

Department of
***Aquatic, Watershed,
 and Earth Resources***

College of Natural Resources

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Professors *Charles P. Hawkins*, stream ecology, conservation biology, and biomonitoring; *Wayne A. Wurtsbaugh*, limnology, fish ecology, and watershed biogeochemistry; **Professors Emeriti** *John A. Kadlec*, wetland ecology and biogeochemistry; *John M. Neuhold*, fisheries biology; **Associate Professors** *Todd A. Crowl*, aquatic ecology and conservation biology; *John C. Schmidt*, fluvial geomorphology and water policy; *Helga Van Miegroet*, biogeochemistry, soils, and ecosystem ecology; **Research Associate Professor** *Jeffrey L. Kershner*, USDA Forest Service, national habitat coordinator, stream ecology and fish-habitat relationships; **Assistant Professors** *Paul W. Box*, geographic information systems, spatial analysis, and modeling; *Phaedra E. Budy*, assistant leader, fisheries, Utah Cooperative Fisheries and Wildlife Research Unit, fisheries management and aquatic ecology; *Robert R. Gillies*, remote sensing and meteorology; *Nancy O. Mesner*, water quality, water policy, and modeling; *Karen E. Mock*, conservation genetics and population biology; *Michael A. White*, ecosystem modeling, remote sensing, and global climatology; **Research Assistant Professor** *Mark R. Vinson*, aquatic invertebrate ecology and biomonitoring; **Adjunct Assistant Professors** *Nicolaas W. Bouwes, Jr.*, fisheries management, aquatic ecology; *Jayne Brim-Box*, invertebrate ecology; *Ronald W. Goede*, fish diseases; *J. Christopher Wilson*, director, State of Utah Division of Wildlife Resources Fisheries Experiment Station, fish pathologist/nutritionist

Degrees offered: Bachelor of Science (BS) in Fisheries and Wildlife; BS, Master of Science (MS), and Doctor of Philosophy (PhD) in Watershed Science; MS and PhD in Ecology; MS and PhD in Fisheries Biology

Undergraduate emphases: *BS in Fisheries and Wildlife*—Fisheries, Conservation Biology

Graduate specializations: *MS, PhD in Ecology*—Aquatic Ecology; *MS, PhD in Fisheries Biology*—Aquatic Ecology, Conservation Biology, Fisheries Management

Undergraduate Programs

Objectives

The Department of Aquatic, Watershed, and Earth Resources offers comprehensive educational opportunities for graduate and undergraduate students in hydrology, geomorphology, biogeochemistry, water quality, watershed management, fisheries, aquatic ecology, remote sensing and geographic modeling. Departmental faculty provide expertise in fisheries, the hydrologic cycle, conservation biology, restoration and management of aquatic and riparian ecosystems, and in the remote sensing and geographic analysis of the earth's landcovers. Graduates of departmental programs become teachers and researchers at major universities, scientists and managers for natural resource agencies, and professionals with consulting and nonprofit environmental firms.

Requirements

Departmental Admission Requirements. Admission requirements for the department are the same as those described for the College of Natural Resources (see pages 100-101).

Graduation Requirements. All Natural Resources core courses and all courses listed as major subject courses must be taken on an *A-B-C-D-F* basis. A grade of *C-* or better is required for all courses used to meet the requirements for a major or minor in the department. The grade point average for all courses taught by the College of Natural Resources must be 2.5 or higher.

Bachelor of Science in Fisheries and Wildlife. The Fisheries and Wildlife major is jointly administered by the Department of Aquatic, Watershed, and Earth Resources (AWER) and the Department of Forest, Range, and Wildlife Sciences (FRWS). Students interested in the Fisheries and Wildlife—Fisheries emphasis should declare the major in AWER. Those interested in the Fisheries and Wildlife—Conservation Biology emphasis may declare the major in either AWER or FRWS.

