEGREES IN ANIMAL AND FOOD SCIENCES

**T**he M.S. degree program in Animal Science and the M.S. degree program in Food Science require a minimum of 30 graduate credit hours, of which six credits must be master's thesis. The programs are usually completed in two to two and one-half years of full-time study. Students, with the assistance of their adviser, are required to prepare and present a research proposal to their graduate committee for review and approval of the proposed research project. The proposal review meeting shall be held during the first two weeks of the second semester following matriculation. Course selections are made with the approval of the student's graduate committee. Candidates for the M.S. degree are required to pass an oral examination on the thesis and allied areas of study. All students pursuing the M.S. degree will complete the following core courses; ANSC 865 Seminar and CHEM 527 Introductory Biochemistry or CHEM 641 Biochemistry, and a statistics course [FREC 608 Research Methods, FREC 806 Research Techniques and Procedures, or equivalent]. Attendance in Graduate Seminar (ANSC 865) is required each semester for all graduate students.

The Ph.D. degree program provides the necessary flexibility to design an appropriate plan of study and therefore has only minimal course requirements. A doctoral committee will be appointed within six months following matriculation. The committee shall consist of not less than four nor more than six faculty or professional members nominated by the graduate advisor and approved by the Department Chairperson. Participation from industry, government or other academic departments on the doctoral committee may be required depending on the student's area of research. At least one member of the committee shall be from outside the Department of Animal and Food Sciences. However, not more than half of the committee members shall be from outside the Department. Departmental Adjunct Faculty shall be considered as "outside" members in their participation on doctoral committees. The committee is responsible for approving the student's course work and research program. The committee will prepare, administer, and evaluate the student's comprehensive and final examinations and will supervise and approve the dissertation. The student's faculty advisor serves as chair of the doctoral committee.

*Core Courses and General Requirements.* All students pursuing the Ph.D. will complete the following core courses; ANSC 865 Seminar, ANSC 969 Doctoral Dissertation, CHEM 641 Biochemistry, CHEM 642 Biochemistry, and a statistics course [FREC 608 Research Methods, FREC 806 Research Techniques and Procedures, or equivalent]. Attendance in Graduate Seminar (ANSC 865) is required each semester for all graduate students. Beyond the core courses, no specific number of courses completed or credits earned are uniformly required. The student and advisor in concert with the doctoral committee will select appropriate course work based on the student's background and major and minor (if applicable) area(s) of specialization for the Ph.D. Consideration will be given to the student's prior training and experience at the undergraduate (B.A. or B.S.) and M.S. and/or D.V.M. (if applicable) level(s). Students with more advanced training and experience will need fewer courses to complete their Ph.D. program. General requirements for the Ph.D. are based on a period of residency, writing of a satisfactory research proposal and dissertation, and passing the comprehensive and the final oral examinations. The candidate's doctoral program will consist of a combination of doctoral committee-approved formal courses, seminars, individual study, and research credits as needed by the student.

*Research Proposal.* Advancement to degree candidacy requires successful oral defense of a research proposal. The proposal will be submitted to the doctoral committee at least ten working days prior to

the scheduled defense. The student will give an oral presentation summarizing the proposal. The committee members will question the student to verify that the student understands the research problem and the experimental approaches needed to address it. The committee will also ensure that the student has the proper training and resources to do the research. As a result of the meeting, the student may be required to revise the proposal and/or take additional course work. The research proposal defense should precede the comprehensive examination.

**Comprehensive Examination.** Successful completion of the comprehensive examination is required of all Ph.D. students prior to their admission to candidacy. The examination normally is given to the student after completion of all course work and selection of a dissertation topic. The student is required to have a minimum grade point average of 3.0 at the time of the examination. The examination will cover the student's major and minor (if applicable) areas of study. Each member of the student's doctoral committee will submit examination questions to the student via the advisor who will administer the written portion of the comprehensive examination. Following completion of the written exam, the advisor will return the student responses to the appropriate committee member for their evaluation. Students passing the written examination may continue for the oral portion of the comprehensive examination generally given within one month of the completion of the written examination. In the oral portion of the comprehensive examination the student must appear before all committee members and demonstrate competency in this forum. A favorable vote by a majority of the committee including the major advisor is required for passing. Based on the performance of the student in the comprehensive examination, the committee may recommend one of the following actions:

1. The student be admitted to candidacy, without qualification or subject to fulfillment of certain conditions.
2. The student be reexamined at later date.
3. The student be disapproved unconditionally for the degree.

