NICHOLAS SCHOOL
OF THE ENVIRONMENT
DUKE UNIVERSITY
forging a sustainable future

Ecosystem Science and Conservation Program

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The Nicholas School offers one overarching ecological program, **Ecosystem Science and Conservation**, which focuses on the natural science, policy, and management issues that relate to the stewardship of our natural resources. Conservation and ecosystem science are becoming ever more integrated as conservation planning moves to increasingly larger scales and addresses a wider range of resources, from biodiversity to watershed function. For curriculum planning purposes, we have defined the program to provide a diversity of alternative perspectives on natural resource ecology and management. The defining feature of the program is a two-dimensional structure, consisting of a focal *Concentration Area* and an *Approach*. The Concentration defines a topical area or disciplinary specialization. The Approach defines a methodological perspective and toolkit. In combination, these choices define a career track and a planning matrix for coursework and research experience for the MEM degree.

The Ecosystem Science and Conservation concentration seeks to provide:

1. A knowledge base with breadth in ecosystem science including ecology and physical science, policy and economics, and an opportunity to concentrate on the management of a resource or ecosystem of focus.

2. Quantitative and analytical skills of statistics and a choice among tools including: applied mathematics and quantitative modeling, geospatial techniques, community-based participatory approaches, and field ecology skills.

3. Management skills to optimize ecosystem function and health, as well as the ability to work in cross-disciplinary settings in the government, non-profit and business sectors;

4. Oral and written skills to communicate scientific studies and management outcomes to a wide audience, especially at the interface of science, policy and the public.

Ecosystem science emphasizes an integrated, systems-level perspective on natural resource management. Within the framework, a Concentration Area typically is identified as a particular ecosystem (e.g., forests, wetlands) although for some specializations the focus is on the unit of analysis (watersheds or landscapes). The Nicholas School has

particular expertise in forests, wetlands, coastal and marine systems, and the neotropics. In conservation practice, areas of concentration often are defined in terms of levels or scales of conservation activity. These include focal species, communities or ecosystems; site assessment and nature reserve design; land use policy and planning; and sustainable development. The Nicholas School has particular expertise in habitat classification and mapping for focal species and communities, site selection and nature reserve system design, and land use policy and sustainable development. Examples of approaches include field-based approaches with an emphasis on natural history, geospatial analysis (emphasizing geographic information systems and remote sensing), community-based methods involving stakeholder participation, and modeling (statistical and simulation). The combination of topical concentrations and toolkits provides for a rich array of professional specializations and, respecting this, curriculum planning within this program is highly individualized. Not all possible combinations are feasible, either because they are not viable career tracks or because the supportive expertise is not available in the Nicholas School. Some popular areas of concentration and approaches are detailed for this program separately on the following pages.

Students interested in forest ecosystems in particular have a choice of degree programs: (a) a forest concentration under Ecosystem Science and Conservation leading to the MEM degree; (b) the Forest Resource Management program leading to the MF degree; or (c) a combination of the two, leading to both degrees in as little as five semesters. To decide among these options, review the required curriculum for each option in light of your interests and your career goals. The MF degree is well established and recognized within forest industry and forest conservation organizations. Some jobs, particularly with private companies (e.g., land trusts) doing consulting forestry and with international forestry organizations, might require the MF degree. The joint MEM/MF degree is increasingly popular with students who complement the MF credentials with the extra breadth and flexibility of the MEM degree.

Curriculum-planning Menus

In the Ecosystem Science and Conservation (ESC) program, a course of study is designed by selecting courses from several menus in key areas. Specific courses selected from each area depend on the Concentration and Approach, and thus the curriculum plan can be tailored to each student's past experience and career goals.

The key areas are (1) *Core knowledge* or fundamentals, which provide the basic foundation in science and policy concepts needed in a particular program area; (2) *Tools*, which depend very much on the selected Approach; and (3) *Specializing Electives*, which further refine an approach or provide additional depth of knowledge in key areas.

On the following pages, the ESC program is outlined in general. Specific courses are suggested in some cases, but there are often a number of alternative courses available to meet track requirements. Listings of available courses should be consulted each semester as an aid to curriculum planning.

Participating Faculty

The ESC program is supported by a number of faculty within and beyond the Nicholas School. Affiliated faculty include:

Faculty:	*Office (email):*
Norm Christensen	A124 (normc@duke.edu)
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Program Definition and Curriculum Planning

The ESC program focuses on science and management issues framed in terms of conserving targeted resources or providing for key ecosystem processes and services (food and fiber, watershed protection). Managing ecosystems entails achieving a balance of competing demands on natural resources and meeting these needs in a sustainable manner.

