**Princeton University**

**Science, Technology and Environmental Policy (STEP) Program**

**Woodrow Wilson School of Public and International Affairs**

**Graduate Program**

**Fall, 2000**

**Methods in Science, Technology and Environmental Policy**

**WWS-589**

**Wednesdays, 1:00 � 4:10**

**Robertson Hall, Room 13**

Professor Denise L. Mauzerall

Robertson Hall, Room 406

Office Hours:� Mon. 1:30-3:00

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Overview:� This course presents a set of basic theories, methods and tools for use in the analysis of policy issues involving science, technology and the environment.�� Topics include: order-of-magnitude estimation; modeling and uncertainty analysis; risk assessment and risk communication; evaluation of air, land and water pollution and industrial ecology.� The goal of the course is to develop a theoretical and operational understanding of these techniques through a combination of lectures, exercises, and the examination of a diverse set of real-world case studies.�� Complex models are becoming commonplace in a diverse range of technical and non-technical policy areas.� This course will provide a set of tools to evaluate the extent to which these models are useful and accurately represent the problem under investigation.� We will also examine the degree to which they can obscure the important dynamics of a situation and alternatives for its solution.

The course will culminate with the in-depth analysis of a particular real-world environmental problem.�� Tools learned in the course will be used to analyze the problem.� The student should leave the course with an increased understanding of how technical information can be used to inform policy decisions, the problems inherent in using such technical information, and the confidence to evaluate its relevance and application.

Prerequisites:� Students should be comfortable with mathematics and statistics at the level of WWS 507.� In addition, some exposure to basic chemistry would be useful. �Students should have some familiarity with microcomputer tools, including spreadsheets and graphical packages.� *Familiarity* is all that is required, however.� The tools necessary for policy analysis of the technical issues covered in the course will be taught as needed in a tutorial fashion.

Course format:� There will be one three-hour meeting per week divided, very roughly, between a lecture on the weeks topic, a discussion or debate, and a practical session devoted to instruction in the tools needed to solve the weekly exercises.� A course project will be conducted with independent term papers written by each student on chosen sub-topics.

Requirements:� Grades will be based on weekly problem sets (50%), in-class presentations and discussion (20%), and work on the final class� project (30%). The homework assignments will consist of short, quantitative, sometimes microcomputer based, applications of course methods to specific case studies.

Weekly problem sets will be due the week after assigned.

Presentations of class report:� Wednesday, January 10 (reading period)

Final paper due:� Wednesday, January 17� (reading period)

Major Course Topics

The course will examine air, land, and water pollution, risk assessment and industrial ecology (the concept by which the interactions between human activities and the environment are systematically analyzed).� Simple models will be constructed and analyzed in order to understand the flow and transformation of materials while risks due to exposure to various pollutants in a variety of media will be evaluated.� The use of these tools will culminate in a course project where the class will apply the methods they have learned to research and write a report on a current environmental problem where they provide a technical analysis to support specific policy recommendations.��� The proposed class project is to utilize the 'Regional Air Pollution INformation and Simulation' (RAINS) model as a tool for the integrated assessment of alternative strategies to reduce air pollution in Europe and Asia.�� The RAINS� model integrates economic activities, chemistry and transport of air pollutants, emission control policies, emission control costs and environmental impacts into a package that can be used on a personal computer to evaluate various control options.

MODELING:� This module introduces a set of widely applicable modeling tools, starting from �back-of-the-envelope� and order-of �magnitude estimation, and from there developing steady-state, computer-spreadsheet, and stock and flow models.� Finally, an integrated assessment model for the evaluation of the impacts and costs of air pollution control will be utilized.� Emphasis will be placed both on constructing and evaluating models, and on their use and misuse in the policy process.� The use of models in evaluating stratospheric ozone depletion and climate change will be discussed.� Modeling exercises will be oriented around environmental problems with background on air, water and land pollution provided in lectures.

The computer modeling exercises will primarily use the *STELLA II* , *Crystal Ball* , and RAINS software packages that are installed on the computers in Robertson 14 and 15 and can be purchased.

RISK ASSESSMENT:� Science and technology decision making routinely involves uncertainty and the evaluation of hazards.� This module introduces a set of risk assessment tools commonly employed in public health, environmental, military and industrial applications.� We will examine probabilistic and exposure assessment methods.� We will also explore the critical step of risk prioritization and communication, both as a tool for �public interest science� and as it is utilized to legitimize/evaluate/inform political decisions.