**Dissertation.** The ability to conduct independent research and competence in scholarly writing must be demonstrated by the preparation of a dissertation on a topic related to the major area of specialization in accordance with the regulations of the Office of Graduate Studies. The contents and conclusions of the dissertation must be defended at the time of the Final Oral Examination (see below) and approved by the doctoral committee. Copies of the dissertation must be available in the departmental office at least ten working days before the date of the Final Oral Examination. Preparation of (a) manuscript(s) for publication of the information contained within the dissertation is expected prior to, or within one month after, approval of the dissertation by the committee at the Final Oral Examination.

**Final Oral Examination.** Upon recommendation of the doctoral committee, a Final Oral Examination of the dissertation will be scheduled for the doctoral candidate who has satisfied all other requirements for the degree. The examination must be scheduled at least three weeks prior to the time the examination is to be held. The examination, which is open to the public, shall be related in a large part to the dissertation but it may cover the entire field of study of the candidate. The examination will be administered by the student's doctoral committee. The student will give an oral presentation (seminar) summarizing the dissertation research. Committee members will question the student about the dissertation and related subject areas to verify that the candidate fully understands the research findings and their implications. A favorable vote of a majority of the members of the committee is required for passing. If the candidate fails, it is the responsibility of the doctoral committee to determine whether he/she may take another examination.

## BIORESOURCES ENGINEERING

Telephone: (302) 831-2468

The Bioresources Engineering Department participates in the interdisciplinary Operations Research program, offering programs leading to the M.S. or the Ph.D. The department provides the students the opportunity to concentrate their course work and thesis research in the areas of soil and water resources, structures and environment, power and machinery, or food process engineering.

### REQUIREMENTS FOR ADMISSION

An applicant for a degree in Operations Research through the Bioresources Engineering Department is expected to have a baccalaureate degree in engineering, engineering technology, or a closely related field. The applicant must have had mathematics through differential equations. The applicant should have a minimum cumulative grade point average of 3.0 on a 4.0 scale. A Graduate Record Examination score of at least 1150 is required. A minimum of three letters of support are required from former professors or supervisors. Exceptions may be made for students with special backgrounds, abilities and interests. Applications must be made according to the guidelines of the Office of Graduate Studies. International applicants, for whom English is not a first language, must achieve a minimum TOEFL score of 600.

### FINANCIAL AID

Please refer to the chapter "Graduate Fellowships and Assistantships" in this catalog.

### REQUIREMENTS FOR THE M.S. DEGREE

A minimum of 33 semester hours of courses including six hours of thesis are required for the Master of Science degree in Operations Research. At least 12 credit hours should be from the Bioresources Engineering related subject matter. At least 12 credit hours should be from the applicable Operations Research courses including ORES 601 and ORES 602 or equivalent. At least two courses should be at the 800 level.

A thesis based on academic research in the Bioresources Engineering Department is required for the M.S. degree in Operations Research. Students should select a thesis adviser and the subject of research based on their interests early in the program. A graduate committee consisting of at least four faculty members with the thesis adviser as chairperson will be appointed by the Department Chairperson.

Upon completion of the thesis, the student is required to pass an oral examination covering the thesis and allied areas of course work. This examination and defense will be open to the public.

### REQUIREMENTS FOR THE Ph.D. DEGREE

For the Ph.D. degree the student is required to take a minimum of 51 credits of course work, nine credits of dissertation and complete a two-year residency. The courses must be approximately equally divided between ORES courses and courses from the major area of study. No more than 27 credits can be at the 600-level. Courses required are ORES 801, ORES 802, ORES 803, ORES 899, MATH 630, MATH 631 and MATH 804 and one of ECON 801, ECON 811, ECON 822, ECON 823, or ECON 824 plus four semesters of ORES seminars.