Students must meet the course requirements for University Studies in addition to the following departmental requirements. The first two years of study include courses designed to give the student a sound scientific background, an introduction to the field of natural resources management, and an introduction to aquatic and earth resources. Supporting math and science courses include: Biol 1210, 1220 (BLS); Chem 1210, 1220 (BPS), 1230, 1240;

Math 1050 (QL), 1100 (QL); Phyx 2110; and Stat 3000 (QI). Natural resource core courses include: EnvS 2340 (BSS); Geog 1130 (BPS) or Geol 1150 (BPS); and NR 2220. Introductory Fisheries and Wildlife core courses include: AWER 3100 (CI), 3110; FRWS 3200 (CI), 3210. University Studies, required, and elective courses must also be included, resulting in a total of approximately 15 credits per semester.

During the junior and senior years, all students take upper-division departmental and college core courses. Additionally, students take departmental elective courses to fulfill their special interests, as well as remaining University Studies courses. Upper-division core courses include: FRWS 3300, 3400; AWER 4500; AWER 4510 or FRWS 4400; AWER 4980 or FRWS 4980; and one management core course (see major requirement sheet for listing of courses). Natural resources upper-division core courses include: NR 3000, 3600 (QI), and 4000. University Studies and elective courses must also be included, resulting in a total of approximately 15 credits per semester and 120 credits required for the major. Elective courses are chosen in consultation with a faculty advisor and may include one of the following areas of emphasis.

Students pursuing the AWER **Fisheries** emphasis are required to take AWER 3700, 4650, and FRWS 5800.

Students pursuing the AWER **Conservation Biology** emphasis are required to take Biol 3200 (QI), 5250 (CI); and FRWS 5800. Students are also strongly encouraged to take AWER 6750.

Fisheries and Wildlife Minor. The minor is designed for students with a strong background in biology. The department head's approval and a minimum of 19 credits are required. Course requirements include: AWER 3100 (CI); FRWS 3200 (CI); NR 2220, 3000; and two of the following courses: EnvS 4110; FRWS 3300, 3400, and 5400.

Bachelor of Science in Watershed Science. All Watershed Science majors must complete the following communication skills/economics courses: Econ 1500 (BAD), Spch 3050 (DSS); and supporting math and science courses: AWER 3600; Biol 1210, 1220 (BLS); Bmet 4300; Chem 1210, 1220 (BPS), 1230; FRWS 3500; Geol 1150 (BPS), 5510 (QI); Math 1210 (QL); Phyx 2110; Soil 3000; Stat 3000 (QI). Majors must also complete the Natural Resources core courses: EnvS 2340 (BSS); NR 2220, 3000, 3600 (QI), 4000; and the Watershed Science core courses: AWER 3700, 4490, 4500, 4530, 5150, 5330, 5660; EnvS 5320. Students must also complete 10 credits of electives in the areas of physical science, watershed ecology, watershed management tools, or watershed policy. For specific courses, see the current major requirement sheet.

Watershed Science Minor (16-17 credits). For the Watershed Science minor, students must complete AWER 3700, 4490, 4530, plus two courses selected from the following: AWER 4500, 5150, 5660, FRWS 5640.

For information about changes in requirements, course sequence, and scheduling, students should confer with a departmental advisor. The undergraduate program can be readily tailored to individual student needs with the help of a faculty advisor.

Career Opportunities

Graduates in Aquatic, Watershed, and Earth Resources (AWER) occupy an expanding niche in the fields of natural resources and environmental management. Degree holders often work as environmental scientists, hydrologists, fisheries biolo-

gists, or specialists in geographic information analysis and remote sensing. With experience and/or advanced degrees, AWER graduates may do natural resource assessment, management planning, and resource impact analysis.

Federal agencies, such as the Forest Service, Fish and Wildlife Service, Geological Survey, Bureau of Land Management, Environmental Protection Agency, National Park Service, Bureau of Reclamation, and National Marine Fisheries Service, hire graduates of AWER academic programs. Graduates also find employment with state natural resource agencies, nongovernmental conservation organizations, and private consulting firms.