Required Texts:

Ford, Andrew. Modeling the Environment, An Introduction to System Dynamics Modeling of Environmental Systems,� Island Press, 1999.

Harte, John*.�*Consider a Spherical Cow:� A Course in Environmental Problem Solving, University Science Books, 1988.

Kammen, D. M., Hassenzahl, D. M.� Should We Risk It?� Exploring Environmental, Health, and Technological Problem Solving, Princeton University Press, 1999.

Meadows, D.H., Meadows, D. L., Randers, J. Beyond the Limits, Chelsea Green Publishing Co., 1992.

Glickman, T.S., Gough, M. (eds.) Readings in Risk, Resources for the Future, Baltimore, MD, 1990.

Recommended Texts:

Graedel, T. E., Crutzen, P.J. Atmosphere, Climate and Change,Scientific American Library, New York, 1997.

Gratt, Lawrence B.� Air Toxic Risk Assessment and Management, van Nostrand Reinhold, 1996.

High Performance Systems, STELLA II: Introduction to Systems Thinking, High Performance Systems, Hanover, NH, 1992.

Schedule of Classes

Week 1:�� Friday September 22.�� Introduction and Overview.

Theory:�

Course overview.� Methods used in decision-making involving science, technology and the environment.� Examples of the use of technical information and models in making environmental policy decisions (ie. stratospheric ozone depletion, climate change, etc.).

Practical:�

Survey of order-of-magnitude and �back-of-the-envelope� estimation techniques.

Discussion of possible course projects.

Readings:

Meadows, D. H., Meadows, D.L. and Randers, J. (1992) Beyond the limits, chapters 1 and 2, p. 1-43.

Ford, Andrew (1999)� Modeling the Environment, Chapter 1, Overview, p. 3-13

Harte, J. (1985) Consider a spherical cow: a course in environmental problem solving, Chapter 1, p. 1-20.

Week 2.� September 27.� Modeling I.

Theory:

Box models, steady-state and non- steady-state models, stocks and flows.�

Introduction and application to air pollution.�

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Practical:�

STELLA introduction, tutorial and modeling session.

Readings:

Meadows, D. H., Meadows, D.L. and Randers, J. (1992) Beyond the limits, chapters 3 and 4, p. 44-140.

Harte, J. (1985)� Consider a spherical cow, pp. 21-44, 111 � 116.

Ford, A. (1999), Modeling the Environment, Chapter 2, pp. 14-20;� Chapter 3, pp.25-31.

Use as a reference (available in computer clusters at the WWS):

High Performance Systems (1992), STELLA II:� Introduction to Systems Thinking (High Performance Systems, Hanover, NH, chapters 1-6 (pp. 1 � 102)

Week 3.� October 11.� Modeling I

Theory:�

General approaches and simple dynamics: methods to characterize dynamical systems, stability and feedback loops.� Complex models are becoming commonplace in a diverse range of technical and non-technical policy areas.� To what extent are these models useful, and to what degree do they obscure the important dynamics of the situation?

Practical:�

Testing the stability and utility of simple global change forecast models.� Introduction to the World3 model.�

Bottom-up and top-down approaches to modeling and estimating growth.� Comparing the strengths and weaknesses of �top-down� (readings:� Meadows, Meadows, and Randers) and �bottom-up� (reading: OTA) approaches to energy consumption forecasts.

Readings:

Meadows, D. H., Meadows, D.L. and Randers, J. (1992) *Beyond the limits*, chapters 4-7, pp. 104-217; Appendix pp. 237-253.

Week 4.� October 4.� Air Pollution

Theory:�

Air pollution resulting from fossil fuel combustion - aerosols, acid rain, smog.

Practical:

Modeling applications for air pollution.

Readings:

Graedel, T. E., Crutzen, P.J. (1997) Atmosphere, Climate and Change,

Chapter 3� �Chemistry in the Air�, pp.34-57.

Chapter 5 �Changing Chemistry�, pp. 89-111

Chapter 6 �Predicting the Near Future�, pp.113-140.

For an excellent more in-depth introduction to atmospheric chemistry, consult Professor Daniel Jacob�s book, �Introduction to Atmospheric Chemistry�, Princeton University Press, available on-line at http://www-as.harvard.edu/people/faculty/djj/book/

Examine the IIASA web site for information on the RAINS models:

http://www.iiasa.ac.at/Research/TAP/

Week 5.� October 18. Water Pollution.