Successful completion of the comprehensive qualifying examination is required of all Ph.D. students prior to their admission to candidacy. The qualifying examination will consist of two written examinations and an oral examination. The qualifying examination

will be taken after all or most of the course work has been completed. One of the written examinations will be in Operations Research and the other will be in Bioresources Engineering material. The oral examination will include presentation of the candidate's dissertation proposal.

The student is required to prepare a dissertation on some topic related to Bioresources Engineering. Upon the completion of the dissertation, the candidate is required to pass a final oral examination covering the dissertation.

## ENTOMOLOGY AND APPLIED ECOLOGY

Telephone: (302) 831-2526

The department offers major programs in Entomology and Applied Ecology leading to the Master of Science (M.S.) and the Doctor of Philosophy (Ph.D.). The M.S. program prepares students for pursuit of the Ph.D. and careers in entomology, wildlife ecology, and other biological disciplines. In addition to studying insects and other arthropods, students in the graduate programs can gain knowledge of vertebrate taxa and of related fields of biology with an emphasis on ecology. The department views entomology as a biological science with important, demanding applications in agriculture. Some students study insects as an avenue to a primary interest in ecology, genetics, physiology, or behavior. An in-depth knowledge of insects as a group is the goal of graduate study for others. Still other students wish to apply their biological interests to the management of insect populations. Other students pursue an interest in the conservation of biodiversity, another aspect of applied ecology. The M.S. and Ph.D. programs accommodate all of these interests.

Plant-insect interactions (herbivory, plant defenses, and insect life history), biological control, and conservation biology are strong themes in the department. Other areas for concentration and graduate research include plant protection, pheromone ecology, genetics of resistance, insect behavior, avian ecology, and ecology and behavior of turtles.

### RESEARCH FACILITIES

Research facilities in and adjacent to Townsend Hall (home of the department) include laboratories, an insectary, programmed growth chambers, a greenhouse, field plots and a 35-acre woodlot on the experimental farm, collections of pinned, liquid, and slide specimens of insects, amphibians and reptiles, bird and mammal skins, digitizer, automated high performance liquid chromatograph, thin layer chromatography scanning system, capillary gas chromatograph, advanced optical systems, and an excellent library collection of pertinent journals and books. The USDA Beneficial Insects Research Laboratory also located on the campus provides additional opportunities.

### REQUIREMENTS FOR ADMISSION

Minimum requirements for admission are an undergraduate academic index of 2.8 overall and 3.0 in the major field of concentration and a combined score of 1050 on the verbal and quantitative portions of the GRE. Graduate GPA (if applicable) should be at least 3.2. A TOEFL score of at least 550 is required for international students. Admission is selective and competitive based on the number of well-qualified applicants and the limits of available faculty and facilities. Those who meet stated minimum academic requirements are not guaranteed admission, nor are those who fail to meet those requirements necessarily precluded from admission if they offer other appropriate strengths. Applicants not meeting these minima may be admitted under unusual circumstances where it is clear that other

strengths outweigh the academic deficiency. Ph.D. applicants also must take the Advanced GRE test in Biology. No minimum scores are required, but the scores will be used to evaluate the candidate. An applicant should have satisfactorily completed the following: General Biology, Organic Chemistry, and General Ecology. Applicants lacking any of those courses must complete the missing course(s) during graduate study. Applicants must have three completed recommendation forms submitted to the department, two of which should be from faculty of the applicant's major department. Ph.D. applicants must also identify a faculty member with whom they wish to work and who agrees to act as the student's advisor. For further details, contact the chairperson of the department's Graduate Admissions Committee. Applications for financial support should be completed by March 1 for Summer or Fall terms and November 1 for entering in Spring term.