Financial Assistance

The main sources of undergraduate financial assistance include University scholarships, grants-in-aid, work-study, and loans; these are listed on pages 22-25 in the *Financial Aid and Scholarship Information* section. In addition, more than 30 scholarships for eligible students in the College of Natural Resources are listed on pages 37-38 of the same section.

Scholarships are awarded for scholastic and professional achievements at the department, College of Natural Resources, and University level. For more information, contact departmental and College of Natural Resources academic advisors. Grants-in-aid and work-study are available from the Financial Aid Office and the Student Employment Office, respectively. In addition, departmental faculty often employ undergraduate students to assist in research, extension, and outreach projects. These projects often involve field and laboratory data collection, data management and analysis, and report preparation.

Additional Information

For additional information about the Bachelor of Science requirements, course sequencing, and departmental specialization options and their related coursework, as well as updated information describing current programs and courses offered by the Department of Aquatic, Watershed, and Earth Resources, visit the Aquatic, Watershed, and Earth Resources main office, Natural Resources 210, or visit <http://www.cnr.usu.edu> and link to the departmental website.

Graduate Programs

Admission Requirements

General admission requirements apply, in addition to the requirements which follow. Although admission to the graduate program is treated on an application-by-application basis, the following are usually required: (1) a bachelor's degree from an accredited college or university; (2) a GPA of 3.2 or better (out of 4.0) for the most recent two years of academic coursework; (3) combined verbal and quantitative GRE scores above the 40th percentile; and (4) a letter of "interest and purpose" detailing the applicant's reasons for seeking an advanced degree. Foreign students should have a TOEFL score of at least 550. The written statement of interest helps match applicants with faculty advisors. A faculty member must agree to serve as the major professor in order for an applicant to be accepted. Prospective students are encouraged to contact faculty members early in the application process to investigate mutual interests, projects, and prospects for financial support.

Previous training in the field is not a prerequisite for admission, although a sound background in the physical and biological sciences is recommended. Successful applicants without the necessary background will be expected to obtain it in the course of their studies for the advanced degree.

Degree Programs

A Master of Science degree in Fisheries Biology or Watershed Science, with emphasis on the management of fisheries or watershed resources directed toward decision-making roles in natural resource agencies, is offered for the applicant with previous agency experience and for the student motivated toward an administrative career. A Doctor of Philosophy degree in Fisheries Biology, Ecology, or Watershed Science is provided for students interested in pursuing a research or academic career.

A thesis or dissertation based on original research performed by the student is required. Written comprehensive examinations are required of all students pursuing the PhD degree. At the discretion of the student's graduate supervisory committee, an additional oral examination may be required.

The minimum requirement for an MS degree is 30 credits, including at least 24 credits in residency and 6 credits of thesis research. The minimum requirement for a PhD degree is 60 approved graduate credits in addition to an MS degree, or 90 approved graduate credits with no MS degree. At least one year (a minimum of 32 credits), including a minimum of two consecutive semesters, of full-time registration must be in residence at USU.

With committee approval, graduate credit may be transferred from accredited graduate schools, provided the minimum residency requirement (including thesis and dissertation credit) at USU is met. Transfer credit, which must not have been used for any other degree, will be shown on official USU transcripts at completion of the degree.

Master of Natural Resources. The department also participates in the College of Natural Resources Master of Natural Resources (MNR) degree program. For more information, see page 374.

Specializations

The MS and PhD degrees in Fisheries Biology and Ecology allow students to specialize in either Fisheries Management or Aquatic Ecology.

Financial Assistance

General aspects of financial support for graduate students at Utah State University are listed on pages 71-72 in the *Graduate Financial Assistance* section. This includes important information on the University-wide policies and terms of reference for research and teaching assistantships, graduate tuition obligations and benefits, Western Regional Graduate Programs, and competitive University-wide fellowships and scholarships.

Assistantships

Research assistantships are available through individual faculty members who hold research grants or contracts. Occasionally, teaching assistantships are available through the department. Recipients of teaching assistantships are usually selected from among PhD students.