Theory:

Introduction to surface and ground-water contamination.

Practical:

Refinement of course project.

Readings:

Bedient, P. B., Rifai, H. S. , Newell, C. J., Ground Water Contamination, 1994,

Chapter 1, *Introduction to ground water contamination,* pp. 1-10.

Chapter 4, *Sources and types of ground water contamination*, pp. 64-90.

Week 6.� October 25.� Waste Disposal / Landfills / Toxic Waste

Theory:�

Waste disposal of municipal, industrial and hazardous solid wastes.

Toxic disposal.� How safe is safe enough?

Readings:

Scrudata, R. J., Pagano, J. J. *Landfill Leachates and Groundwater Contamination* in� Groundwater Contamination and Control, Zoller, Uri (ed.), Marcel Dekker, New York, 1994, pp. 169-187.

Week 7.� November 8.� Risk Assessment I

Theory:�

Methods in quantifying risk.

Readings:

Please read the following articles in:

Glickman, T. S., Gough, M. (eds.)� Readings in Risk,

Morgan, Granger *Probing the Question of Technology-Induced Risk*, p.5-16.

Morgan, Granger, *Choosing and Managing Technology-Induced Risk*, p. 17-29.

Fischhoff, B., C. Hope, S. R. Watson, *Defining Risk*, p. 30-41.

Kammen and Hassenzhal, ch. 1, pp. 3-30.

Pimentel, D. et al. (1993) �Assessment of environmental and economic impacts of pesticide use�, in The pesticide question:� environment, economics, and ethics, Pimentel, D. and Lehman, H (eds), pp. 47-84.

Week 8.� November 15.� Risk Assessment II

Theory:

Estimating exposure, dose and response to toxins.

Practical:

Workshop session #1 for class project.

Readings:

Kammen and Hassenzhal,

chapter 2, Basic Models and Risk Problems pp.31-82,

read chapter 3, if you want a review of statistics for risk analysis,

chapters 4-8 pp. 122-265.

Week 9.� November 22, Risk Assessment III

Theory:

Risk/benefit analysis and cost/benefit analysis

Practical:�

Crystal Ball and Monte Carlo laboratory Session

Readings:

Hall, J. V., et al. *Valuing the Health Benefits of Clean Air*, Science, vol. 255, pp. 812-816, 1992.

Vose, D.� *Monte Carlo Risk Analysis Modeling*, in Fundamentals of Risk Analysis and Risk Management, Lewis Publishers, 1996.

Please read the following articles in:

Glickman, T. S., Gough, M. (eds.)� Readings in Risk,

Kelman, S.� *Cost-benefit analysis:� an ethical critique*, pp. 129-137.

Rasmussen, N. C*.� The application of probabilistic risk assessment techniques to energy technologies*, pp. 195-205

Keeney, R.L., Kulkarni, R. B., Keshavan, N.� *Assessing the risk of a LNG terminal*, pp. 207-217.

Week 10.� November 29, Risk Assessment IV

Theory:� Risk communication and risk policy

Practical:� The case of Alar:� from science to 60 Minutes

Readings:

Please read the following articles in:

Glickman, T. S., Gough, M. (eds.)� Readings in Risk,

Plough, A., Krimsky, S.� *The emergence of risk communication studies:� social and political context,�*pp. 223-231.

Sandman, P. M. *Getting to Maybe:� Some communications aspects of siting hazardous waste facilities*, pp. 233- 245.

Week 11.� December 6, Class Project Workshop

Group initial findings will be distributed and discussed.

Week 12.� December 13, Industrial Ecology

Theory:� Product flows and material management

Readings:

From Industrial Ecology and Global Change (1994):

Socolow, R.� Six perspectives from Industrial Ecology, pp. 3- 16.

Graedel, T.� Industrial ecology:� definition and implementation, pp. 23-41.�

Thomas, V. , Spiro, T.� Emissions and exposure to metals:� cadmium and lead, pp. 297- 318.

Graedel, T., Horkeby, I., Norberg-Bohm, V., Prioritizing Impacts in Industrial Ecology, pp. 359-370.

Presentations of class report:� Wednesday, January 10 (reading period)

Final paper due:� Wednesday, January 17� (reading period)