### REQUIREMENTS FOR THE DEGREES

Requirements for the M.S. degree in Entomology and Applied Ecology are (1) completion of at least 30 graduate credit hours, including 12 credit hours of required courses and a thesis describing independent research (6 credit hours); (2) passing an insect family recognition test; (3) passing an oral, general knowledge examination, centering on the student's training in entomology and related areas; (4) presenting the thesis research in a formal departmental seminar; and (5) passing a thesis defense. The written thesis must reflect the ability to do independent scholarly research and to report the results in a publishable manner.

Requirements for the Ph.D. degree are (1) completing a course program approved by the student's graduate committee; (2) passing a written and oral qualifying examination; (3) completing a significant teaching experience as approved by the graduate committee; (4) making at least one presentation of a research paper at a regional or national conference; (5) presenting the dissertation research in a formal departmental seminar; and (6) passing a dissertation defense and final oral examination. The written dissertation must present original research and must meet the generally accepted professional and literary standards in the student's field.

All graduate students must maintain a minimum GPA of 3.0. Written details concerning curriculum, selection of the student's advisor and committee, and procedures for exams and seminar are available from the department office.

## FOOD AND RESOURCE ECONOMICS

Telephone: (302) 831-2511

The Department of Food and Resource Economics offers a program leading to the Master of Science degree. The program offers students the perspectives and skills necessary to understand and work in the agribusiness or government sectors of the economy. Also, a strong intermediate level of training is offered so that students may continue graduate work and obtain the Ph.D. degree. The department has ready access to computer terminals for mainframe computer connection and microcomputers.

### REQUIREMENTS FOR ADMISSION

Students making application are required to have satisfactorily completed an approved undergraduate program of study. On a 4.0 system, applicants must have a general academic index of 2.5. Students who have an academic index below 2.5 may be granted provisional admission if they have Graduate Record Examination scores above 1050 with good letters of reference. Students for whom English is not their first language must attain a minimum score of 550 on the

TOEFL examination. Admission is selective and competitive based on the number of well-qualified applicants and the limits of available faculty and facilities. Those who meet stated minimum academic requirements are not guaranteed admission, nor are those who fail to meet those requirements necessarily precluded from admission if they offer other appropriate strengths.

### REQUIREMENTS FOR THE DEGREE

**S**tudents are required to complete a minimum of 30 credit hours including either a thesis or a non-thesis option. Under the thesis option, students complete 24 hours of course work and 6 hours of thesis work. Under the non-thesis option, students complete 27 hours of course work and 3 hours of a directed project. All students must take ECON 801 and either ECON 552 or ECON 802. All students must take four of the following quantitative courses: FREC 608, FREC 615, FREC 674, FREC 682, FREC 801, FREC 806, ECON 822 and ECON 823. Students writing a thesis must take two 800-level FREC courses while students under the non-thesis option must take three 800-level FREC courses from the following: FREC 810, FREC 826, FREC 827, and FREC 834. In addition, no more than three credits of independent study may be taken unless approved by the department chair, advisor and the department graduate committee. Agricultural and resource economics courses taken previously may partially meet the requirements if they do not count towards the fulfillment of another degree.

The student plans a course program in consultation with the major professor, in order to attain competency in economics, quantitative methods, and agricultural and resource economics.

Students must achieve an overall index of 3.0 on a 4.0 scale for all graduate course work taken. The student's progress toward the degree will be monitored by the academic adviser and the department graduate committee.

A student choosing the thesis option is required to prepare a thesis that reflects a substantive analysis of a subject in the field of agricultural and resource economics. An oral examination covering both course work and thesis will be given to determine whether the student has a breadth of understanding of the field. A student selecting the non-thesis option is required to complete a directed research project to be presented at a department seminar.

## OPERATIONS RESEARCH

Telephone: (302) 831-6242

**T**he Operations Research Program at the University of Delaware is an interdisciplinary graduate program, drawing its faculty and students from various participating academic units that include: the College of Agriculture and Natural Resources (Bioresources Engineering and Food and Resource Economics), the College of Business and Economics (Business Administration and Economics), the College of Engineering (Civil and Environmental Engineering and Electrical and Computer Engineering), the College of Arts and Science (Computer and Information Sciences, Mathematical Sciences), the College of Human Resources, Education and Public Policy (School of Urban Affairs and Public Policy), and the College of Marine Studies. Programs of study are tailored to student and faculty interests and emphasize research. Course work includes a core in operations research, mathematical optimization, statistics, and applied probability, in addition to supporting courses related to areas of application.

