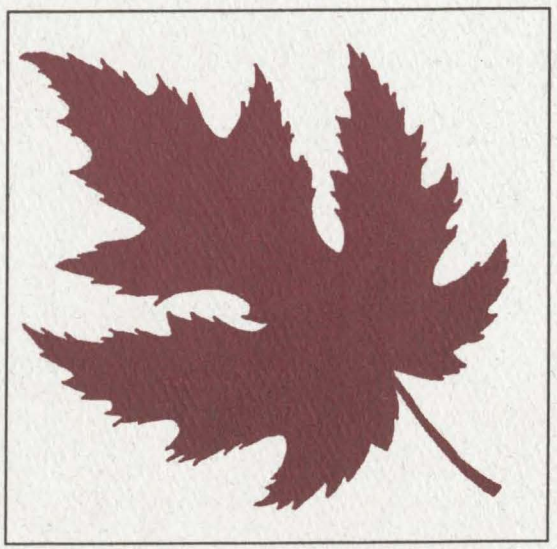
COURSES ON THE ENVIRONMENT

A Student Guide to University of Minnesota

Courses on Environmental Issues on the Twin Cities Campus



1990 1991

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1990 - 1991

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CONTENTS

GENERAL INFORMATION

Courses on the Environment is a supplemental guide to official University bulletins of the various colleges and institutes of the University of Minnesota. Although there is no environmental studies department at the University and no formal undergraduate degree program in environmental studies, a large number of courses and programs at the University have implications for the study of environmental issues. Over 360 courses in 43 different departments are listed in this 1990-1991 guide.

There are programs in the College of Liberal Arts and University College in which students can design their own environmental studies major. For information about CLA's special learning opportunities and individualized programs contact the Office for Special Learning Opportunities, 220 Johnston Hall (624-7577). For information about UC's degree programs contact the Inter-College Program, 7 Wulling Hall (624-2004), or the University College Program for Individualized Learning, 201 Wesbrook Hall (624-4020).

Part I of this guide is a subject index where courses are arranged by twenty-two subject areas. It is designed to help students interested in pursuing an interdisciplinary area of environmental study find courses of interest in various colleges and departments. While some courses are obviously found in a certain department, it is difficult to be aware of all the courses which pertain to a particular area. For example, courses dealing with the area of environmental health and pollution control or courses about resource management are found in several departments and described in various University bulletins, but can be located by using the subject index. All courses listed in Part I are described in Part II.

Part II lists courses by field of instruction and gives course descriptions and the name of a contact person who is prepared to advise students desiring more information. Several collegiate units offer, through their departments, degree programs that include a primary concentration on environmental studies. Part II is designed to serve as a guide to students pursuing an environmental studies emphasis within a given departmental major or minor. Students interested in exploring the full extent of degree programs and course offerings in a specific department should consult the appropriate college bulletin.

Part III of this guide provides a listing of special centers and libraries. The special centers section lists units at the University of Minnesota that participate in environmentally related activities (often including research) in which interested students and faculty members might become involved. In some cases students may obtain credit for work completed in such activities. The libraries section lists University and other Twin Cities libraries that have material on the environment in their collections.

ADDITIONS TO 1990-1991 GUIDE

Fifty-eight courses have been added to the 1990-1991 course guide. These courses are marked "**new**" at the beginning of the course description in Part II. Changes (such as contact person, course title, course description, credits or prerequisites) have been made in the entries for over sixty-five courses, and the listings for twenty-eight courses have been dropped because they are no longer offered. Three new subject areas have been added to the subject index in Part I: Ecology, Waste Management, and Lake Itasca Forestry and Biological Station (for courses held at Itasca). See "Lake Itasca" in Part III for a description of the Station. There are two new programs listed in Part II: 1) Conservation Biology and 2) Extractive Metallurgical Engineering. See "Mineral Resources Research Center" in Part III for a description of the latter program.

COURSE SYMBOLS

new New course added to this 1990-91 guide.

† All courses preceding this sign must be completed before credit will be granted for any quarter of the sequence.

§ Credit will not be granted if equivalent course listed after this symbol has been taken for credit.

¶ Concurrent registration allowed with course listed after this mark.

Consent of instructor is required for registration.

Δ Consent of department or school offering the course is required for registration.

H Honors course.

f,w,s,su Following a course number indicate fall, winter, spring, or summer quarters.

PART I. COURSES LISTED BY SUBJECT AREA

BIOLOGICAL PEST AND DISEASE CONTROL

Entomology (Ent)

Ent 1005. ECONOMIC ENTOMOLOGY.
Ent 5210. INTEGRATED PEST MANAGEMENT.
Ent 5250. FOREST ENTOMOLOGY.
Ent 5280. LIVESTOCK ENTOMOLOGY.
Ent 5610. AQUATIC ENTOMOLOGY.
Ent 8240. COLLOQUIUM IN INSECT ECOLOGY.

Plant Pathology (PlPa)

PlPa 5002. INTRODUCTORY PLANT PATHOLOGY.
PlPa 5007. AIR POLLUTION AND THEIR EFFECTS ON PLANTS.
PlPa 5050. FOREST PATHOLOGY.
PlPa 5102. FUNGAL ECOLOGY.
PlPa 5105. INTRODUCTION TO THE STUDY OF FUNGI.
PlPa 5106. MYCOLOGY: ASCOMYCETES - FUNGI IMPERFECTI.
PlPa 5107. MYCOLOGY: BASIDIOMYCETES.
PlPa 8003. PLANT DISEASE THEORY III, POPULATIONS.
PlPa 8111. FUNGAL GENETICS.

CULTURE, SOCIETY, AND ENVIRONMENTAL PROBLEMS

Anthropology

Anth 5116. CULTURAL ECOLOGY.
Anth 5117. ANTHROPOLOGY OF RESOURCE MANAGEMENT.

Architecture

Arch 3001. ENVIRONMENTAL DESIGN: THEORY AND PROCESS.
Arch 3002. ENVIRONMENTAL DESIGN: PEOPLE AND ENVIRONMENT.
Arch 3060. TECHNOS: FORCE, FORM AND ARCHITECTURE.

Business, Government, and Society

BGS 3002. BUSINESS AND SOCIETY.

History of Science and Technology

HSci 3331/5331. TECHNOLOGY IN AMERICAN CULTURE.

Humanities

Hum 3366. LANDSCAPE AND IDEOLOGY, 1600-1875.

Landscape Architecture

LA 1021. HISTORY OF ENVIRONMENTAL DEVELOPMENT: ARCHITECTURE.
LA 1022. HISTORY OF ENVIRONMENTAL DEVELOPMENT: LANDSCAPE ARCHITECTURE.
LA 1023. HISTORY OF ENVIRONMENTAL DEVELOPMENT: PLANNING.
LA 3001. ENVIRONMENTAL DESIGN: PEOPLE AND ENVIRONMENT.
LA 3002. ENVIRONMENTAL DESIGN: TOOLS AND PROCESSES.
LA 8330. CONCEPTS OF LANDSCAPE EVALUATION.

Rhetoric

Rhet 1310. HUMANITIES: THE LAND IN AMERICAN EXPERIENCE.
Rhet 3375. HUMANITIES: AGRICULTURAL HERITAGE.

Sociology

Soc 3551. WORLD POPULATION PROBLEMS.

EARTH SCIENCES

Geography

Geog 1401. PHYSICAL GEOGRAPHY.
Geog 3441. LANDFORM GEOGRAPHY.

