Science and Public Affairs Education: the Case of Columbia's School of International and Public Affairs

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1.0 Background: Science and Public Policy Analysis

When the first public administration graduate programs were established in the early decades of the twentieth century, their focus was on public law, government and the requirements of citizenship in a democracy. The Institute of Public Administration at Columbia and the Maxwell School of Citizenship and Public affairs at Syracuse University were the best known early efforts to provide training in public administration. An effort to develop a “science” of Public Administration emerged along with the New Deal as a response to the increased volume and complexity of government’s work. The 1940’s saw the development and use of operations research during World War II and the increased use of economic theory in a new effort to manage national economies (e.g. Keynes and his successors).

The growth of the American industrial economy and the increased complexity of modern economic life generated “policy shops” that analyzed public policies with applied economic and quantitative techniques. The work of the Rand Corporation for the Department of Defense during the Vietnam War and the work of applied economists in the Office of Economic Opportunity (OEO) during the War on Poverty of the same era helped create the new field of policy analysis. This led to increased use of quantitative analytic techniques in a group of public policy schools in the late 1960’s and early 1970’s. Most prominent among these were The Kennedy School at Harvard, the Woodrow Wilson School at Princeton and a new set of schools that formed the Association for Public Policy Analysis and Management in the late 1970’s. According to APPAM’s website:

“In 1978 the Sloan Foundation sponsored a conference on the public policy and management curriculum at Hilton Head, South Carolina, at which a proposal was made to create a new professional association of graduate schools of public policy and management. APPAM formally was created at a May 1979 conference at Duke University by representatives of 15 policy schools and research institutes.”
http://www.appam.org/about/generalinfo.asp

Columbia was an early member of the Association, and its newly created MPA program (1977) identified with this new group. There was a split at that time between more traditional, less analytic public administration programs and these newer public policy programs. The newer programs included a number of prominent applied economists among their faculty. Much was made at the time of the split between these two types of schools, but the addition of public management to the curricula of the newer programs and the addition of economics to the curricula of the older programs led to a convergence of the two in the 1990’s that largely ended this schism.
The addition of economics to public administration curricula had two objectives:

- Providing an understanding of modern economies and facilitating public policy regarding economic life (largely through applied macroeconomics).
- Providing a set of formal analytical tools that supplied policy analysts with a range of methods for developing and assessing issue-specific policy proposals (largely though applied microeconomics).

Over the past quarter century, we have seen the economics discipline move further from applied policy analysis, becoming increasingly theoretical. In turn, a growing group of policy-oriented economists have found their intellectual homes in public policy programs.

The growing complexity of economic life and financial transactions has been complicated further by the increased technical and scientific content of the goods and services provided by our post-industrial society. For example, the free market marvel of Henry Ford’s Model T has been replaced by today’s highly regulated automobile - a vehicle that includes pollution control technology, required safety equipment and a range of computer controls and other technologies. Similarly, American farming has come a long way from “40 acres and a mule” to become a highly mechanized, computer-controlled agribusiness.

Public policy requires an understanding of science and technology to be effective. Farming practices influence food safety, public health and water supplies, and even generate ethical issues that stem from cloning and genetic engineering. One cannot regulate those activities in the public interest if one does not understand the science and technology upon which they are based. How can one create policy on “how clean is clean” at a toxic waste site—how far clean-up must proceed before it is complete—without some understanding of the transport, toxicity and latency of the individual and interacting chemicals?

Just as policy analysts a generation ago needed to add statistics and economics to their toolkit, today they must add an understanding of science and technology as well.

2.0 The Increased Importance of Science and Technology

The names Henry Ford, Alexander Graham Bell and Thomas Edison are well known and are of a time when technology and the economy was simple enough for inventors to become “heroes” and even players in the national economy. Today’s version of these innovators, like Bill Gates and Steve Jobs, may not be “inventors”, but are technically sophisticated managers who depend on huge R & D machines to develop new products. They continue the 20th century practice that tied economic growth to technological innovation.
New products, made with new and more efficient production techniques, are constantly introduced and upgraded: autos, electricity and illumination, refrigeration, air conditioning, radio, telephones, black and white TV, color TV, digital TV, main frame computers, laptop computers, satellite communication, air travel, cell phones, Blackberries, the internet, and computer software. **Modern economic life is dominated by the development and introduction of new technologies.**

Just as economic life is dominated by science and technology, increasingly public policy issues are shaped by scientific and technological developments as well. Understanding public policy requires increased levels of scientific literacy. For example (not an exhaustive list):

- **National security**: Arms, aircraft, submarines, ships, missiles, atomic weapons and spy satellites are all subject to constant technological change and advancement. Modern warfare is dominated by the importance of new technology and the ability or inability to develop counter-measures to these new technologies. The verification of limits on underground nuclear testing greatly benefited from advances in seismology research instruments, as demonstrated by Paul Richards and Lynn Sykes of Columbia University’s Lamont Doherty Earth Observatory.