Western Regional Graduate Programs

The MS and PhD in Watershed Science are Western Regional Graduate Programs. For more information, see page 71.

Aquatic, Watershed, and Earth Resources Courses (AWER)

AWER 1200 (BLS). Biodiversity: Its Conservation and Future. Today, species extinctions are occurring at an unprecedented rate. People in developed countries are concerned with this loss. Solving this problem requires knowledge of what determines biodiversity, how it is being threatened, and how its loss can be countered. (3 cr) (Sp)

AWER 2250. Introductory Internship/Co-op. Introductory-level educational experience in internship/cooperative education position approved by department. (1-3 cr) (F,Sp,Su) ®

AWER 3000 (DSC). Oceanography. Examines fundamental interrelationships between physical environment of the oceans and the life forms they support. Suitable for nonbiologists. (3 cr) (Sp)

AWER 3100 (CI). Fish Diversity. Systematics, physiology, ecology, and evolution of major groups of marine and freshwater fishes. Stresses functional morphology, physiological ecology, and community interactions explaining fish abundance and distribution. Prerequisite: Biol 1220. (3 cr) (F)

AWER 3110. Fish Diversity Laboratory. Focuses on field collection, identification, and habitat relationships of freshwater fishes in North America. Prerequisite: AWER 3100 (may be taken concurrently). (1 cr) (F)

AWER 3600. Geomorphology. Geomorphic processes, origin of landforms and surficial deposits. Emphasizes fluvial and hillslope landscape elements, and surficial geologic mapping. Three one-hour lectures and one three-hour lab per week. Prerequisite: Geol 1100 or 1150 or Geog 1130. Also taught as Geol 3600. (4 cr) (F)

AWER 3700. Fundamentals of Watershed Science. Study of water movement, hillslope processes, and nutrient movement in catchments, and its relevance to the properties, land use, and management of watersheds as natural resource units. Prerequisite: Soil 3000 or permission of instructor. (3 cr) (Sp)

AWER 3820 (DSC, QI). Global Climatology. Emphasizes physical basis of climate (climate dynamics) and the mechanisms and processes for its fluctuations on sub-seasonal to interannual time scales (climate variations), and on regional to hemispheric/global time scales. Prerequisite: Bmet 2000 or Geog 1130. Also taught as Bmet 3820. (4 cr) (F)

AWER 3900. Spatial Analysis. Analysis of geographic data, including spatial economic theory, spatial quantitative methods, and spatial distributions. Prerequisite: Stat 2000. (3 cr) (Sp)

AWER 4250. Advanced Internship/Co-op. Internship/cooperative education work experience; increased complexity to help student gain a more professional level of experience. (1-9 cr) (F,Sp,Su) ®

*****AWER 4490 (d5490).¹ Small Watershed Hydrology.** Detailed exploration of concepts of hydrologic processes in small, wildland watersheds. Concentrates on recent research findings concerning examining key hydrological processes. Particular attention paid to study of partitioning of water in the hydrologic cycle, sources for runoff generation, snow and snowmelt, and erosion. Features process modeling and

parameter estimation techniques as related to wildland systems. Prerequisites: Math 1210, AWER 3700. (4 cr) (F)

AWER 4500. Freshwater Ecology. Ecosystem analysis of physical, chemical, and biological interactions in lakes and streams. Application of these concepts for managing aquatic system. Prerequisites: Chem 1210 and NR/Biol 2220. (3 cr) (F)

AWER 4510. Aquatic Ecology Practicum. Integration of limnological theory and methods of conducting field and laboratory analyses of physical, chemical, and biological parameters in writing. Field trips required. Prerequisite: AWER 4500 (may be taken concurrently). (3 cr) (F)