Geology

Geo 1001. PHYSICAL GEOLOGY.
Geo 1012. INTRODUCTION TO COMPARATIVE PLANETOLOGY.
Geo 1021. INTRODUCTION TO GEOLOGY LAB: GEOLOGY OF MINNESOTA.
Geo 1111. INTRODUCTORY PHYSICAL GEOLOGY.
Geo 1601. OCEANOGRAPHY.
Geo 3401. INTRODUCTORY MINERALOGY.
Geo 5004. MINERALOGY.
Geo 5108. ADVANCED ENVIRONMENTAL GEOLOGY.
Geo 5201. STRUCTURAL GEOLOGY.
Geo 5251. GEOMORPHOLOGY.
Geo 5261. GLACIAL GEOLOGY.
Geo 8617. TRANSPORT PHENOMENA IN NATURAL POROUS MEDIA.

Extractive Metallurgical Engineering

MetE 5800. MINERAL PROCESSING I.
MetE 5801. MINERAL PROCESSING II.
MetE 5901. PRINCIPLES OF METALS EXTRACTION.

ECOLOGY

Anthropology

Anth 5116. CULTURAL ECOLOGY.

Biology

Biol 1009. GENERAL BIOLOGY.
Biol 5041. ECOLOGY.
Biol 5841. ECOLOGY.

Conservation Biology

CB 8452. CONSERVATION BIOLOGY: GENETIC AND DEMOGRAPHIC ISSUES.

Ecology, Evolution, and Behavior

EEB 3001. INTRODUCTION TO ECOLOGY.
EEB 3101. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.
EEB 5008. QUATERNARY ECOLOGY.
EEB 5014. ECOLOGY OF PLANT COMMUNITIES.
EEB 5016. ECOLOGICAL PLANT GEOGRAPHY.
EEB 5052. THEORETICAL POPULATION ECOLOGY.
EEB 5606. ECOLOGY OF FISHES.
EEB 5607. ECOLOGY OF ANIMAL PLANKTON.
EEB 5608. ECOSYSTEMS: FORM AND FUNCTION.
EEB 5613. ASSESSING THE ECOLOGICAL EFFECTS OF POLLUTION.
EEB 5814. PLANT COMMUNITY ECOLOGY.
EEB 5817. VERTEBRATE ECOLOGY.

Entomology

Ent 5040. INSECT ECOLOGY.
Ent 5250. FOREST ENTOMOLOGY.
Ent 5320. ECOLOGY OF AGRICULTURE.
Ent 8240. COLLOQUIUM IN INSECT ECOLOGY.

Forest Resources

FR 3101. FIELD FOREST ECOLOGY.
FR 3104. FOREST ECOLOGY.
FR 5104. FOREST ECOLOGY.
FR 5406. FORESTRY WORKSHOP FOR TEACHERS.
FR 5408. FORESTRY IN THE URBAN ENVIRONMENT.

Fisheries and Wildlife

FW 1002. WILDLIFE: ECOLOGY, VALUES AND HUMAN IMPACT.
FW 5603. ECOLOGY AND MANAGEMENT OF FISH AND WILDLIFE HABITATS.

Geology

Geo 5108. ADVANCED ENVIRONMENTAL GEOLOGY.

Plant Biology

PBio 3201. INTRODUCTORY PLANT SYSTEMATICS.
PBio 5811. FRESHWATER ALGAE.

Plant Pathology

PlPa 5102. FUNGAL ECOLOGY.
PlPa 5106. MYCOLOGY: ASCOMYCETES - FUNGI IMPERFECTI.
PlPa 5107. MYCOLOGY: BASIDIOMYCETES.

ENERGY USE

Anthropology

Anth 5117. ANTHROPOLOGY OF RESOURCE MANAGEMENT.

Architecture

Arch 3064-3065. ENVIRONMENTAL MANAGEMENT AND CONTROL.

Business, Government, and Society

BGS 3003. BUSINESS AND THE NATURAL ENVIRONMENT.

Civil Engineering

CE 5212. TRANSPORTATION PRODUCTIVITY AND ENERGY CONSERVATION.

Geology

Geo 1005. GEOLOGIC PERSPECTIVES ON ENERGY.

Geography

Geog 3345. ENERGY AND MINERALS.

Mechanical Engineering

ME 5712. SOLAR ENERGY UTILIZATION.

Natural Resources and Environmental Studies

NRES 1040. NATURAL RESOURCES AS RAW MATERIALS.

Public Affairs

PA 5711. ENERGY POLICY I.

PA 5712. ENERGY POLICY II.

PA 8791-99. WORKSHOP/SEMINAR: ADVANCED TOPICS IN TECHNOLOGY, ENERGY, AND ENVIRONMENTAL POLICY.

Soil Science

Soil 5550. PEATLANDS: FORMATION, CLASSIFICATION, AND UTILIZATION.

ENVIRONMENT, TECHNOLOGY, AND PUBLIC POLICY

Business, Government, and Society

BGS 3003. BUSINESS AND THE NATURAL ENVIRONMENT.

BGS 8019. MANAGEMENT TOPICS: BUSINESS, THE PHYSICAL ENVIRONMENT, AND NATURAL RESOURCE ISSUES.

BGS 8055. BUSINESS, GOVERNMENT AND MACROECONOMICS.

BGS 8202. EXTERNAL AFFAIRS MANAGEMENT.

Biology

Biol 3051. BIOLOGY AND THE FUTURE OF THE EARTH.

Biol 3052. ENVIRONMENT, HEALTH, AND TOXICOLOGY.

Biol 5951. SOCIAL USES OF BIOLOGY.

Forest Resources

FR 5241. NATURAL RESOURCE MANAGEMENT: POLITICAL AND ADMINISTRATIVE PROCESSES.

Interdepartmental Study

ID 3525-3526. GARBAGE, GOVERNMENT, AND THE GLOBE.

ID 3970. DIRECTED STUDIES.

Journalism

Jour 5133. INTERPRETIVE REPORTING ABOUT SCIENCE.

Law School

Law 5215. ENVIRONMENTAL LAW.

Management

Mgmt 8019. MANAGEMENT TOPICS: BUSINESS, THE PHYSICAL ENVIRONMENT, AND NATURAL RESOURCE ISSUES.

Natural Resources and Environmental Studies

NRES 1010. ISSUES IN THE ENVIRONMENT.
NRES 1040. NATURAL RESOURCES AS RAW MATERIALS.

Plant Pathology

PlPa 5007. AIR POLLUTION AND THEIR EFFECTS ON PLANTS.

Political Science

Pol 3321. ISSUES IN AMERICAN PUBLIC POLICY.
Pol 5523. THE POLITICS OF THE REGULATORY PROCESS.

Public Affairs

PA 5701, 5702. TECHNOLOGY PLANNING I AND II.
PA 5721. ENVIRONMENTAL POLICY I.
PA 5722. ENVIRONMENTAL POLICY II.
PA 8791-99. WORKSHOP/SEMINAR: ADVANCED TOPICS IN TECHNOLOGY, ENERGY, AND ENVIRONMENTAL POLICY.

Public Health

PubH 5576. THE POLITICAL PROCESS IN PUBLIC HEALTH.

Soil Science

Soil 1020. THE SOIL RESOURCE.

ENVIRONMENTAL HEALTH AND POLLUTION CONTROL

Biology

Biol 3052. ENVIRONMENT, HEALTH, AND TOXICOLOGY.

Civil Engineering

CE 5506. ENVIRONMENTAL WATER CHEMISTRY.
CE 5510. SOLID AND HAZARDOUS WASTE MANAGEMENT.
CE 5515. WATER AND WASTEWATER MICROBIOLOGY.
CE 5540. ANALYSIS OF GROUNDWATER-SOIL POLLUTION ABATEMENT TECHNOLOGY.
CE 8560. SEMINAR: SPECIAL TOPICS IN ENVIRONMENTAL ENGINEERING.