- **Health care**: From immunizations to MRI’s, health care and the associated calculation of costs and benefits are constantly changing due to the development of new drugs and technologies. Moreover, the effect of the use of non-medical technologies on human health requires both an understanding of those technologies and of their impact on human biology and chemistry. People are living longer and healthier lives as a result of medical technologies. These technologies are reshaping our economies, societies and politics in profound ways that we are only beginning to understand.

- **Environmental Protection and Sustainability**: The entire range of human activity influences a web of biological relationships in our ecosystems that eventually lead back to humans and their health. We are learning more every day about the science of our planet, how it is changing due to human impacts and what we need to do to minimize our negative impact or “footprint”. We need to learn more about how to provide food, water, energy and other resources based on the principles of reuse and sustainability.

Scientific and technical literacy is essential for understanding and governing the modern world. To maximize the benefits and reduce the costs of using new technologies, decision-makers must develop a more sophisticated understanding of the science of the new technologies they are selling or trying to regulate. For example, in the 1950’s and 1960’s engineers knew that the toxic waste they were
dumping the ground could kill people and ruin the environment, but the business leaders they worked for were largely ignorant of those scientific facts. Most of the elected leaders responsible for the communities “hosting” these dumpsites did not even know they existed or, if they did, that they were dangerous. At the infamous Love Canal in Niagara Falls, New York, the Hooker Chemical Company sold the land they dumped chemicals on to the local government for a dollar. The community then built a school on top of the site, with a playground directly over the dump. Eventually the chemicals leached off the site, causing great harm to the local community. It is difficult to know how much it will cost us to clean up this nation’s toxic waste, but the job is far from over and the bill is probably over $100 billion. Ignorance was far from bliss. In the 21st century we need to do a better job of teaching our leaders to understand science and technology.

3. What Science Needs to Be Taught to Policy Students

When thinking about teaching science to public policy students, it is important to understand that they are not graduate students who plan to become scientists, or even undergraduates who may someday become scientists. Public Policy students are being trained to become problem-solving public sector professionals. However, as indicated above, the problems they are seeking to solve have an increasing level of technical content.

Policy students need to learn how to verify scientific findings and separate sound from unsound science. They need to serve as translators between the scientific community and policymakers who are untrained in science. The specific fields of scientific knowledge most important to policy students will vary by the areas of public policy that they work in. For example:

- Students preparing to be development practitioners, working and hoping to bring sustainable development to impoverished areas of the world, need to learn agricultural science and some elements of health science as well. This includes understanding diseases such as malaria and HIV/AIDS as well as some of the basic public health concepts that minimize disease from exposure to human and animal wastes and other water-borne diseases.

- Students working in security policy will need to understand the engineering science that is the basis of modern weapon systems and the science that provides an understanding of the impact of these weapons on people, ecosystems and human structures.

- Students working in energy policy will need to understand the science of solar, wind and geothermal energy as well as the science and engineering of carbon capture and storage. They will also need to understand a range
of engineering issues related to the transport of energy in its various forms - from oil and gas to the transmission of electricity.

- **Finance** students that work in carbon and sulfur dioxide markets will need to be familiar with the chemical properties of the materials they are trading.

### 4.0 Environmental Science in Public Administration and Public Policy

**Masters Programs**

The U.S. News and World Report ranking of the best graduate programs in public affairs has a specific ranking for Environmental Policy and Management specializations. Within the top ten programs, the following four include science courses:

- Indiana University: Dual Master of Public Affairs (MPA) and Master of Science in Environmental Science (MSES), ranked 1st
- Duke University: Dual Master of Environmental Management (MEM) and Master of Public Policy (MPP), ranked 3rd
- University of Michigan: Dual Master of Science (MS) in Natural Resources and Environment and Master of Public Policy (MPP), ranked 6th
- Columbia University: Master of Public Administration in Environmental Science and Policy (MPA-ESP), ranked 9th

Although all these degrees focus on policy and science issues, the first three are dual degrees, combining two distinct curricula and requiring on average three years of study. Columbia’s MPA in Environmental Science and Policy is the only standalone program that requires environmental science in an MPA degree. Table 1 summarizes the curricula of the three dual degree programs. Table 2 summarizes the curricula of the programs that are not dual degrees. The six other schools in the top ten offer specializations on environmental issues, with a focus on subjects like environmental policy, law, economics, risk analysis and management, but have no science requirements.