The student is encouraged to select an adviser among the affiliated or core faculty at the early stage of enrollment. The director of the program will assist in the search. After the first semester, but no later than during the second semester, a student should have an adviser for course selection and thesis/dissertation purposes. Changes in

the adviser are possible with special justification, but all concerned including the director of the program must agree. The program encourages coadvisors for students, if it is in their interest.

The master's program allows students to take either the thesis or non-thesis option. The thesis option requires a research-oriented thesis (six credits) and course work including the ORES 600-level sequence, OR-related courses, two semesters of seminar attendance, and course offerings in the area of application, for a total of 33 credit hours. A thesis committee consisting of at least four members, two of which are OR faculty, should be formed after the first year of study to advise the candidate and administer the thesis defense exam. One member should be external to the student's home department. The non-thesis option requires an internship and a related research report in place of the thesis. Students can also participate in a formalized internship program called CORP (Corporation Operation Researchers Program). Students in this program usually intern at the corporation during the academic year (September to May), 20 hours per week.

The Ph.D. program is intended to prepare well-qualified students for management, research or teaching careers in industry, government, or academia. Dissertations for the Ph.D. degree are a blend of empirical and theoretical research combining OR methodologies with application from a particular discipline. A dissertation committee consisting of at least five members, three of whom are OR faculty, should be formed after the second year of study to advise the candidate and administer the final dissertation defense exam. The degree requires at least 51 credit hours, with nine credits fulfilling the dissertation requirement and the remainder about equally divided among OR-related courses and course offerings from the area of application. Ph.D. candidates must take the ORES 800-level course sequence and register for four semesters of seminar attendance. Comprehensive exams are administered in three areas (OR and two of the student's chosen concentration areas) after a majority of the course work has been successfully completed.

### GOALS OF THE PROGRAM

**S**tudents should acquire through the program:

1. Standard working knowledge of OR models and solution techniques including:
  - a. assumptions and limitations of models
  - b. an understanding of why analysis of a model should yield the results received
  - c. ability to question results for consistency and logic
  - d. appreciation of sensitivity analysis
2. Art of model building (i.e., ability to fit models to problems)
3. Computer skills (such as programming and software applications)
4. Presentation skills
5. Appreciation of recent literature on:
  - a. a problem domain of student's choice and
  - b. advances in an OR technique and relations to practical problem solving.

### REQUIREMENTS FOR ADMISSION

**S**tudents should apply to the Operations Research program. The Director will assist the applicant in selecting a suitable home department (unit). Applicants should meet that unit's admission requirements. In addition, a student must have a minimum average grade of B in undergraduate studies with a grade of B or higher in calculus and linear algebra and a minimum combined verbal and quantitative score of 1150 on the Graduate Record Examination.

Admission to the Operations Research Program is selective and competitive based on the number of well-qualified applicants and the

limits of available faculty and facilities. Those applicants who meet the stated minimum academic requirements are not guaranteed admission, nor are those applicants who fail to meet those minimum requirements necessarily precluded from admission if they offer other appropriate strengths.

Foreign students must have a minimum TOEFL score of 600 for admission to the Operations Research Program.

For fall admission, the application deadline is May 1. For spring admission, the application deadline is October 1.

### FINANCIAL AID

Various forms of partial and comprehensive financial aid are available on a competitive basis to students with excellent credentials. Applications for aid should be made along with the application for admission. In most cases, individual home departments (units) are responsible for granting assistantships. Teaching assistantships provide a stipend plus full tuition for fall and spring semesters. Additional stipends are sometimes available for summer. At present, a high proportion of full-time students receive some financial support after having initially established very good academic records in the Operations Research Program at the University of Delaware. Research assistants work up to 20 hours per week (partially funded students work 10 hours per week) on faculty projects and are expected to maintain full-time status (9 credit hours per semester). Teaching assistants help with departmental instruction and are also expected to maintain full-time status. Assistantships are normally awarded on the semester basis, are reviewed after each semester, and are renewed if the student's overall performance (academic performance and work responsibilities) in the program is satisfactory.