Ecology, Evolution, and Behavior

EEB 5613. ASSESSING THE ECOLOGICAL EFFECTS OF POLLUTION.

Fisheries and Wildlife

FW 5460. POLLUTION IMPACTS ON AQUATIC SYSTEMS.

Interdepartmental Study

ID 3525-3526. GARBAGE, GOVERNMENT, AND THE GLOBE.

Mechanical Engineering

ME 5609. AIR POLLUTION.

Public Health

PubH 5151. ENVIRONMENTAL HEALTH.
PubH 5152. ENVIRONMENTAL HEALTH.
PubH 5153. CASE STUDIES IN ENVIRONMENTAL HEALTH.
PubH 5155. ISSUES IN ENVIRONMENTAL AND OCCUPATIONAL HEALTH.
PubH 5158. HEALTH RISK EVALUATION.
PubH 5161. ADMINISTRATION OF ENVIRONMENTAL HEALTH PROGRAMS.
PubH 5171. ENVIRONMENTAL MICROBIOLOGY.
PubH 5181. AIR POLLUTION.
PubH 5184. AIR ANALYSIS.
PubH 5186. ENVIRONMENTAL CHEMISTRY.
PubH 5201. RADIATION PROTECTION AND MEASUREMENT.
PubH 5202. RADIATION LABORATORY.
PubH 5253. INTRODUCTION TO HAZARDOUS WASTE MANAGEMENT.
PubH 5261. GENERAL ENVIRONMENTAL TOXICOLOGY.
PubH 5262. METABOLISM AND DISTRIBUTION OF XENOBIOTICS.
PubH 5266. RISK ASSESSMENT AND MANAGEMENT.
PubH 5267. ENVIRONMENTAL AND OCCUPATIONAL TOXICOLOGY.
PubH 5268. SEMINAR: TOXICOLOGY AND HUMAN POPULATIONS.
PubH 5576. THE POLITICAL PROCESS IN PUBLIC HEALTH.
PubH 8185. ANALYSIS OF TOXICANTS.
PubH 8261. MOLECULAR TOXICOLOGY.
PubH 8269. SEMINAR IN TOXICOLOGY.

FISH AND WILDLIFE

Ecology, Evolution, and Behavior

EEB 5136. ICHTHYOLOGY.
EEB 5606. ECOLOGY OF FISHES.
EEB 5817. VERTEBRATE ECOLOGY.
EEB 5834. FIELD ORNITHOLOGY.

Forest Resources

FR 5458. WATER QUALITY MANAGEMENT: ECOSYSTEM APPROACHES.

Fish and Wildlife

FW 1001. ORIENTATION IN FISHERIES AND WILDLIFE.
FW 1002. WILDLIFE: ECOLOGY, VALUES AND HUMAN IMPACT.
FW 1101. ETHICS AND VALUES IN RESOURCE MANAGEMENT.
FW 3052. INTRODUCTION TO FISHERIES AND WILDLIFE.
FW 3167. TECHNIQUES OF FOREST WILDLIFE MANAGEMENT.
FW 3600. FISHERIES AND WILDLIFE FIELD TECHNIQUES.
FW 5129. MAMMALOGY.
FW 5455. AQUACULTURE.
FW 5459. ENVIRONMENTAL PHYSIOLOGY OF FISHES.
FW 5570. AVIAN CONSERVATION AND MANAGEMENT.
FW 5601. ASSESSMENT AND MANAGEMENT OF VERTEBRATE POPULATIONS.
FW 5603. ECOLOGY AND MANAGEMENT OF FISH AND WILDLIFE HABITATS.
FW 5604. FISHERY AND WILDLIFE MANAGEMENT.

Veterinary Biology

VB 5330. WILD BIRD MEDICINE.

FOREST MANAGEMENT

Forest Resources

FR 1001. FOREST RESOURCES ORIENTATION.
FR 1200. INTRODUCTION TO FOREST RESOURCES.
FR 1202. FARM AND SMALL WOODLANDS FORESTRY.
FR 3100. IMPORTANT FOREST PLANTS.
FR 3101. FIELD FOREST ECOLOGY.
FR 3102. SOUTHERN FOREST RESOURCE TOUR.
FR 3104. FOREST ECOLOGY.
FR 3201. FIELD FOREST MEASUREMENTS.
FR 3225. DIRECTED STUDY EXPERIENCE.
FR 5100. SILVICULTURE.
FR 5101. FIELD SILVICULTURE.
FR 5103. ADVANCED FOREST TREE BIOLOGY.
FR 5104. FOREST ECOLOGY.
FR 5106. SENIOR SILVICULTURE SEMINAR.
FR 5110. FORESTRY APPLICATIONS OF MICROCOMPUTERS.
FR 5114. FOREST HYDROLOGY.
FR 5115. FOREST HYDROLOGY, FIELD APPLICATIONS.
FR 5120. INTRODUCTORY TREE PHYSIOLOGY AND GENETICS.
FR 5121. TREE PHYSIOLOGY LABORATORY.
FR 5126. SILVICULTURE: SOIL-SITE RELATIONSHIPS.
FR 5140. APPLICATION OF SILVICULTURE IN NORTH AMERICAN FOREST TYPES.
FR 5241. NATURAL RESOURCE MANAGEMENT: POLITICAL AND ADMINISTRATIVE PROCESSES.
FR 5152. FOREST GENETICS.
FR 5153. ADVANCED FOREST HYDROLOGY.
FR 5160. PRACTICUM IN FOREST BIOLOGY AND MEASUREMENTS.
FR 5212. NATURAL RESOURCES INVENTORY.
FR 5215. FOREST FIRE MANAGEMENT.
FR 5216. SPECIAL TOPICS IN FOREST FIRE MANAGEMENT.
FR 5217. FIELD TECHNIQUES FOR PRESCRIBED BURNING.
FR 5218. FIELD TECHNIQUES FOR FOREST FIRE CONTROL.
FR 5220. REMOTE SENSING, FOREST RESOURCES INVENTORY.
FR 5226. FOREST ECONOMICS AND PLANNING.
FR 5231. RANGE MANAGEMENT.
FR 5236. FOREST RECREATION PLANNING.
FR 5240. NATURAL RESOURCE POLICY AND ADMINISTRATION.
FR 5248. HARVESTING AND ENGINEERING.
FR 5253. FOREST BIOMETRY.
FR 5255. FOREST RESOURCES SURVEY DESIGN.
FR 5264. QUANTITATIVE TECHNIQUES IN FOREST MANAGEMENT.
FR 5401. SENIOR TOPICS.
FR 5406. FORESTRY WORKSHOP FOR TEACHERS.
FR 5408. FORESTRY IN THE URBAN ENVIRONMENT.
FR 5458. WATER QUALITY MANAGEMENT: ECOSYSTEM APPROACHES.
FR 5500. URBAN FOREST MANAGEMENT.
FR 5700. COLLOQUIUM IN FOREST BIOLOGY.
FR 8100. RESEARCH PROBLEMS: SILVICULTURE.

FR 8101. RESEARCH PROBLEMS: FOREST TREE PHYSIOLOGY.
FR 8102. RESEARCH PROBLEMS: FOREST TREE GENETICS.
FR 8103. RESEARCH PROBLEMS: FOREST HYDROLOGY.
FR 8105. ADVANCED FIELD SILVICULTURE.
FR 8106. TOPICS IN SILVICULTURE--FOREST SOILS.
FR 8200. RESEARCH PROBLEMS: FOREST MANAGEMENT.
FR 8201. RESEARCH PROBLEMS: FOREST ECONOMICS.
FR 8202. RESEARCH PROBLEMS: FOREST MEASUREMENTS.
FR 8203. RESEARCH PROBLEMS: FOREST RECREATION.
FR 8204. RESEARCH PROBLEMS: FOREST POLICY.
FR 8205. RESEARCH PROBLEMS: REMOTE SENSING.
FR 8207. ECONOMIC ANALYSIS OF FORESTRY PROJECTS.
FR 8210. RESEARCH METHODS IN FORESTRY.
FR 8211. SEMINAR: NATURAL RESOURCE POLICY ISSUES.
FR 8213. TOPICS IN WILDLAND HYDROLOGY.