All four programs combining science and policy are based on very similar rationales: the importance of a strong background in science to be able to translate science into policy and effectively communicate within the environmental policy arena. Importance is given to a diverse combination of skills to become “natural resources policy practitioners”.
<table>
<thead>
<tr>
<th>University</th>
<th>Degree Offered</th>
<th>Core Science Requirements</th>
<th>Core Policy Requirements</th>
<th>Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Indiana University--Bloomington</td>
<td>Dual Master of Public Affairs (MPA) and Master of Science in Environmental Science (MSES) degree.</td>
<td>• Applied Mathematics for Environmental Science; • Applied Ecology; • Environmental Chemistry; • Environmental Engineering</td>
<td>• Public Management; • Statistical Analysis for Effective Decision Making; • Public Management Economics; • Law and Public Affairs; • Public Finance and Budgeting</td>
<td>• Environmental Management; • Environmental Systems Analysis and Modeling; • Specialized Concentration; • Any MSES or MPA concentration</td>
</tr>
<tr>
<td>3 Duke University</td>
<td>Dual Master of Environmental Management (MEM) and Master of Public Policy (MPP) degree</td>
<td>At least 36 credits within the Nicholas Schod, depending on the concentration chosen.</td>
<td>• Policy Analysis; • Statistics and Data Analysis; • Ethics and Policy Making; • Microeconomics; • Politics of the Policy Process; • Quantitative Evaluation Models; 1-2 Electives • Master's Project and Summer internship required</td>
<td>• Ecosystem Science and Conservation; • Ecotoxicology and Environmental Health; • Forest Resource Management; • Water and Air Resources; • Coastal Environmental Management; • Energy and Environment; • Environmental Economics and Policy; • Global Environmental Change</td>
</tr>
<tr>
<td>6 University of Michigan--Ann Arbor</td>
<td>Dual Master of Science (MS) in Natural Resources and Environment and Master of Public Policy (MPP) degree</td>
<td>• At least 25 credits in Natural Resources and Environment; • Two Analytics Courses; • Integrative Master's Opus</td>
<td>• Microeconomics; • Statistics; • Values, Ethics, and Public Policy; • Political Environment Policy Making or Public Policy; • Foreign Policy; • Public Management; • Participation in an Integrated Policy Exercise; • Ten-week public-sector internship</td>
<td>MS has 8 specialization &quot;sub-plans&quot;: • Aquatic Sciences: Research and Management; • Conservation Biology; • Behavior, Education and Communication; • Environmental Justice; • Environmental Policy and Planning; • Environmental Informatics: GIS and Modeling; • Sustainable Systems; • Terrestrial Ecosystems</td>
</tr>
</tbody>
</table>
4.1 Curriculum Descriptions of Several Top 10 Dual Degree Programs

The three dual degree programs offer similar curricula, with core science and policy requirements as well as several concentrations to choose from, allowing for deeper specialization within an environmental topic of choice. Depending on the focus of the concentration, students can pick and choose electives, deciding on a more science- or policy-based curriculum.

The Indiana University School of Public and Environmental Affairs program is the only dual degree that is embedded within one school and includes specific concentrations designed for the dual program.

As shown in Table 1, there are four possible concentrations. Of these concentrations, the first two, Environmental Management and Environmental Systems Analysis and Modeling, offer a comprehensive choice of elective options out of which students must choose an equal number of science- and policy-based courses. Examples of science courses offered are Aquatic Chemistry, Environmental Toxicology, and Fundamentals of Air Pollution. Social science courses vary from Data Analysis, Risk Analysis and Communication to Management, Law and Economics. The latter two concentrations are broadly defined, allowing for students to combine courses from the MPA and MSES or choose a specific concentration within either program, combining it with courses from the other degree.

Table 1 also shows the specific core science and policy requirements for the dual degree. These must be taken, regardless of the concentration chosen. All students thus receive the same instruction in a broad range of courses, covering environmental science (Applied Ecology, Environmental Chemistry, and Environmental Engineering), economics (Public Management Economics and Public Finance and Budgeting), mathematics (Applied Mathematics for Environmental Science and Statistical Analysis for Effective Decision Making), and public policy (Public Management and Law and Public Affairs).

Duke University offers a dual degree that combines a program from the Sanford Institute of Public Policy with one from the Nicholas School of the Environment. Students must fulfill requirements for both degrees.

As Table 1 indicates, the Environmental Management and Public Policy dual degree offers eight concentrations. The four first concentrations are mainly science-based, with a focus on natural resources and ecosystem sciences, and require a minimum of one social science course, while the other four are more focused on policy and environmental management. Courses and foci vary greatly across these concentrations, ranging from Biology and Conservation of Sea Turtles and Environmental Epidemiology to Energy Technology and Political Ecology, though, as the table shows, all concentrations build a strong knowledge
base in the sciences, all requiring at least 36 science credits within the Nicholas School. Each concentration also requires the completion of a Master’s Project representing an in-depth analysis of a chosen environmental issue.

The Sanford Institute requires 39 credits to be completed, and a Master’s Project as well as a relevant summer internship are required to complete the program.

The University of Michigan offers a dual degree that combines a program from the School of Natural Resources and the Environment with one from the Ford School of Public Policy. Students must fulfill separate requirements for each degree. The Natural Resources and Environment MS offers eight concentrations. As shown in the table, these “specialization sub-plans” include more science- and technology-based tracks like Conservation Biology, Terrestrial Ecosystems, and Environmental Informatics: GIS and Modeling, as well as more policy-oriented options like Environmental Justice, Environmental Policy and Planning, and Behavior, Education, and Communication. A wide array of courses, from Limnology and Biology of Insects to Psychology of Environmental Stewardship are offered. Students are also required to complete an “Integrative Master's Opus”.

As noted in Table 1, the Ford School requires six core policy courses, and students must participate in the “Integrated Policy Exercise” (a school-wide policy simulation) and a ten-week public-sector internship (the Natural Resources Opus and this internship can be combined).