AWER 4530 (d6530). Water Quality and Pollution. Reviews biological and social problems caused by point and nonpoint source water pollution; toxicology; abiotic and biotic water quality parameters; and use criteria of the Clean Water Act. Graduate-level class will require additional readings of the peer-reviewed literature and an additional class meeting to have in-depth discussions of those readings. Each graduate student will be responsible for making a presentation at the beginning of class, and leading the discussion. (3 cr) (Sp)

AWER 4600 (d6600). Principles of Surface Hydrology. Study of physical elements of the water cycle, surface hydrological processes, and watershed responses. Explores basic hydrologic concepts and terminology, as well as collection, analysis, and presentation of hydrologic data. Includes field laboratory. Prerequisite: Soil 3000 or instructor's permission. Also taught as Soil 4600/6600. (3 cr) (Sp)

AWER 4650 (d6650). Principles in Fishery Management. Emphasizes management of fish populations within context of community and ecosystem dynamics. Stresses use of simulation models to assess effects of growth, recruitment, and mortality on age-structured populations. (3 cr) (Sp)

AWER 4750. Fundamentals of Remote Sensing. Develops the scientific principles behind remote sensing. Examines the basic physics of electromagnetic radiation and the interactions of radiation with the surface and the atmosphere. Prerequisites: Math 1060, 1210; Phyx 2210. (3 cr) (F)

AWER 4930. Geographic Information Systems. Examines structure and operation of Geographic Information Systems (GIS). Explores design, theory, and implementation of GIS software, digitizing, fundamentals of vector and raster GIS processing, georeferencing, map accuracy, and site location. (4 cr) (F)

AWER 4950. Special Topics. Individual study and research upon selected aquatic, watershed, and earth resources problems. (1-3 cr) (F,Sp,Su) ®

AWER 4960. Directed Readings. Provides one-on-one interaction between student and instructor. (1-3 cr) (F,Sp,Su) ®

AWER 4970. Undergraduate Research. Individual or team research. Prerequisite: Advisor approval. (1-3 cr) (F,Sp,Su) ®

AWER 4980. Undergraduate Seminar. Intended to bring upperclassmen up-to-date on aquatic, watershed, and earth resources topics. (1 cr) (F,Sp)

AWER 5130 (d6130). Terrestrial Ecosystem Modeling. Introduces concepts of terrestrial ecosystem cycles, using computer modeling techniques. Includes discussions of modeling concepts, as well as in-class student projects. Prerequisites: Math 1050 and NR/Biol 2220; or permission of instructor. (3 cr) (Sp)

AWER 5150 (d6150). Fluvial Geomorphology. Focuses on physical processes in streams that control their shape, plan form, slope, bed material, and distribution of channel bars. Emphasizes field analysis of these topics, and application of geomor-

phology to aquatic ecology and environmental restoration. Prerequisite: Geol/AWER 3600. Also taught as Geol 5150/6150. (4 cr) (F)

****AWER 5160 (d6160). Hillslope and Landscape Geomorphology.** Includes basics of hillslope weathering, transport, and hydrologic processes. Surveys classic and recent literature on hillslope-scale and landscape-scale geomorphic research. Three lectures and several Saturday field trips. Prerequisite: Geol/AWER 3600. Also taught as Geol 5160/6160. (3 cr) (Sp)

***AWER 5200. Fish Habitat Relationships in Managed Forests.** Examines biological and social factors influencing aquatic ecosystems and fish habitats within the context of forest management. Analyzes ecological relationships of fish habitats within forest ecosystem, and how these are influenced by forest management practices. Provides examples of forest habitat issues in major regions of North America, illustrating that both biological and social factors must be considered in developing management strategies and programs. (3 cr) (F)

AWER 5330 (d6330). Large River Management. Focuses on constituencies participating in modern management of large river basins, including water developers, irrigators, municipalities, power consumers, recreationists, environmentalists, and scientists. Primary examples drawn from Colorado, Columbia, Rio Grande, and Missouri river basins. (3 cr) (F)