Plant Pathology

PlPa 5050. FOREST PATHOLOGY.

Soil Science

Soil 5550. PEATLANDS: FORMATION, CLASSIFICATION, AND UTILIZATION.

LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

Biology

Biol 1951,1952,1953. BIOLOGY COLLOQUIUM.
Biol 5841. ECOLOGY.

Ecology, Evolution, and Behavior

EEB 5814. PLANT COMMUNITY ECOLOGY.
EEB 5817. VERTEBRATE ECOLOGY.
EEB 5834. FIELD ORNITHOLOGY.

Entomology

Ent 5600. FIELD ENTOMOLOGY.
Ent 5610. AQUATIC ENTOMOLOGY.

Forest Resources

FR 3100. IMPORTANT FOREST PLANTS.
FR 3101. FIELD FOREST ECOLOGY.
FR 3201. FIELD FOREST MEASUREMENTS.
FR 5160. PRACTICUM IN FOREST BIOLOGY AND MEASUREMENTS.

Fish and Wildlife

FW 3600. FISHERIES AND WILDLIFE FIELD TECHNIQUES.

Plant Biology

PBio 5801. PLAINS AND BOREAL FLORA.
PBio 5811. FRESHWATER ALGAE.

LAKES AND WETLANDS

Civil Engineering

CE 8430. LAKE AND RESERVOIR HYDRODYNAMICS.
CE 8551. SEMINAR: MODELS OF AQUATIC ENVIRONMENTS.

Ecology, Evolution, and Behavior

EEB 5601. LIMNOLOGY.
EEB 5607. ECOLOGY OF ANIMAL PLANKTON.
EEB 5621. LIMNOLOGY LABORATORY.

Geology

Geo 5601. LIMNOLOGY.
Geo 8602. ADVANCED LIMNOLOGY.

Plant Biology

PBio 5231. INTRODUCTION TO THE ALGAE.

LAND USE

Agricultural and Applied Economics

AgEc 5600. LAND ECONOMICS.
AgEc 8360. LAND ECONOMICS AND POLICY.

Forest Resources

FR 5262. REMOTE SENSING OF NATURAL RESOURCES.

Geography

Geog 3343. LAND USE AND STATE GOVERNMENT.
Geog 3344. LAND USE AND THE FEDERAL GOVERNMENT.
Geog 8340. SEMINAR: LAND USE PLANNING.
Geog 8344. SEMINAR: PUBLIC LAND POLICY IN MINNESOTA.
Geog 8345. SEMINAR: PUBLIC LAND POLICY IN MINNESOTA.

Landscape Architecture

LA 1031. INTRODUCTION TO LANDSCAPE ARCHITECTURE.
LA 5107. REGIONAL LANDSCAPE DESIGN.
LA 5562. INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS.
LA 8390. DESIGNING THE LONG-TERM LANDSCAPE.

Public Affairs

PA 5601. LAND USE.
PA 5622. DEVELOPMENT MANAGEMENT SYSTEMS.
PA 8600. SEMINAR: LAND USE PLANNING.
PA 8691-99. WORKSHOP/SEMINAR: ADVANCED TOPICS IN LAND USE AND HUMAN SETTLEMENTS.

LIFE SCIENCES

Biology

Biol 1008. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH.
Biol 1008H. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH.
Biol 1009. GENERAL BIOLOGY.
Biol 1009H. GENERAL BIOLOGY.
Biol 1103. GENERAL BOTANY.
Biol 1106. GENERAL ZOOLOGY.
Biol 1951,1952,1953. BIOLOGY COLLOQUIUM.
Biol 3012. PLANT BIOLOGY.
Biol 3112. BIOLOGICAL RHYTHMS.
Biol 5001. BIOCHEMISTRY.
Biol 5041. ECOLOGY.
Biol 5841. ECOLOGY.

Conservation Biology

CB 8452. CONSERVATION BIOLOGY: GENETIC AND DEMOGRAPHIC ISSUES.

Ecology, Evolution, and Behavior

EEB 3001. INTRODUCTION TO ECOLOGY.
EEB 3101. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.
EEB 5051. ANALYSIS OF POPULATIONS.
EEB 5052. THEORETICAL POPULATION ECOLOGY.
EEB 5132. HERPETOLOGY.
EEB 5608. ECOSYSTEMS: FORM AND FUNCTION.

Entomology

Ent 5040. INSECT ECOLOGY.
Ent 5320. ECOLOGY OF AGRICULTURE.

Fish and Wildlife

FW 5129. MAMMALOGY.

Genetics and Cell Biology

GCB 3002. HUMAN GENETICS, SOCIAL AFFAIRS.

Microbiology

MicB 3103. GENERAL MICROBIOLOGY.
MicB 5352. APPLIED MICROBIOLOGY.

Plant Biology

PBio 5183. WATER, MINERALS, AND TRANSLOCATION.

METEOROLOGY AND CLIMATOLOGY

Forest Resources

FR 3103. METEOROLOGY AND CLIMATOLOGY FOR RESOURCE MANAGERS.

Geology

Geo 8262. QUATERNARY PALEOECOLOGY AND CLIMATE.

Geography

Geog 1425. INTRODUCTION TO METEOROLOGY.
Geog 3421. CLIMATOLOGY.
Geog 5424. APPLIED CLIMATOLOGY.
Geog 8420. SEMINAR: CLIMATOLOGY.

Physics

Phys 1071. INTRODUCTORY METEOROLOGY.
Phys 1075. INTRODUCTORY METEOROLOGY LABORATORY.
Phys 5461. PHYSICS AND CHEMISTRY OF THE EARTH'S UPPER ATMOSPHERE.

Soil Science

Soil 1262. INTRODUCTION TO METEOROLOGY.
Soil 5240. MICROCLIMATOLOGY (SOILS).
Soil 5424. APPLIED CLIMATOLOGY.

WASTE MANAGEMENT

Agricultural Engineering

AgEn 5910. AGRICULTURAL WASTE MANAGEMENT ENGINEERING I.

Architecture

Arch 3064-3065. ENVIRONMENTAL MANAGEMENT AND CONTROL.

Biology

Biol 3051. BIOLOGY AND THE FUTURE OF THE EARTH.

Civil Engineering

CE 5501. ANALYSIS AND DESIGN OF WASTEWATER SYSTEMS.
CE 5510. SOLID AND HAZARDOUS WASTE MANAGEMENT.
CE 5515. WATER AND WASTEWATER MICROBIOLOGY.
CE 8500. PHYSICAL AND CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT.
CE 8501. PHYSICAL AND CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT - PART II.
CE 8502. BIOLOGICAL AND CHEMICAL PROCESSES FOR WASTEWATER TREATMENT.

Extractive Metallurgical Engineering

MetE 5800. MINERAL PROCESSING I.
MetE 5801. MINERAL PROCESSING II.

Forest Resources

FR 5241. NATURAL RESOURCE MANAGEMENT: POLITICAL AND ADMINISTRATIVE PROCESSES.

Interdepartmental Study

ID 3525-3526. GARBAGE, GOVERNMENT, AND THE GLOBE.

Landscape Architecture

LA 5010. PRINCIPLES OF OUTDOOR RECREATION DESIGN AND PLANNING.