Program Requirements

In addition to the Nicholas School's prerequisites for all MEM degrees, the ESC program requires a prerequisite course in Principles of Ecology. The MEM degree requires a total of 48 units of coursework. The planning guides outlined here for ESC dictates the distribution of courses within key areas for 11 courses (approximately 33 units) of the student's total program. With the Master's Project hours (ENVIRON 399, 4-6 credits) and MP seminar (ENVIRON 398.03: enroll every semester; 1 credit earned on completion of program), this still leaves 2-4 courses to be selected at the student's discretion. We suggest additional specializing electives, although alternative plans (*e.g.*, foreign languages) are acceptable.

Areas of Concentration

Topical areas in the ESC program focus might on a particular ecosystem, and the Nicholas School has expertise in forests, wetlands, the tropics, and coastal/marine systems. Additionally, students can focus on watersheds or landscapes as Concentrations, recognizing these as the functional unit for integration and planning in many applications

today. For students interested more generally in conservation (i.e., without reference to a specific ecosystem), concentrations typically focus on scales of conservation activity. The Nicholas School is heavily invested in conservation planning at the scale of functional landscapes or reserve systems, but also has expertise at the level of focal species or, at larger scales, in land use and sustainable development. Concentration areas are flexible and subjective; the litmus test for a feasible concentration is that it implies a coherent body of knowledge and a reasonably well-bounded arena for practical applications.

Approaches

Typical approaches within ESC include (1) field methods, (2) geospatial analyses, (3) community-based and participatory approaches, and (4) assessments based on models (statistical or simulation). Again, approaches and toolkits may be tailored to individual interests and career goals. Tool courses can be found within the Nicholas School as well as across campus and at other Triangle universities; students are encouraged to take advantage of these resources.

Course Menus

Courses supporting the ESC program are taught within the Nicholas School, at several other departments at Duke, as well as through UNC-Chapel Hill and NCSU. The list of courses below is not exhaustive; see the Nicholas School's Advising webpage (http://www.nicholas.duke.edu/advising) for additional course suggestions and current updates on course availability.

Prerequisites: NS prerequisites (computer familiarity, calculus, statistics); principles of ecology; microeconomics recommended for some specializations. Note that microeconomics is not required for the ESC program but it *is* required for Resource & Environmental Economics (ENVIRON 270), a course taken by a large number of ESC students. Prerequisites not met before entering the program *must* be satisfied within the first year.

Core Courses:

Choose a total of 4 courses: an overview course, two core natural sciences (one of which *must* be in the selected system of concentration), and one core social science course, for a minimum of 12 credits.

Overview: **Ecosystem Management** (ENVIRON 320 or its equivalent in modules) or **Conservation Biology** (ENVIRON 203 or equivalent) — required. In the case that 320 [1-credit] modules are not offered (e.g."Ecosystem Management", "Adaptive Management") students will be provided with other options by the ESC chair.

Core Natural Science: The two core courses should be complementary and provide a solid foundation in the fundamental concepts needed for the topical concentration. The core natural science courses must total at least 6 credits.

For an ecosystems focus: Forest Ecosystems (ENVIRON 213), Tropical Ecology (ENVIRON 217), Wetlands Ecology/Management (ENVIRON 312), Soil Resources (ENVIRON 221L), Biogeochemistry (EOS/BIO 272). If the area of concentration is watershed management, then take Watershed Hydrology (ENVIRON 234); if functional landscapes, then take Landscape Ecology (ENVIRON 214). For conservation focus: Biodiversity Science and Applications (ENVIRON 257L), Landscape Ecology (ENVIRON 214), Primates and Tropical Forest Conservation (BAA 184), Plant Ecology (UNC/BIOL 661), Landscape Biogeography (UNC/GEOG 444), many others.

Core Social Sciences: One general course that will provide an overview and context for the concentration. The most appropriate choices include Resource and Environmental Economics (ENVIRON 270), Environmental Politics (ENVIRON 274), and Environmental Law (LAW 235), although alternatives are available.

Approaches/Tools:

Choose one general statistics course (advanced, if introductory level course already met in prerequisites), plus two courses from a single approach, plus one additional course from a different but complementary approach, for a minimum of 12 credits. Note that because many of these options are not full 3-credit courses, the requirements are tallied in terms of course equivalents (3 credits = 1 course).

Basic Statistics: Applied Data Analysis for Environmental Science (ENVIRON 210) is intended to serve as the basic course in statistics for this program. Other similar courses (e.g., at NCSU or UNC) may be substituted with the advisor's consent.