A graduate assistant financially supported by the home department has the obligation to work for and finish his or her degree in that department. If, in an exceptional and compelling case, a transfer is in the interest of all parties (current and future home department, the OR Program, and the student), an orderly transfer should be sought after discussion among the principals involved.

Students can also work for 20 hours per week during the academic year as corporate interns in the Corporation Operation Researchers Program (CORP). The intern's performance is evaluated each semester and the internship is continued subject to performance, availability of funds, and corporate needs. Normally, students intern after their first year of study. Interns are expected to maintain full-time graduate student status. Tuition for interns is borne by the University.

### PLANT AND SOIL SCIENCES

Telephone: (302) 831-2532

The Department of Plant and Soil Sciences offers graduate programs that lead to degrees of Master of Science and Doctor of Philosophy in plant and soil sciences. The objectives of the programs are to equip the student with background and techniques necessary for degree completion, opportunities for advanced study in the plant and soil sciences, and for job placement.

In addition to a modern research facility, special items available for student research include field, state-of-the-art greenhouse and growth chamber facilities, radioisotope room, scintillation counters, gas and liquid chromatographs, x-ray diffractometer, Fourier transform infrared spectrometer, pressure-jump relaxation apparatus, atomic absorption spectrophotometers, inductively coupled plasma spectrometer, low- and high-speed centrifuges, microtomes, electrophoretic apparatus, cold rooms, atomic force microscope, and carbon-nitrogen-sulfur analyzer.

### REQUIREMENTS FOR ADMISSION

Students seeking admission must provide Graduate Record Examination scores, grade transcripts, evaluation by three professionals, evidence of English language proficiency for applicants whose native tongue is not English, and a completed Graduate Studies application form. A member of the department also must agree to serve as the faculty adviser to the student.

### FINANCIAL AID

Please refer to the chapter "Graduate Fellowships and Assistantships" in this catalog.

### REQUIREMENTS FOR THE DEGREES

A minimum of 30 semester hours is required for the Master of Science degree, to include 24 semester hours of approved course work and 6 hours of thesis 869 or research 868. All M.S. students must take a minimum of 12 hours in one of two research areas (plant improvement or soil science), and they must register at least once in PLSC 865 Plant Science Seminar and in PLSC 802 Professional Development. In addition to the University general requirements for advanced degrees, the awarding of the Master of Science degree is contingent upon an approved research proposal, the successful oral defense of research performed, and an acceptable thesis. A non-thesis Master's degree is also offered. Students must complete 30 credits of coursework, present a seminar (PLSC 865) that is based on a required independent study project (PLSC 666), complete PLSC 867, and pass an oral examination administered by the student's graduate advisory committee at the end of the degree program. Advancement to Ph.D. degree candidacy is contingent upon an approved research proposal and successful completion of written and oral qualifying examinations administered by the student's advisory committee. There is no minimum number of course credits required, but candidates must enroll in Seminar (865) and Dissertation (969), and must present an acceptable dissertation.

An approved program of study is required for both degrees. The program is developed with close supervision and assistance of a faculty adviser and advisory committee and arranged according to the academic and professional needs of the student. The program is usually developed by the end of the first semester of study. There is no language requirement other than English proficiency for the Master of Science or Doctor of Philosophy degree.