Natural Resources and Environmental Engineering

NRES 1010. ISSUES IN THE ENVIRONMENT.

Public Affairs

PA 8791-99. WORKSHOP/SEMINAR: ADVANCED TOPICS IN TECHNOLOGY, ENERGY, AND ENVIRONMENTAL POLICY.

Public Health

PubH 5253. INTRODUCTION TO HAZARDOUS WASTE MANAGEMENT.
PubH 5254. HAZARDOUS WASTE MANAGEMENT.

NATURALIST STUDIES

Biology

Biol 5001. BIOCHEMISTRY.
Biol 5841. ECOLOGY.

Conservation Biology

CB 8452. CONSERVATION BIOLOGY: GENETIC AND DEMOGRAPHIC ISSUES.

Ecology, Evolution, and Behavior

EEB 5008. QUATERNARY ECOLOGY.
EEB 5014. ECOLOGY OF PLANT COMMUNITIES.
EEB 5016. ECOLOGICAL PLANT GEOGRAPHY.
EEB 5122. PLANT/ANIMAL INTERACTIONS.
EEB 5132. HERPETOLOGY.
EEB 5134. INTRODUCTION TO ORNITHOLOGY.
EEB 5814. PLANT COMMUNITY ECOLOGY.
EEB 5129. MAMMALOGY.

Entomology

Ent 3005. INTRODUCTORY ENTOMOLOGY.
Ent 5600. FIELD ENTOMOLOGY.

Forest Resources

FR 3100. IMPORTANT FOREST PLANTS.
FR 5103. ADVANCED FOREST TREE BIOLOGY.
FR 5152. FOREST GENETICS.
FR 5160. PRACTICUM IN FOREST BIOLOGY AND MEASUREMENTS.
FR 5221. PLANT MOLECULAR EVOLUTION.
FR 5700. COLLOQUIUM IN FOREST BIOLOGY.

Geography

Geog 3431. INTRODUCTION TO PLANT AND ANIMAL GEOGRAPHY.

Plant Biology

PBio 1009. MINNESOTA PLANT LIFE.
PBio 1012. PLANTS USEFUL TO HUMANS.
PBio 3201. INTRODUCTORY PLANT SYSTEMATICS.
PBio 5103. ALGAE, FUNGI, AND BRYOPHYTES.
PBio 5183. WATER, MINERALS, AND TRANSLOCATION.
PBio 5801. PLAINS AND BOREAL FLORA.
PBio 5811. FRESHWATER ALGAE.

Plant Pathology

PlPa 5002. INTRODUCTORY PLANT PATHOLOGY.
PlPa 8003. PLANT DISEASE THEORY III, POPULATIONS.

Soil Science

Soil 5610. SOIL BIOLOGY.

OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

Agricultural Engineering

AgEn 5540. EROSION CONTROL, WATERSHED ENGINEERING.

Aerospace Engineering and Mechanics

AEM 5687. INTRODUCTION TO ACOUSTICS AND ENVIRONMENTAL NOISE.

Communication Disorders

CDis 5704. NOISE AND MAN.

Environmental and Occupational Health

PubH 5155. ISSUES IN ENVIRONMENTAL AND OCCUPATIONAL HEALTH.
PubH 5161. ADMINISTRATION OF ENVIRONMENTAL HEALTH PROGRAMS.
PubH 5185. FIELD INSTRUMENTATION.
PubH 5191. OCCUPATIONAL SAFETY.
PubH 5192. OCCUPATIONAL SAFETY.

PubH 5194. INJURY PREVENTION IN THE WORKPLACE, COMMUNITY AND HOME.
PubH 5195. SEMINAR: SAFETY IN THE WORKPLACE.
PubH 5196. PROBLEMS: SAFETY IN THE WORKPLACE.
PubH 5197. TOPICS: INJURY PREVENTION IN THE WORKPLACE, COMMUNITY, AND HOME.
PubH 5211. INDUSTRIAL HYGIENE ENGINEERING.
PubH 5213. ERGONOMICS IN OCCUPATIONAL HEALTH.
PubH 5215. APPLIED OCCUPATIONAL TOXICOLOGY.
PubH 5218. FIELD PROBLEMS IN OCCUPATIONAL HEALTH.
PubH 5219. SEMINAR: OCCUPATIONAL HEALTH.
PubH 5233. BIOLOGICAL SAFETY.
PubH 5239. MICROBIOLOGY OF THE HUMAN ENVIRONMENT: SEMINAR.
PubH 5254. HAZARDOUS WASTE MANAGEMENT.
PubH 5267. ENVIRONMENTAL AND OCCUPATIONAL TOXICOLOGY.
PubH 5268. SEMINAR: TOXICOLOGY AND HUMAN POPULATIONS.
PubH 5271. OCCUPATIONAL EPIDEMIOLOGY.
PubH 5274. PRINCIPLES IN OCCUPATIONAL EPIDEMIOLOGY.
PubH 5275. EPIDEMIOLOGY AND THE LAW.
PubH 5281. TOPICS IN OCCUPATIONAL MEDICINE.
PubH 5590. THEORY AND PRACTICE OF OCCUPATIONAL HEALTH NURSING.
PubH 5592. PLANNING EMPLOYEE HEALTH SERVICE PROGRAMS AND CORPORATE COST CONTAINMENT.
PubH 8185. ANALYSIS OF TOXICANTS.
PubH 8191. RESEARCH: INJURY PREVENTION IN THE WORKPLACE, COMMUNITY, AND HOME.

Mechanical Engineering

ME 5603. THERMAL ENVIRONMENTAL ENGINEERING.

RECREATION AND OUTDOOR EDUCATION

Elementary Education

Elem 5348. WORKSHOP: OUTDOOR SCIENCE EDUCATION.

Forest Resources

FR 3232. MANAGEMENT OF RECREATIONAL LANDS.
FR 5231. RANGE MANAGEMENT.
FR 5233. PRINCIPLES OF OUTDOOR RECREATION DESIGN AND PLANNING.
FR 5236. FOREST RECREATION PLANNING.
FR 5257. RECREATION LAND POLICY.
FR 5259. ANALYSIS OF OUTDOOR RECREATION BEHAVIOR.
FR 5403. FUNDAMENTALS OF NATURAL RESOURCE EDUCATION.
FR 5406. FORESTRY WORKSHOP FOR TEACHERS.
FR 5408. FORESTRY IN THE URBAN ENVIRONMENT.
FR 8206. ADVANCED MANAGEMENT OF RECREATIONAL LANDS.

Landscape Architecture

LA 5010. PRINCIPLES OF OUTDOOR RECREATION DESIGN AND PLANNING.
LA 5105. RECREATIONAL PLANNING AND DESIGN.

Recreation, Park, and Leisure Studies

Rec 5160. CONSERVATION OF PARK RESOURCES.
Rec 5250. FINANCING LEISURE SERVICES.
Rec 5300. FOUNDATIONS OF OUTDOOR EDUCATION.
Rec 5310. PROGRAMMING IN OUTDOOR EDUCATION.
Rec 5350. WILDERNESS OUTDOOR RECREATION PROGRAMMING.

RESOURCE MANAGEMENT

Agricultural and Applied Economics

AgEc 3610. RESOURCE DEVELOPMENT AND ENVIRONMENTAL ECONOMICS.
AgEc 5650. ECONOMICS OF NATURAL RESOURCE POLICY.
AgEc 8264. RESOURCE ECONOMICS.
AgEc 8364. SEMINAR: RESOURCE AND ENVIRONMENTAL ECONOMICS.

Anthropology

Anth 5117. ANTHROPOLOGY OF RESOURCE MANAGEMENT.