Geospatial: Fundamentals of Geospatial Analysis (GSA, ENVIRON 259.), GSA for Conservation & Management (ENVIRON 261), GSA for Marine and Coastal Management (ENVIRON 265), Spatial Analysis in Ecology (ENVIRON 352), Satellite Remote Sensing for Environmental Analysis (ENVIRON 357), Advanced Geospatial Analysis (ENVIRON 359). Note that while some of these are 4-credit courses, only 3 credits count per course.

Community-based, Participatory: E.g., Social Science Surveys (ENVIRON 280), Environmental Conflict Resolution (ENVIRON 296), Environmental Decision Analysis (ENVIRON 385), Community-based Environmental Management (ENVIRON 298.31); others. Note that Conflict Resolution (2 credits) and Community-based Environmental Management (1 credit) serve as a single 3-credit course equivalent.

Field Ecology: E.g., Forest Resource Field Skills (ENVIRON 201), Forest Vegetation Sampling (ENVIRON 206), Wetland Field Skills (ENVIRON 298.17), Primate Field Biology (BAA144L); various natural-history courses (ornithology, entomology, etc.).

Modeling: E.g., Water Quality Management/Modeling (ENVIRON 236), Applied Regression Analysis (ENVIRON 255), Multivariate Analysis in Community &

Landscape Ecology (ENVIRON 358), Ecological Models and Data (ENVIRON231L/BIO268L), Risk Assessment (UNC/ENVR 470), advanced regression or other advanced statistics courses as appropriate.

Specializing Electives (3 courses):

Courses selected to provide system-specific expertise or additional tools. Select at least one natural science course and one social science course; the total can also include additional tools as appropriate to the concentration and approach (9 credits minimum). These courses can be selected from any of those listed above as core or tool courses, as well as many others suggested on the Advising webpage. These selections should support your Master's Project as well as enriching your career track; discuss these courses with your faculty advisor.

Sample Curricula

These examples are intended only to convey the range of possibilities available.

Case 1: Watershed management/geospatial analysis. A student interested in water quality management at the watershed scale, using geospatial methods, might choose this curriculum:

Core: Ecosystem Management (ENVIRON 320), Watershed Hydrology (ENVIRON 234), Landscape Ecology (ENVIRON 214), and Environmental Law (LAW 235)

Tools: Applied Data Analysis for Environmental Science (ENVIRON 210), Fundamentals of GSA (ENVIRON 259), GSA for Conservation & Management (ENVIRON 261), and Wetland Field Skills (ENVIRON 298.17)

Electives: Satellite Remote Sensing for Environmental Analysis (ENVIRON 357), Watershed Systems (UNC/GEOG 441), and Land Use and Environmental Policy (UNC/PLAN 740,741).

Notes: This example could be redesigned to emphasize a modeling toolkit by substituting courses such as Water Quality Modeling (ENVIRON 236) and Risk Assessment (UNC/ENVR 175) for the geospatial courses above. Similarly, substituting Wetlands Restoration (ENVIRON 309) as a specializing elective and Multivariate Analysis in Community & Landscape Ecology (ENVIRON 358) as a tool would tailor the curriculum more to wetland restoration.

Case 2: Nature reserve design/geospatial toolkit. A focus on reserve systems might lead to a curriculum that differs on several courses while sharing many of the same tools:

Core: Conservation Biology (ENVIRON 203), Applied Population Ecology (ENVIRON216), Landscape Ecology (ENVIRON 214), and Resource and Environmental Economics (ENVIRON 270)

Tools: Applied Data Analysis for Environmental Science (ENVIRON 210), Fundamentals of GSA (ENVIRON 259), GSA for Conservation Management (ENVIRON 261), and Environmental Decision Analysis (ENVIRON 385)

Electives: Protected Areas, Tourism and Development (ENVIRON 275), Spatial Analysis in Ecology (ENVIRON 352), Advanced Geospatial Analysis (ENVIRON 359)

Here, the fourth geospatial course also leads to a Certificate in Geospatial Analysis.

Case 3: Land-use planning/Community-based methods. A student interested in developing regional "greenprints" in collaboration with local citizens and planners might select:

Core: Conservation Biology (ENVIRON 203), Landscape Ecology (ENVIRON 214), Plant Geography (UNC/BIOL143), and Environmental Politics (ENVIRON 274)

Tools: Applied Data Analysis for Environmental Science (ENVIRON 210), Social Science Surveys (ENVIRON 280), Environmental Decision Analysis (ENVIRON 385), Fundamentals of GSA (ENVIRON 259)

Electives: Protected Areas, Tourism and Development (ENVIRON 275), Environmental Conflict Resolution (ENVIRON 296) + Community-based Environmental Management (ENVIRON 298.31), Land Use and Environmental Planning (UNC/PLAN 740,741)