It is important to note that other schools within the top ten ranking offer courses that relate in some way to science, but are not hard science courses or are not part of the curriculum per se. For example, Syracuse University’s MPA in Environmental Policy and Administration (ranked second) offers a course entitled Climate Change: Science, Perception & Policy. However, the degree in and of itself focuses essentially on administrative, political and legal aspects of environmental issues. Students do have the opportunity to choose electives from the State University of New York College of Environmental Science and Forestry, but this is an off-campus option and is not considered here as part of the curriculum itself. In the same vein, students enrolled in the University of Wisconsin’s MPA (ranked 10th) can simultaneously take six courses to obtain an “Energy Analysis and Policy” certificate through the Nelson Institute for Environmental Studies. Courses offered include “Air Resource Science and Policy” and “Scientific Background to Global Environmental Problems”. Also of interest, the University of Washington’s MPA (ranked 5th) offers a course entitled “Role of Scientific Information in Environmental Decisions”, which is part of a series of electives labeled “Environmental Policy Processes”. Although the program does not offer science training, this particular course acknowledges the important role of scientists in framing debates and decisions, and could be an excellent component of an environmental science and policy program.
4.2 Science Instruction

The proportion of science instruction varies greatly within the three dual degree programs, depending on concentrations and electives chosen by the students. The only degree with several specific science course requirements is the Indiana program, whereas the other curricula are more dependent on individual choices. The nature of the degree received is thus also variable, with some individuals graduating as proficient scientists and others as policy experts. However, as one half of the degree is always public policy, the variable remains the amount of science instruction actually received.

Conversely, although the Columbia MPA in Environmental Science and Policy program offers a choice of electives in its second and third semesters, its curriculum is essentially predetermined, without any concentration options. This ensures that students are exposed to the mix of science and policy instruction that was originally designed by the program’s faculty. Students graduate with a balanced degree and are trained to master fundamentals of earth systems, making them well-versed earth problem solvers.

The option to choose from several concentrations has the advantage of giving students the flexibility to design their curriculum and is attractive for that reason. Although the dual degrees were analyzed alongside the MPA in Environmental Science and Policy program at Columbia, they are essentially very different programs. While Columbia’s program is designed to train a specific type of professional, the dual degrees qualify graduates with very diverse skill-sets, specialized in public policy and a particular area of focus within the environmental arena. A combination of two different degrees is very different from a specific degree created with a precise objective in mind. Students at Columbia may also enroll in a stand-alone science degree, and complete a dual degree as well. A number of options are available including environmental health science, environmental engineering, urban design, ecology and environmental science.

Another key difference of the MPA in Environmental Science and Policy is that it has tailored courses that provide a mix of science and policy, as in the program’s three-semester integrative workshop. This course offers students a chance to combine science and policy analysis through an interdisciplinary problem-solving exercise. In their first two semesters, students are required to analyze a piece of legislation that has been proposed but not enacted, communicate its science elements to nonscientists, and develop a detailed program implementation plan. The proposed legislation is related to aspects of climate change, natural resources or other environmental issues, requiring both a science- and policy-based analysis. In their first semester, students begin by identifying the environmental problem at hand and explaining the science behind this problem. Once this has been established, a solution is proposed and analyzed, with a focus on the science behind this solution and related controversies. The
semester wraps up with the identification of ways to measure the success of the proposed program.

The second semester is policy-based and students delve deeper into questions of implementation. Issues such as political analysis, budgeting and performance management are tackled as students develop a master calendar, specifying the steps that must be taken to ramp up the new program. The final semester differs slightly as workshop groups act as consultants for a government or nonprofit environmental organization. Examples of projects vary from analyzing payments for ecosystem services, calculating the carbon footprint of an organization to analyzing energy policies or the potential effects of climate change on national parks. As this sample shows, more often than not there is the need to explain complex scientific or technical dynamics in a way that can be understood and used by policy makers or general audiences.

4.3 Analysis

Within this notion of “translating science to non-scientists” lies one of the fundamental purposes of science and policy interaction. The world of policy is one of tough deadlines, swift decision-making and short attention spans. The best policy analysts must also be excellent communicators. Environmental policy professionals must be conversant in relevant scientific systems and able to transfer information from the scientific realm to the political, decision-making sphere. By familiarizing students with legislation, confronting them with group work and requiring them to present complex findings in accessible ten-minute presentations, the MPA in Environmental Science and Policy workshop trains students to work effectively within the realities of policy-making.

An interesting aspect of the MEM at Duke and the MS at Michigan is that they both offer policy courses within their concentrations. As stand-alone, science-oriented degrees, they still include public policy within their curricula. On the other hand, other than Columbia, none of the policy programs within the top ten environmental programs requires science instruction. This seems to indicate that scientists have come to understand the need to add environmental policy to environmental science sooner than environmental policy folks have come to add environmental science to their policy concentrations. Our view is that sophisticated environmental policy and management analysis requires that understanding of fundamental environmental and ecological science.