Business, Government, and Society

BGS 8019. MANAGEMENT TOPICS: BUSINESS, THE PHYSICAL ENVIRONMENT, AND NATURAL RESOURCE ISSUES.

Economics

Econ 5611. RESOURCE AND ENVIRONMENTAL ECONOMICS.

Fisheries and Wildlife

FW 1101. ETHICS AND VALUES IN RESOURCE MANAGEMENT.
FW 5455. AQUACULTURE.

Forest Resources

FR 1201. CONSERVATION OF NATURAL RESOURCES.
FR 1203. INTRODUCTION TO MINNESOTA'S NATURAL RESOURCES.
FR 3103. METEOROLOGY AND CLIMATOLOGY FOR RESOURCE MANAGERS.
FR 3250. ROLE OF RENEWABLE NATURAL RESOURCES IN DEVELOPING COUNTRIES.
FR 3300. ELEMENTS OF SURVEYING.
FR 5200. AERIAL PHOTO INTERPRETATION.
FR 5212. NATURAL RESOURCES INVENTORY.
FR 5220. REMOTE SENSING, FOREST RESOURCES INVENTORY.
FR 5240. NATURAL RESOURCE POLICY AND ADMINISTRATION.
FR 5250. ROLE OF RENEWABLE NATURAL RESOURCES IN DEVELOPING COUNTRIES.
FR 5262. REMOTE SENSING OF NATURAL RESOURCES.
FR 5269. INTERDISCIPLINARY SEMINAR I.
FR 5270. INTERDISCIPLINARY SEMINAR II.
FR 5403. FUNDAMENTALS OF NATURAL RESOURCE EDUCATION.
FR 5412. ADVANCED REMOTE SENSING.
FR 8205. RESEARCH PROBLEMS: REMOTE SENSING.
FR 8211. SEMINAR: NATURAL RESOURCE POLICY ISSUES.
FR 5130. GEOGRAPHIC INFORMATION SYSTEMS IN NATURAL RESOURCE ANALYSIS.
FR 5241. NATURAL RESOURCE MANAGEMENT: POLITICAL AND ADMINISTRATIVE PROCESSES.

Geography

Geog 3345. ENERGY AND MINERALS.
Geog 5344. HISTORICAL GEOGRAPHY OF RESOURCE USE IN THE UNITED STATES.

Landscape Architecture

LA 8390. DESIGNING THE LONG-TERM LANDSCAPE.

Management

Mgmt 8019. MANAGEMENT TOPICS: BUSINESS, THE PHYSICAL ENVIRONMENT, AND NATURAL RESOURCE ISSUES.

Natural Resources and Environmental Studies

NRES 1001. ORIENTATION TO NATURAL RESOURCES AND ENVIRONMENTAL STUDIES.
NRES 1040. NATURAL RESOURCES AS RAW MATERIALS.
NRES 3001. COLLOQUIUM IN NATURAL RESOURCES AND ENVIRONMENTAL STUDIES.
NRES 3050. EXPERIENCE AND TRAINING IN A FIELD SETTING.
NRES 3099. PROBLEM SOLVING IN NATURAL RESOURCES AND ENVIRONMENTAL STUDIES I.
NRES 3100. PROBLEM SOLVING IN NATURAL RESOURCES AND ENVIRONMENTAL STUDIES II.
NRES 5210. SURVEY, MEASUREMENT, AND MODELLING METHODS FOR NATURAL RESOURCES.

Soil Science

Soil 5104. AGRICULTURAL SYSTEMS ANALYSIS AND MODELING.

SOIL RESOURCES

Agricultural Engineering

AgEn 5540. EROSION CONTROL, WATERSHED ENGINEERING.
AgEn 5550. DRAINAGE AND IRRIGATION ENGINEERING.
AgEn 8700. MOISTURE AND HEAT TRANSFER.

Agricultural Engineering Technology

AgET 5400. DRAINAGE AND IRRIGATION.

Environmental and Occupational Health

PubH 5186. ENVIRONMENTAL CHEMISTRY.

Forest Resources

FR 5126. SILVICULTURE: SOIL-SITE RELATIONSHIPS.
FR 8105. ADVANCED FIELD SILVICULTURE.
FR 8106. TOPICS IN SILVICULTURE--FOREST SOILS.

Geography

Geog 3451. GEOGRAPHY OF SOILS.

Soil Science

Soil 1020. THE SOIL RESOURCE.
Soil 3118. SEMINAR: SOIL AND WATER POLLUTION AND PUBLIC POLICY.
Soil 3125. BASIC SOIL SCIENCE.
Soil 3225. PHYSICAL SOIL MANAGEMENT AND CONSERVATION.
Soil 5340. ORGANIC AND PESTICIDAL RESIDUES.
Soil 5550. PEATLANDS: FORMATION, CLASSIFICATION, AND UTILIZATION.
Soil 5560. USES AND INTERPRETATION OF SOIL SURVEY INFORMATION.
Soil 5610. SOIL BIOLOGY.

Soil Science

Soil 5340. ORGANIC AND PESTICIDAL RESIDUES.
Soil 5560. USES AND INTERPRETATION OF SOIL SURVEY INFORMATION.

WATER RESOURCES

Agricultural Engineering

AgEn 5540. EROSION CONTROL, WATERSHED ENGINEERING.
AgEn 8500. HYDROLOGIC MODELING - SMALL WATERSHEDS.

Civil Engineering

CE 5401. WATER RESOURCES ENGINEERING.
CE 5405. HYDROLOGY AND HYDROLOGIC DESIGN.
CE 5425. GROUNDWATER MECHANICS.
CE 5426. COMPUTER MODELING OF GROUNDWATER FLOW.
CE 8406. SEMINAR: ADVANCED HYDROLOGY.
CE 8419. WATER RESOURCES SYSTEMS SIMULATION.
CE 8425. ADVANCED GROUNDWATER MECHANICS.
CE 8505. AQUATIC CHEMISTRY FOR ENVIRONMENTAL ENGINEERS.
CE 8506. AQUATIC CHEMISTRY FOR ENVIRONMENTAL ENGINEERS.

Fish and Wildlife

FW 5460. POLLUTION IMPACTS ON AQUATIC SYSTEMS.

Geology

Geo 8612. ANALYTICAL GEOHYDROLOGY.
Geo 5611. GROUNDWATER GEOLOGY.

Geography

Geog 5444. GEOGRAPHY OF WATER RESOURCES.

Public Health

PubH 5186. ENVIRONMENTAL CHEMISTRY.

Soil Science

Soil 3118. SEMINAR: SOIL AND WATER POLLUTION AND PUBLIC POLICY.

WATER SUPPLY AND WATER QUALITY

Agricultural Engineering

AgEn 5910. AGRICULTURAL WASTE MANAGEMENT ENGINEERING I.

Agricultural Engineering Technology

AgET 5410. HYDROLOGY AND WATER QUALITY.

Civil Engineering

CE 5500. ANALYSIS AND DESIGN OF WATER SUPPLY SYSTEMS.
CE 5501. ANALYSIS AND DESIGN OF WASTEWATER SYSTEMS.
CE 5505. WATER QUALITY ENGINEERING.
CE 5506. ENVIRONMENTAL WATER CHEMISTRY.
CE 5507. TECHNIQUES OF WATER AND WASTEWATER ANALYSIS.
CE 5540. ANALYSIS OF GROUNDWATER-SOIL POLLUTION ABATEMENT TECHNOLOGY.
CE 8500. PHYSICAL AND CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT.
CE 8501. PHYSICAL AND CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT - PART II.
CE 8502. BIOLOGICAL AND CHEMICAL PROCESSES FOR WASTEWATER TREATMENT.
CE 8550. ANALYSIS AND MODELING OF AQUATIC ENVIRONMENTS.
CE 8551. SEMINAR: MODELS OF AQUATIC ENVIRONMENTS.