*****AWER 5490 (d4490). Small Watershed Hydrology.** Detailed exploration of concepts of hydrologic processes in small, wildland watersheds. Concentrates on recent research findings concerning examining key hydrological processes. Particular attention paid to study of partitioning of water in the hydrologic cycle, sources for runoff generation, snow and snowmelt, and erosion. Features process modeling and parameter estimation techniques as related to wildland systems. Additional oral and written assignments required for graduate students. Prerequisites: Math 1210, AWER 3700. (4 cr) (F)

AWER 5550. Freshwater Invertebrates. Taxonomy, ecology, and biology of major freshwater invertebrate taxa, including insects, crustaceans, molluscs, and oligochaetes. Several weekend field trips and a collection required. Prerequisite: One year of general biology or zoology, or permission of instructor. Also taught as Biol 5550. (3 cr) (Sp)

AWER 5660. Watershed and Stream Restoration. Overview of the current theory and practice of watersheds and streams. Emphasizes field visits with restoration projects and specialists. Prerequisites: AWER/FRWS 5490/4490, AWER/Geol 5150, FRWS 5610 (or equivalent). (2 cr) (Sp)

AWER 5670. Watersheds and Stream Restoration Practicum. Capstone experience. Development of a restoration plan for a site, involving site planning and design. (2 cr) (Sp)

***AWER 5680 (d6680). Paleoclimatology.** Covers climate through the past four billion years of geologic time. Explores driving forces behind climate changes. Examines data and methods used in paleoclimate research. Includes discussion of literature and stresses local paleoclimate records. Three lectures per week, along with field trips. Prerequisite: Geol/AWER 3600 or permission of instructor. Also taught as Geol 5680/6680 and Bmet 5680/6680. (3 cr) (Sp)

AWER 5760 (d6760). Remote Sensing: Modeling and Analysis. Advanced techniques in the analysis of the earth's surface using remotely-sensed imagery and data in a digital format. Projects employ and/or develop research models. (3 cr) (Sp)

AWER 5930 (6930). Geographic Information Analysis. Techniques of geographic information systems, data structures, data input and output, and data manipulation and analysis. Prerequisites: Stat 2000; AWER 4930 or NR 3600 or instructor's permission. (4 cr) (Sp)

***AWER 6100 (d7100). Aquatic Production and Fish Ecology.** Reviews current literature on bacterial, algal, invertebrate, and fish production in lakes, rivers, and the sea. Analyzes physiological, behavioral, population, and community concepts of fish interactions with their environment. Prerequisite: AWER 4500 or equivalent, or instructor's permission. (3 cr) (Sp)

****AWER 6120 (d7120). Aquatic Production Biology.** Review of current literature on bacterial, algal, invertebrate, and fish production in lakes, rivers, and the sea. Particular emphasis is placed on whole-ecosystem productivity studies. (2 cr) (Sp)

AWER 6130 (d5130). Terrestrial Ecosystem Modeling. Introduces concepts of terrestrial ecosystem cycles, using computer modeling techniques. Includes discussions of modeling concepts, as well as in-class student projects. Prerequisites: Math 1050 and NR/Biol 2220; or permission of instructor. (3 cr) (Sp)

AWER 6150 (d5150). Fluvial Geomorphology. Focuses on physical processes in streams that control their shape, plan form, slope, bed material, and distribution of channel bars. Emphasizes field analysis of these topics, and application of geomorphology to aquatic ecology and environmental restoration. Prerequisite: Geol/AWER 3600. Also taught as Geol 6150/5150. (4 cr) (F)

****AWER 6160 (d5160). Hillslope and Landscape Geomorphology.** Includes basics of hillslope weathering, transport, and hydrologic processes. Surveys classic and recent literature on hillslope-scale and landscape-scale geomorphic research. Three lectures and several Saturday field trips. Prerequisite: Geol/AWER 3600. Also taught as Geol 6160/5160. (3 cr) (Sp)

****AWER 6230 (d7230). Fish Ecology.** Reviews current literature on physiological, behavioral, population, and the community ecology of fishes. Particular emphasis placed on current literature relevant to management of sport and endangered freshwater species. Prerequisite: AWER 4500 or equivalent, or instructor's permission. (2 cr) (Sp)