5.0 Public Policy in Environmental Science and Environmental Studies Masters Programs

A few U.S. universities offer environmental programs that combine science and policy courses but are not specifically Public Administration or Public Policy degrees. Five of these programs have been analyzed and are presented below.
• Boston University: MA in Energy and Environmental Analysis
• Columbia University: MA in Conservation Biology
• Johns Hopkins: MS in Environmental Science and Policy
• Purdue University: MS in Ecological Science and Engineering
• Yale University: Master of Environmental Management

These programs vary greatly in their emphasis on the public policy component. The Columbia and Purdue degrees are natural science degrees but require some components of public policy within their curricula. The other three degrees offer a close balance between science and policy requirements. Again, most of these programs propose several concentrations from which students must choose options.

5.1 Curriculum Descriptions of Well-known Programs

**Boston University** offers this MA through its Graduate School of Arts and Sciences. As shown in Table 2, core requirements combine courses in quantitative methods, natural science and policy. In order to expose students to the “broad, interwoven nature of the environmental field”, students must choose two courses within a “Theory and Methods” cluster as well as a “Modeling and Analysis” cluster. Examples of such courses are Marine Biochemistry, Global Environmental Negotiation and Policy Geographic Information Systems, and Groundwater Modeling.

In addition to the core curriculum, students also select a concentration in which they must complete four courses. A broad variety of courses is offered, from geology, green manufacturing and solid waste management to environmental psychology, for concentrations that include resource management, policy analysis and evaluation, and environmental health, to name a few of those shown below.
<table>
<thead>
<tr>
<th>University</th>
<th>Degree Offered</th>
<th>Core Requirements</th>
<th>Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston University</td>
<td>MA in Energy and Environmental Analysis</td>
<td>• Quantitative Methods;</td>
<td>• Resource Management;</td>
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<tr>
<td></td>
<td></td>
<td>• Physical or Ecological Environmental Principles;</td>
<td>• Modeling and Systems Analysis;</td>
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<td>• Energy, Society, and the Environment;</td>
<td>• Energy Facility Planning;</td>
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<td>• Environmental Policy Analysis</td>
<td>• Systems Engineering;</td>
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<tr>
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<td></td>
<td>• Physical or Ecological Environmental Principles;</td>
<td>• Policy Analysis and Evaluation;</td>
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<tr>
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<td></td>
<td>• Energy, Society, and the Environment;</td>
<td>• Comparative Systems Analysis;</td>
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<td></td>
<td></td>
<td>• Environmental Policy Analysis</td>
<td>• Resources Environment and Economic Development;</td>
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<tr>
<td></td>
<td></td>
<td>• Physical or Ecological Environmental Principles;</td>
<td>• Environmental Health</td>
</tr>
<tr>
<td>Columbia University</td>
<td>M.A. in Conservation Biology</td>
<td>• Fundamentals of Ecology and Evolution;</td>
<td>None, but three possible tracks:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Conservation Biology;</td>
<td>Academic; Professional; and Educational</td>
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<tr>
<td></td>
<td></td>
<td>• Environmental Policy, politics and management;</td>
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<td></td>
<td></td>
<td>• Electives in conservation science, and environmental policy</td>
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</tr>
<tr>
<td>Johns Hopkins</td>
<td>MS in Environmental Science and Policy</td>
<td>• Quantitative Methods for Environmental Sciences;</td>
<td>• Environmental Monitoring and Analysis;</td>
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<td></td>
<td></td>
<td>• Chemistry of Natural Processes;</td>
<td>• Ecological Management;</td>
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<tr>
<td></td>
<td></td>
<td>• Geological Foundations of Environmental Science;</td>
<td>• Environmental Management;</td>
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<td>• Hydrology and Water Resources;</td>
<td>• Environmental Planning</td>
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<td></td>
<td>• Oceanic and Atmospheric Processes;</td>
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<td></td>
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<td>• Principles and Methods of Ecology;</td>
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<td></td>
<td></td>
<td>• Environmental Policymaking and Policy Analysis</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Five electives</td>
<td></td>
</tr>
<tr>
<td>Purdue University</td>
<td>MS in Ecological Science and Engineering</td>
<td>• Biology;</td>
<td>• Ecological &amp; Biological Sciences;</td>
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<td></td>
<td></td>
<td>• Environmental Policy, Economics, Human Dimensions, and/or Institutional Analysis;</td>
<td>• Life Cycle Thinking &amp; Sustainability;</td>
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<tr>
<td></td>
<td></td>
<td>• 2-credit course or summer internship;</td>
<td>• Environmental Policy, Economics, &amp; Institutional Analysis;</td>
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<tr>
<td></td>
<td></td>
<td>One course each from two of the following:</td>
<td>• Biogeochemistry;</td>
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<tr>
<td></td>
<td></td>
<td>• Life Cycle Thinking/Sustainable Design;</td>
<td>• Hydrological Sciences;</td>
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<td></td>
<td>• Biogeochemistry;</td>
<td>• Ecosystem Analysis Tools;</td>
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<td></td>
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<td>• Hydrological Sciences;</td>
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<tr>
<td></td>
<td></td>
<td>• Ecosystem Analysis Tools</td>
<td></td>
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<tr>
<td>Yale University</td>
<td>Master of Environmental Management</td>
<td>One in each category:</td>
<td>• Ecology, Ecosystems and Biodiversity;</td>
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<tr>
<td></td>
<td></td>
<td>• Earth and Climate Science;</td>
<td>• The Social Ecology of Conservation and Development;</td>
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<td></td>
<td>• Ecosystem Science and Biodiversity;</td>
<td>• Forest Science, Management, and Conservation;</td>
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<td>• Sustainable Development and Social Ecology;</td>
<td>• Global Change Science and Policy;</td>
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<td></td>
<td></td>
<td>• Economics;</td>
<td>• Environment, Health, and Policy;</td>
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<td></td>
<td>• Policy, Institutions and Law;</td>
<td>• Industrial Environmental Management Training;</td>
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<td></td>
<td></td>
<td>• Environmental Health and Urban and Industrial Ecosystems;</td>
<td>• Policy, Economics, and Law;</td>
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<td></td>
<td>• Information and Data Analysis</td>
<td>• Urban Ecology and Environmental Design;</td>
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<td></td>
<td>• Water Science, Policy, and Management</td>
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</tbody>
</table>