Ecology, Evolution, and Behavior

EEB 5608. ECOSYSTEMS: FORM AND FUNCTION.

Forest Resources

FR 5114. FOREST HYDROLOGY.
FR 5115. FOREST HYDROLOGY, FIELD APPLICATIONS.
FR 5153. ADVANCED FOREST HYDROLOGY.
FR 5458. WATER QUALITY MANAGEMENT: ECOSYSTEM APPROACHES.

Public Health

PubH 5242. ENVIRONMENTAL HEALTH ASPECTS OF GROUNDWATER SYSTEMS.
PubH 5243. WATER AND HEALTH.

PART II. FULL COURSE DESCRIPTIONS LISTED BY FIELD OF INSTRUCTION

AEROSPACE ENGINEERING AND MECHANICS (AEM)

Institute of Technology

107 Akerman, 625-8000

AEM 5687. INTRODUCTION TO ACOUSTICS AND ENVIRONMENTAL NOISE. (4 cr; prereq Phys 1291 or Phys 1341 or equiv, Math 3321 or equiv; 3 lect and 1 lab hrs per wk)
Derivation of the wave equation, plane wave solution, transmission and reflection at boundaries, resonators and mufflers, three-dimensional wave propogation, properties of environmental noise sources, hearing and perception of sound, acoustical properties of rooms, laboratory experience in sound and noise measurements and noise control techniques.

AGRICULTURAL AND APPLIED ECONOMICS (AgEc)

College of Agriculture

231 Classroom Office Building, 625-1222
K. William Easter, 317G Classroom Office Building, 625-7728

AgEc 3610. RESOURCE DEVELOPMENT AND ENVIRONMENTAL ECONOMICS. (3 cr; prereq 1020-1030 or Econ 1001-1002 or #)
Basic concepts of resource use including physical and economic classifications; physical and economic feasibility; benefits and costs; external effects; cost sharing; selected resource use problems. Economic areas and units for planning and development; generation of alternative program elements and development of consequences; problems in choosing elements for an optimum resource development program.

AgEc 5600. LAND ECONOMICS. (4 cr for undergrad, 3 cr for grad; prereq 3101, 3102, or Econ 3101, 3102 or #)
Land as a factor of production; land use, classification, and value; sales and rental markets for land; domestic and foreign land policies.

AgEc 5650. ECONOMICS OF NATURAL RESOURCE POLICY. (4 cr for undergrad, 3 cr for grad; prereq 3101 or Econ 3101 or Econ 5151 or #)
Application of economic analysis, including project evaluation, to current natural resource issues. Emphasis on conservation and resource scarcity, environmental quality, population growth, and resource use issues and their implications for public policy.

AgEc 8264. RESOURCE ECONOMICS. (3 cr; prereq Econ 5162 or ¶Econ 5162 or #)
Economic analysis relevant to resource use and management; concepts of joint production and joint costs; external effects of resource decisions; applications of public finance, welfare economics, capital theory, and discount rates; cost-benefit analysis and other decision-making approaches; investment and management problems related to water resources, outdoor recreation, forestry, and fisheries; economic problems of air pollution and environmental quality.

AgEc 8360. LAND ECONOMICS AND POLICY. (3 cr; offered when demand warrants)

AgEc 8364. SEMINAR: RESOURCE AND ENVIRONMENTAL ECONOMICS. (3 cr; offered when demand warrants)

AGRICULTURAL ENGINEERING (AgEn)

Institute of Technology

213 Agricultural Engineering, 625-7733
J. L. Nieber, 203 Agricultural Engineering, 625-6724
C. J. Clanton, 230 Agricultural Engineering, 625-9218

AgEn 5540f. EROSION CONTROL, WATERSHED ENGINEERING. (4 cr; prereq IT upper division or grad IT major, 3052 or CE 3300, CE 5401 or #; 3 lect and 3 lab hrs per wk)
Measurement and mechanics of watershed runoff and soil erosion. Estimating peak runoff, soil losses, and sediment yields. Environmental effects. Principles of small watershed planning for flood control, water storage, and sediment control. Hydraulic design of graded and storage-type terraces, grass waterways, diversions, and erosion control structures.

AgEn 5550w. DRAINAGE AND IRRIGATION ENGINEERING. (4 cr; prereq IT upper division or grad IT major, 3052 or CE 3300, CE 5401 or #; 3 lect and 3 lab hrs per wk)
Flow of water through agricultural soils. Irrigation and drainage requirements, salinity control, evapotranspiration, water supply development and control. Conveyance of drainage and irrigation waters. Considerations for design, layout, and construction of irrigation and drainage systems. Institutional, environmental, and economic aspects of soil moisture control.

AgEn 5910w. AGRICULTURAL WASTE MANAGEMENT ENGINEERING I. (4 cr; prereq 3052, Chem 1005, CE 3400, upper div IT or grad IT major; 3 lect and 3 lab hrs per wk)
Sources and characteristics of agricultural wastes including livestock, processing, and domestic wastes. Physical, biological, chemical, rheological, and microbiological properties. Effects on environment. Collection, storage, treatment (aerobic and anaerobic), and utilization/disposal. Land application.

AgEn 8500s. HYDROLOGIC MODELING - SMALL WATERSHEDS. (4 cr; prereq CE 5405, grad IT major; 3 lect and 1 rec hrs per wk; offered 1988-89 and alt yrs)
Study and representation of hydrologic processes by mathematical models; infiltration, overland flow, return flow, evapotranspiration, channel flow, and storage. Time-flow relationships. Linear and nonlinear methods. Frequency-relationships. Emphasis on parametric methods.

AgEn 8700. MOISTURE AND HEAT TRANSFER. (3 cr; prereq knowledge of differential equations and #, grad IT major; offered alt yrs)
new Mathematical study of transfer of moisture and heat in agricultural crops and soils.

AGRICULTURAL ENGINEERING TECHNOLOGY (AgET)

College of Agriculture

213 Agricultural Engineering, 625-7733
J. L. Nieber, 203 Agricultural Engineering, 625-6724
C. J. Clanton, 230 Agricultural Engineering, 625-9218

AgET 5400s. DRAINAGE AND IRRIGATION. (4 cr; prereq Soil 3210; 3 lect and 2 lab hrs per wk)
Soil moisture excesses and deficiencies. Theory and design of tile drainage, surface drainage, and sprinkler irrigation systems. Development of irrigation water supplies. Selection of pumps and power units for drainage and irrigation. Economic feasibility. Legal problems and procedures.

AgET 5410w. HYDROLOGY AND WATER QUALITY. (5 cr; prereq Math 1111, Phy 1041, Chem 1004, 1005; 3 lect, 3 lab, and 1 rec hrs per wk)
The hydrologic cycle--precipitation, infiltration, evaporation, surface and subsurface runoff, and groundwater recharge. Flow in streams, flow in aquifers, flow measurement. Soil erosion, sediment transport and deposition. Chemical pollution of surface water and ground water.

ANTHROPOLOGY (Anth)

College of Liberal Arts

215 Ford Hall
T. Dunnigan, 214 Ford Hall, 625-0879

Anth 5116. CULTURAL ECOLOGY. (4 cr; prereq 1101, 1102 or 5102, one ethnographic area course or #)
The literature of cultural ecology, biological approach to ecosystems and population studies.

Anth 5117. ANTHROPOLOGY OF RESOURCE MANAGEMENT. (4 cr; also offered as Extension course under the title ENERGY, RESOURCE USE, AND SYSTEM CHANGE)
Social-cultural system factors in the development, production, control, distribution and use of energy, water and other key natural resources in the United States and other societies. Social-cultural evolution. Interaction among different societies, growth and no-growth issues, climate warming, emerging global interdependence.