AWER 6240. Graduate Internship/Co-op. Graduate-level educational experience in internship/cooperative education position approved by department. (1-9 cr) (F,Sp,Su) ®

AWER 6330 (d5330). Large River Management. Focuses on the scientific basis of river management and the constituencies participating in modern management of large rivers, including water developers, irrigators, municipalities, power consumers, recreationists, environmentalists, and scientists. Primary examples drawn from Colorado, Columbia, Rio Grande, and Missouri river basins. (3 cr) (F)

****AWER 6520. Applied Hydraulics.** Basic fluid mechanics applied to wildland watershed systems and directed at nonengineering students. Explores nature of fluid state, fluid motion, and steady uniform and varied flow in open channels, under both subcritical and supercritical conditions. Surveys concepts of boundary layers, turbulence, convection, dispersal, and wave formation in unsteady flows. Emphasizes problem formulation and solving. Prerequisites: AWER 5490/4490; Math 2280 (recommended). Also taught as CEE 6520. (3 cr) (Sp)

AWER 6530 (d4530). Water Quality and Pollution. Reviews biological and social problems caused by point and nonpoint source water pollution; toxicology; abiotic and biotic water quality parameters; and use criteria of the Clean Water Act. Graduate-level class will require additional readings of the peer-reviewed literature and an additional class meeting to have in-depth discussions of those readings. Each graduate student will be responsible for making a presentation at the beginning of class, and leading the discussion. (3 cr) (Sp)

AWER 6550. Assessment of Abundance and Related Parameters for Biological Populations. Students learn to estimate population abundance and associated error bounds using mark-recapture, area-swept, declining catch, line-transect, and other techniques. Emphasizes sampling design considerations to match objectives of an assessment to appropriate/feasible level of accuracy and precision. (3 cr) (Sp)

AWER 6600 (d4600). Principles of Surface Hydrology. Study of physical elements of the water cycle, surface hydrological processes, and watershed responses. Explores basic hydrologic concepts and terminology, as well as collection, analysis, and presentation of hydrologic data. Includes field laboratory. Prerequisite: Soil 3000 or instructor's permission. Also taught as Soil 6600/4600. (3 cr) (Sp)

AWER 6650 (d4650). Principles in Fishery Management. Emphasizes management of fish populations within context of community and ecosystem dynamics. Stresses use of simulation models to assess effects of growth, recruitment, and mortality on age-structured populations. (3 cr) (Sp)

***AWER 6680 (d5680). Paleoclimatology.** Covers climate through the past four billion years of geologic time. Explores driving forces behind climate changes. Examines data and methods used in paleoclimate research. Includes discussion of literature and stresses local paleoclimate records. Three lectures per week, along with field trips. Prerequisite: Geol/AWER 3600 or permission of instructor. Also taught as Geol 6680/5680 and Bmet 6680/5680. (3 cr) (Sp)

***AWER 6750 (d7750). Advanced Conservation Biology.** Examines cases and consequences of population and species declines, including activities such as habitat fragmentation and introduction of exotic species, as well as natural causes due to genetics and demography. (3 cr) (Sp)

AWER 6760 (d5760). Remote Sensing: Modeling and Analysis. Advanced techniques in the analysis of the earth's surface using remotely-sensed imagery and data in a digital format. Projects employ and/or develop research models. (3 cr) (Sp)

AWER 6800 (d7800). Aquatic, Watershed, and Earth Resources Departmental Seminar. (1 cr) (F,Sp) ®

AWER 6820 (d7820). Stream Ecology. Explores structure, function, and dynamics of flowing water ecosystems. Prerequisites: NR/Biol 2220 and AWER 4500. (3 cr) (F)

AWER 6870. Ecology Seminar. The Ecology Center schedules regular seminars throughout the school year with ecological scientists from other institutions participating. Ecology majors are required to attend a minimum of 10 such lectures. Students should register for fall semester, but attend through spring semester. Also taught as Biol 6870, EnvS 6870, and FRWS 6870. (1 cr) (F,Sp) ®