Table 2: Public Policy in Environmental Science and Environmental Studies Masters Programs
Columbia University's Department of Ecology, Evolution and Environmental Biology (E3B) proposes an MA degree in Conservation Biology that requires students to take at least three policy-based courses. Core requirements also include courses in conservation science.

As noted in Table 2, there are three possible tracks to choose from: an academic track that emphasizes scientific aspects of conservation; a professional track that focuses on policy perspectives of conservation; and an educational track that concentrates on engaging the broader public in issues of conservation. Although this is a natural science degree, policy plays an important role in the curriculum, as students must take some policy classes, regardless of the track chosen.

Johns Hopkins University offers a MS in Environmental Science and Policy through the Zanvyl Krieger School of Arts and Sciences.

This degree requires more science than policy classes within its core curriculum, as shown in Table 2. However, all four concentrations, Environmental Monitoring and Analysis, Ecological Management, Environmental Management, and Environmental Planning, offer a balanced mix of both disciplines, requiring the following courses: Environmental Policymaking and Policy Analysis; an independent graduate project; and three of the following: Geological Foundations for Environmental Science; Oceanic and Atmospheric Processes; Hydrology and Water Resources; and Principles and Methods in Ecology.

Purdue University's Center for the Environment, like Columbia, proposes a science-based Master degree that requires at least one policy or social science course.

Although the required curriculum does not impose a policy class per se, students have the opportunity to choose an "Environmental Policy, Economics & Institutional Analysis" concentration. This is the only concentration that offers policy classes; all the rest (Ecological and Biological Sciences, Biogeochemistry, among others) are purely science-based. Course options notably include International Environmental Policy, Environmental Sociology, and Technology and Values.

Yale University's Master of Environmental Management is offered through the School of Forestry and Environmental Studies.

There are no required courses, but students must choose one course within each of the seven categories shown in Table 2. The mix of categories makes this degree very interdisciplinary, requiring one course each in Earth and Climate Sciences; Ecosystem Science and Biodiversity; Sustainable Development and Social Ecology; Economics; Policy, Institutions and Law; Environmental Health and Urban and Industrial Ecosystems; and Information and Data Analysis.
As noted in table 2, students have nine areas of concentration to choose from. The courses within these concentrations range from Landscape Ecology and Agroforestry Systems to Economics of Pollution and Coastal Ecosystems Governance. Again, the amount of science or policy instruction depends on the concentration (for example, the science emphasis of Ecology, Ecosystems and Biodiversity versus the policy end of Policy, Economics and Law), but every student receives a minimum instruction in both disciplines through the core seven courses.

5.2 Public Policy in Environmental Science Programs: Description and Rationale

A recurring rationale in the five Public Policy in Environmental Science and Environmental Studies programs in Table 2 is the idea of preparing students to be problem solvers and environmental managers, with important emphasis on professional training. All of the programs share the view that a professional environmental degree, be it science- or policy-based should provide at least minimum instruction in both disciplines.

Like Columbia, Johns Hopkins offers an environmental policy and science degree, but not within a public policy framework. Interestingly, the science curricula of these programs are quite similar as both require courses in chemistry, hydrology, ecology and climatology. Unlike Columbia's highly prescriptive program, the Hopkins MS proposes a choice of concentrations, though is clearly designed with the goal of integrating science and policy for environmental professionals. In this case, the concentrations are specialization areas in which students enhance their knowledge in both disciplines.

Hopkins' Environmental Management and Environmental Planning concentrations offer courses from the Business School and the School of Engineering and contribute to its interdisciplinary curricula. On the other hand, the Ecological Management concentration stays very close to principles of ecology, with a focus on ecosystem management and conservation. Finally, the Hopkins Environmental Monitoring and Analysis concentration offers courses in biotechnology, public health and engineering. Students thus have a broad set of subjects to choose from, with the option of not specializing within a specific concentration but instead picking and choosing courses.