### LONGWOOD GRADUATE PROGRAM IN PUBLIC HORTICULTURE

Telephone: (302) 831-2517

The Longwood Graduate Program in Public Horticulture was established at the University in 1967 with the support of the Longwood Foundation. The program leads to the Master of Science. The program is unique in its educational approach to leadership in public gardens and the public horticulture profession. Students who have completed the program have found employment in arboreta, botanical gardens, display gardens, horticultural societies, ornamental horticulture cooperative extension, park systems, and garden-related foundations. Graduate Fellows participate at the University in an academic course of study tailored to their individual strengths and needs. Original thought and study are encouraged by the requirement of a thesis. Additionally, the student completes a leader's internship at Longwood Gardens, working with the management staff in administration, business, education, horticulture and maintenance. This joint effort of the University with Longwood Gardens qualifies students as useful professionals in programs of nonprofit horticultural institutions, organizations and societies.

An important part of the program is the Longwood Symposium, which brings specialists in different topics from various areas of the United States into direct contact with the Longwood Fellows.

The University offers a concentration of courses in personnel and financial management and in museum studies for students planning leadership careers in museums, botanical gardens, arboreta or historical agencies. Longwood Fellows benefit from interaction with students in the Winterthur and Hagley Programs in addition to others.

The Libraries of the University of Delaware and Longwood Gardens provide an extensive collection of horticultural books and periodicals as source material in problem-solving and research.

### REQUIREMENTS FOR ADMISSION

Applicants should demonstrate technical competence in horticulture, and interest in public horticulture. In addition they should provide evidence of strong leadership potential. They are asked to submit a Graduate Record Examination Aptitude Test combined score (verbal and quantitative) of at least 1050, four letters of recommendation from persons familiar with their academic and job performance, two official transcripts of the undergraduate record, and one copy each of the Longwood Graduate Program Fellowship application and the University graduate application for admission. The University application, test scores, and transcripts are to be sent to the University Office of Graduate Studies. Letters of recommendation and the Longwood Graduate Program Fellowship application are to be sent to the Coordinator of the Program. Any additional inquiries about the Program should be directed to the Coordinator, Longwood Graduate Program, 153 Townsend Hall, University of Delaware, Newark, DE 19717-1303. Admission is selective and competitive based on the number of well-qualified applicants and the limits of available faculty and facilities. Those who meet stated minimum academic requirements are not guaranteed admission, nor are those who fail to meet those requirements necessarily precluded from admission if they offer other appropriate strengths. The admission file must be completed by December 1 for consideration.

### FINANCIAL AID

Longwood Fellowships in the Program are awarded on a competitive basis. Academic competence, achievement at the undergraduate

level, practical, supervisory and management experiences, and leadership potential are stressed. A background in plant science is desirable, but consideration will be given candidates who have undergraduate majors in other disciplines. Applications for fellowships should be addressed to the coordinator of the program.

### REQUIREMENTS FOR THE DEGREE

A total of 38 hours of credit is required for the Master's degree in Public Horticulture Administration as follows:

|               |                                           |
|---------------|-------------------------------------------|
| PLSC 831      | Taxonomy of Ornamental Plants (3)         |
| PLSC 832      | Botanic Garden Management, Section 11 (3) |
| PLSC 864      | Seminar Planning and Development (1+1)    |
| PLSC 865      | Seminar (1+1)                             |
| PLSC 868      | Research (5)                              |
| PLSC 869      | Master's Thesis (2)                       |
| MMST 802      | The Management of Museums (3)             |
| MMST 804      | Museum Internship (3)                     |
|               | Another Museum Studies Course (3)         |
|               | Management Courses (12)                   |
| Total Credits | 38                                        |

Longwood Fellows may, with the assistance of their research committee, choose other course credits from disciplines that will support the research area.

The program begins July 1 with the leader's internship at Longwood Gardens. Fellows participate directly in the work and planning associated with the daily operation of Longwood. During the first year, effort is made to expose Fellows to a wide variety of work situations. Academic study begins at the University with the opening of the fall term. Selection of a thesis problem must be made by December 31 of the first year, and work on the problem should begin during the first semester.

During the second summer of internship at Longwood, the Fellows will be channeled into specific areas that their experience and aptitude suggest will be most beneficial to them. The last two terms at the University will be used to complete course work and thesis.

Graduate students not connected with the Longwood Program may, at the discretion of the instructor concerned, elect any of the courses.