AWER 6900. Graduate Special Topics. Offers credit for special assignments, reading, and seminars beyond regularly scheduled courses. (1-6 cr) (F,Sp,Su) ®

AWER 6910. Directed Study. Offers credit for special assignments, reading, and seminars beyond regularly scheduled courses. (1-6 cr) (F,Sp,Su) ®

AWER 6930 (5930). Geographic Information Analysis. Techniques of geographic information systems, data structures, data input and output, and data manipulation and analysis. Prerequisites: Stat 2000; AWER 4930 or NR 3600 or instructor's permission. (4 cr) (Sp)

AWER 6960. Graduate General Ecology. General concepts, history, and issues in all major areas of the science of ecology including: environmental biophysics; and physiological, behavioral, evolutionary, community, ecosystem, and applied ecology in both terrestrial and aquatic environments. Also taught as Biol 6960, EnvS 6960, and FRWS 6960. (5 cr) (F)

AWER 6970. Thesis Research. Offers credit for field or laboratory research at master's level. (1-12 cr) (F,Sp,Su) ®

AWER 6990. Continuing Graduate Advisement. Offers credit for students currently enrolled in a master's program, who are not currently taking classes. Students

may be conducting research or waiting for final approval from School of Graduate Studies. (1-9 cr) (F,Sp,Su) ®

***AWER 7100 (d6100). Aquatic Production and Fish Ecology.** Reviews current literature on bacterial, algal, invertebrate, and fish production in lakes, rivers, and the sea. Analyzes physiological, behavioral, population, and community concepts of fish interactions with their environment. Prerequisite: AWER 4500 or equivalent, or instructor's permission. (3 cr) (Sp)

***AWER 7120 (d6120). Aquatic Production Biology.** Review of current literature on bacterial, algal, invertebrate, and fish production in lakes, rivers, and the sea. Particular emphasis is placed on whole-ecosystem productivity studies. (2 cr) (Sp)

***AWER 7230 (d6230). Fish Ecology.** Reviews current literature on physiological, behavioral, population, and the community ecology of fishes. Particular emphasis placed on current literature relevant to management of sport and endangered freshwater species. Prerequisite: AWER 4500 or equivalent, or instructor's permission. (2 cr) (Sp)

***AWER 7750 (d6750). Advanced Conservation Biology.** Examines cases and consequences of population and species declines, including activities such as habitat fragmentation and introduction of exotic species, as well as natural causes due to genetics and demography. (3 cr) (Sp)

AWER 7800 (d6800). Aquatic, Watershed, and Earth Resources Departmental Seminar. (1 cr) (F,Sp) ®

AWER 7820 (d6820). Stream Ecology. Explores structure, function, and dynamics of flowing water ecosystems. Prerequisites: NR/Biol 2220 and AWER 4500. (3 cr) (F)

AWER 7900. Graduate Special Topics. Offers credit for special assignments, reading, and seminars beyond regularly scheduled courses. (1-6 cr) (F,Sp,Su) ®

AWER 7910. Directed Study. Offers credit for special assignments, reading, and seminars beyond regularly scheduled courses. (1-6 cr) (F,Sp,Su) ®

AWER 7970. Dissertation Research. Offers credit for field or laboratory research at doctoral level. (1-12 cr) (F,Sp,Su) ®

AWER 7990. Continuing Graduate Advisement. Offers credit for students currently enrolled in a doctoral program, who are not currently taking classes. Students may be conducting research or waiting for final approval from School of Graduate Studies. (1-9 cr) (F,Sp,Su) ®

® Repeatable for credit. Check with major department for limitations on number of credits that can be counted for graduation.

¹Parenthetical numbers preceded by *d* indicate a *dual* listing.

*Taught 2002-2003.

**Taught 2003-2004.

***This course is taught alternating years. Check with department for information about when course will be taught.