Two out of the five programs described in Table 2 are clearly science-oriented yet integrate elements of policy in their instruction. The Columbia and Purdue programs stand out as they are in essence science-based degrees (Conservation Biology and Ecological Science and Engineering, respectively). In the same vein as the Duke MEM and Michigan MS described in Table 1, these programs have acknowledged the advantages of a two-pronged approach; at Columbia, candidates for the MA in Conservation Biology must take at least three policy courses, while those at Purdue must take at least one.
Through this research, we found that other universities, including the Universities of Chicago, South Florida, Wisconsin, Clark, George Mason and Johns Hopkins, offer environmental science and policy programs. This approach is thus not unique to the Columbia MPA in Environmental Science and Policy program. However, none of these other programs are embedded within a public administration or public policy degree. In fact, the Columbia degree is the only MPA program with a specific specialization in environmental science and policy, out of over 500 public policy and administration programs found through “gradschools.com”. Other policy programs that offer an environmental focus do not include any science requirements or, if they do, are generally in the form of dual degrees.

As this research shows, very few public policy programs in environmental studies require students to study natural science. In fact, science degrees have a higher tendency to incorporate policy requirements within their curricula. In sum, to pursue a public policy degree in environmental issues, with some elements of natural sciences, one could either choose the one-year MPA in Environmental Science and Policy program at Columbia or a dual degree that requires over two years of study at several other schools. Prospective students who wish to enter environmental studies outside of the public policy domain have more choice. They could indeed pursue a science-based program that requires policy courses, an environmental science and policy program, or an environmental management program.

6.0 The Case of Environmental Science in SIPA’s Environmental Policy Programs

At SIPA, most of our experience in bringing science education to our policy students is in the field of environmental policy. SIPA’s original environmental policy concentration and the Department of Earth and Environmental Sciences have worked together since the inception of the program in 1987 to develop science curricula specifically for environmental policy students. The groundbreaking environmental policy program required the new course “Environmental Science for Decision Makers”, taught by Professor Jim Simpson for a number of years. Professor Simpson also worked closely with Steve Cohen and Barnard professor Stephanie Pfirman to design the science curriculum for the MPA ESP Program. Last year, Simpson’s original course was replaced by a similar course, entitled “Science for Sustainable Development”, a course that was primarily designed for the PhD in Sustainable Development and the Environmental Policy Concentration. As Simpson noted in the syllabus for his version of the course in 2003,

“Many environmental problems are inherently international and they all may have some impact on public policy. The demands of increasing human populations for earth resources and the concomitant generation of
waste stresses a variety of earth systems. Assessment of complex interactions between nonrenewable resource use, pollutant generation and renewable resource contamination requires understanding of a number of natural systems of the Earth's environment and their sensitivity to a variety of stresses.

Although you can expect to learn some specific factual information about several subjects in environmental science during this course, probably the most important result of participation should be to gain confidence in analyzing the dynamics of the natural world on your own, especially through simple, order of magnitude calculations.” (emphasis added) http://www.ldeo.columbia.edu/edu/dees/U4735/syllabus.html#goals

Thus, the goal here was to expose students to modes of scientific analysis, and have them gain an appreciation of how scientists approach research issues. With only a single three-credit course to work with, the goals of the original environmental policy program at SIPA were by necessity focused and modest. When we set about designing the science curriculum for the MPA ESP, we allocated 12 points of the 18 required in the program’s first semester to science courses. This “summer of science” allows for the teaching of specific scientific information of importance to policymaking, along with the mode of inquiry mentioned by Simpson.

6.1 The Science Curriculum in SIPA’s MPA in Environmental Science and Policy

The science component of the program is designed to enable students to understand enough science to manage and translate the work of science experts. Our goal is for students to be capable of more than passive consumption or understanding of environmental science. However, we do not expect MPAs to become producers of scientific research. The focus of the environmental science taught in the program is on understanding the environmental processes that directly affect human health and well-being.

The policy and management issues our graduates are being trained to address include global issues such as global warming, but more frequently focus on:

- The provision of safe drinking water;
- Environmentally-sound sewage treatment and disposal;
- Solid and toxic waste management; and
- The control of local sources of air pollution.

The science courses required in the MPA in Environmental Science and Policy program are designed to support both global and local environmental decision-making and management. Courses required are: Environmental Chemistry, Toxicology, Climatology, Hydrology and Ecology.
• **Environmental Chemistry**
  The course teaches key chemical processes central to environmental science and allows students to build an understanding of the fundamental chemical processes related to pollution generation and control. This is accomplished through the study of the dynamics that affect the fate and transport of specific compounds acting as contaminants on a local to global scale, allowing students to analyze the types of chemical information they will encounter as environmental managers.

• **Environmental Toxicology**
  This course explores the effects of different contaminants on organism health within an ecosystem with a particular focus on human health. While toxicologists study a wide variety of toxins, from naturally occurring poisons (venoms) to synthetic chemicals, this course focuses on anthropogenic toxins. The main goal is to foster an understanding of how environmental scientists think about and solve related environmental issues and, most importantly, to develop expertise in assessing the validity of scientific research in this field and its conclusions.

• **Climatology**
  In this course, students learn how the atmosphere, oceans, and freshwater systems interact to affect climate. Causes of greenhouse warming, energy production and alternatives are studied. A main goal of this course is to build an appreciation of the predictability as well as the uncertainty associated with Earth systems. The course assesses anthropogenic impact on climate and how human-induced change can be characterized and distinguished from natural fluctuations. Other concepts examined include an integrated view of Earth’s energy budget, the structure and circulation of the atmosphere, as well as interactions between oceans and the atmosphere.

• **Hydrology**
  Students in this course are introduced to the hydrologic cycle as well as the processes governing water quantity and quality. Students learn how the atmosphere, oceans, and freshwater systems interact to affect the hydrologic cycle and climate. This course focuses on basic physical principles (evaporation, condensation, precipitation, runoff, stream flow, percolation, and groundwater flow), as well as environmentally relevant applications based on case studies. Students are also given the opportunity to simulate policy decisions applied to real-life scenarios such as water scarcity in Darfur.

• **Ecology and Biodiversity**
  This course focuses on the applied science of striving to maintain Earth’s biological diversity, landscapes, and resources. It covers the biological principles relevant to the conservation of biodiversity at the genetic,
population, community, and landscape levels. It surveys applications and problem-solving in conservation biology, developing an understanding of how human populations affect the environment through land use and development.

The MPA in Environmental Science and Policy program is now in its eighth year, and, as one might expect, we have learned a great deal about how best to teach these subjects to our students. The content of these science courses has evolved over time. Our science faculty has learned that constant work is required to connect the science they are teaching to specific and relevant policy issues. Even students with a science background (about half of the program’s students) demand that the focus of these courses be on “policy relevant” science. Another trend is an increased emphasis on how to communicate science to policymakers, and our summer workshop course focuses on the development of this skill.

In 2009, a three-course specialization in applied science will be added to SIPA’s curriculum, allowing students to enroll simultaneously in these courses and a five-course policy concentration. Initially, the specialization will be primarily composed of courses taught in departments and schools other than SIPA. However, just as SIPA’s curriculum, mainly composed of courses in traditional social science departments throughout the 1950’s, 60’s and 70’s, was gradually expanded to include school-specific social science courses, over time we expect the evolution of a growing number of SIPA-specific natural science courses as well.

7.0 The Politicization of Science

In the past decade, we have seen a revival of science debates in the American political system. Some of this simply represents the “traditional” misunderstanding of normal scientific disputes by non-scientifically trained political elites. However, there is an increasing frequency of deliberate attacks on the values of scientific inquiry from two sources: 1. Fundamentalists who believe that the Bible contains divine truths that must be interpreted literally, and 2. Those whose values lead them to conclude that some types of scientific inquiry are unethical. Specifically, the former group considers evolution as merely one theory explaining the development of life on Earth, and believes that students should also be taught what they have termed “intelligent design”. The latter group opposes stem cell research because they believe that human life is destroyed during such research. More recently, a third group has emerged with objections to climate change research, intentionally injecting doubt into the scientific debate to serve political and economic interests regardless of personal beliefs. This group includes elected leaders who are dependent on the energy industry for political contributions and those in the business community, specifically the fossil fuel industry, who cannot support the conclusions of climate change research for the sake of their individual livelihoods.
This trend leads to a need for enhanced scientific literacy by all of those entering public service professions. As indicated above, certain types of policy areas require specific types of scientific knowledge. However, just as all policy students should be taught the rudiments of political and economic processes in their core curriculum, there is a good argument for providing similar instruction on the basics of scientific knowledge. In Columbia’s undergraduate College, we have seen a gradual expansion of required science courses in the Core Curriculum. It would not be surprising to see a similar development in the curricula of graduate public policy programs over the next generation. As the preceding discussion indicates, problems faced by public managers are characterized by a growing level of scientific and technical content. Public Affairs education should respond to these changes with an enhanced science curriculum.

8.0 Conclusions

While we believe that the use of physical and natural sciences in public policy and administration curricula will continue to grow in this century, it has not taken root in many educational institutions at this point. It is possible that the very distinct disciplinary traditions of the sciences and public policy may result in the continued “dual degree” approach we have seen thus far and detailed in Table 1. Schools of Sustainability and Environmental Studies, rather than Public Administration or Business Schools, may end up as the home for programs that bridge science, policy and management. That would be a loss for the policy schools since, in our view, the increasingly complex and technological nature of our economy and public policy require a deeper understanding of science than that present in current curricula.

Teaching science to public policy and administration students is not a simple task. In our MPA in Environmental Science and Policy program it is made more difficult by the fact that, by design, half of our students have a background in science and the other half do not. We have developed a set of courses that is challenging to nonscientists but still holds the interest of students with science backgrounds. One way we accomplish this is through an emphasis on group work and encouragement of students with science background to work on their science communication skills by helping the non-scientists learn the basic concepts.

In the case of Columbia, we could not have done this without the active and engaged participation of our science colleagues at the Earth Institute. Without their deep commitment to training policy students to understand environmental science, this would be an unreachable pedagogic objective.

\[\text{\textsuperscript{i}}\text{“Natural Resources and Environment and Public Policy (MS/MPP). fordschool.umich.edu, 22 June 2009. http://www.fordschool.umich.edu/curriculum/ms.php}\]