ARCHITECTURE (Arch)

College of Architecture and Landscape Architecture

110 Architecture, 624-7866
Julia Robinson, 110 Architecture, 624-7866

Arch 3001. ENVIRONMENTAL DESIGN: THEORY AND PROCESS. (4 cr; §LA 3001; soph standing)
Design process and theory making and interpreting environments. Exploration of issues and theories at various scales. Lectures, readings, discussions, projects.

Arch 3002. ENVIRONMENTAL DESIGN: PEOPLE AND ENVIRONMENT. (4 cr; §LA 3002; prereq Arch 3001; soph standing)
Interaction of people with the environment. Relations between individuals, groups, culture and environment. The biological, social, and cultural basis is presented for concepts such as home, place, comfort, public and private. Focus on range of scales: rooms, buildings, cities and landscapes. Lectures, readings, discussions, and projects.

Arch 3060. TECHNOS: FORCE, FORM AND ARCHITECTURE. (4 cr; prereq Arch 1021, Arch major, and ¶Arch 3081)
Introduction to fundamental conceptual frameworks that relate science, technology, and building expression to architectural form. Present day to ancient periods. Climate, force, materials and structures case studies.

Arch 3064-3065f,w. ENVIRONMENTAL MANAGEMENT AND CONTROL. (4 cr per qtr; prereq Arch major or adult special, 3062, 3083 or #; 4 lect hrs per wk)
Environmental-mechanical considerations including comfort technology, space habitability, climate, psychometrics, control and management systems; waste management including plumbing systems and waste disposal techniques. Electrical systems, energy, power distribution and machinery; lighting systems, physiology of seeing, light sources and control; spatial acoustics, noise barriers, absorption.

BIOLOGY (Biol)

College of Biological Sciences

123 Snyder Hall, 624-2244
Kathleen Peterson, 223 Snyder Hall, 624-9717

Biol 1008. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH. (4 cr)
Description of evolution as the unifying principle in biology; organization and change in the biological world and the origin of humans.

Biol 1008H. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH. (4 cr)
For description, see 1008. Intended especially for honors students or their equivalent who plan to major in a life science discipline.

Biol 1009. GENERAL BIOLOGY. (5 cr)
Introduction to the principles of biology. The cell, metabolism, heredity, reproduction, ecology, and evolution. Includes laboratory.

Biol 1009H. GENERAL BIOLOGY. (5cr; prereq honors division or 3-4 years high school math, high school chem or #)
Intended especially for honors students or their equivalent who plan to major in a life science discipline.

Biol 1103f,w,s,su. GENERAL BOTANY. (5 cr; §3012; prereq 1009; students who plan to major in biology in CLA or in any bioscience major in CBS should take 3012)
Levels of organization of plants, plant function, plant growth and development, plant reproduction.

Biol 1106f,w,s,su. GENERAL ZOOLOGY. (5 cr; prereq 1009)
Survey of animal phyla; structure, function, behavior, adaptation, and evolutionary relationships.

Biol 1951f,1952w,1953s. BIOLOGY COLLOQUIUM. (S-N only)
An introduction to the diversity of biology through seminars, lab tours, undergrad research, trips to Itasca Biological Station, and interaction with other biology students and faculty.

Biol 3012f,w,s. PLANT BIOLOGY. (5 cr; §1103; prereq 1009, Chem 1005)
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants.

Biol 3051. BIOLOGY AND THE FUTURE OF THE EARTH. (4 cr; A-F or S-N; bioscience students may not apply these creedits to the major)
Nontechnical discussion of biological principles in environmental and social systems, e.g. air and water pollution, energy policy, population growth, resource management, food supplies, wilderness values, waste disposal, environmental health, toxicology, biodiversity, war, bioethics and ecophilosophy.

Biol 3052s. ENVIRONMENT, HEALTH, AND TOXICOLOGY. (4 cr; prereq 1009 or #; bioscience majors may use either 3052 or 5951 toward the major, but not both)
An overview of biochemical, cellular, organismic, and ecological principles of environmental health and toxicology. What are toxic and hazardous materials and how do they affect us and our environment? How do we evaluate the relative risks of various environmental hazards and how can we reduce or eliminate their effects?

Biol 3112w. BIOLOGICAL RHYTHMS. (4 cr; §5112; prereq 1009 or #)
Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular nature.

Biol 5001. BIOCHEMISTRY. (4 cr; prereq 1009, 12 cr organic chemistry or #)
new Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents, and cellular regulatory mechanisms.

Biol 5041. ECOLOGY. (4 cr; §5841, prereq Math 1142 or 1211, Biol 1103 or 1106 or 3011 or 3012)
Growth, structure, and evolution of populations. Pairwise biotic interactions between species, effect on diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems.

Biol 5951. SOCIAL USES OF BIOLOGY. (4 cr; S-N only; prereq 10 cr sciences)
Influence of biological science on the quality of human life: agriculture, medicine, occupational health, environmental science, and theories of human nature. Responsibilities and roles of biologists in policy formulation in the scientific and political world.

Biol 5841. ECOLOGY. (5 cr; §5041; prereq 1103 or 1106 or 3011 or 3012, Math 1142 or 1221, Δ)
new Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems. Field work at the Itasca station.

BUSINESS, GOVERNMENT, AND SOCIETY (BGS)

School of Management

30 Management and Economics, 625-0027
A. Marcus, 830 Management and Economics, 624-2812

BGS 3002. BUSINESS AND SOCIETY. (4 cr; prereq at least 90 cr completed or in progress; may not be taken S-N)
Examines the strategic and dynamic relations of business and society in a goal-oriented and problem-solving context. Focuses on the interfaces of business institutions with the physical environment, the social milieu, the political process and economic activity. Gives specific attention to the ongoing debate regarding national priorities and the respective roles of the private and public sectors concerning the challenges confronting U.S. society. Includes assessment of the concept, determinants, and indicators of the "quality of life" and the social responsibilities of business.

BGS 3003. BUSINESS AND THE NATURAL ENVIRONMENT. (4 cr; prereq jr or sr and at least 90 credits completed or in progress; may not be taken S-N)
Business and its relationship to the natural environment. The use by industry of renewable and nonrenewable resources. Environmental deterioration caused by businesses to air, land, and water. Business solutions to environmental problems. May emphasize energy in some quarters.

BGS 8019. MANAGEMENT TOPICS: BUSINESS, THE PHYSICAL ENVIRONMENT, AND NATURAL RESOURCE ISSUES. (3 cr)
(Same as Mgmt 8019) The impacts of business on the natural environment are very great. These impacts are both national and international in nature. Subsequent social, legal, and economic reactions to these environmental impacts may have consequences not only for an individual firm's profitability and survival, but also for global competitiveness and economic development. Solutions to environmental problems range from moral appeals and voluntary assumption of corporate responsibility to government regulation and government-imposed incentive strategies. This course will examine the reciprocal impacts of the firm and environmental/natural resource issues and will investigate various possible solutions to business-related environmental problems. It will focus on how companies cope with these issues, assessing both the role of internal corporate functions and of corporate external relations and stakeholder management.

BGS 8055. BUSINESS, GOVERNMENT AND MACRO-ECONOMICS. (4 cr)
Roles of government and business in society; alternative systems of economic and political values; social, political, economic, and cultural conflicts affecting the business sector.

BGS 8202. EXTERNAL AFFAIRS MANAGEMENT. (4 cr; prereq MBA 8055, grad mgmt/IR student or # and grad school mgmt approval)
Managing key aspects and issues that face business managers including environmental protection and natural resource issues. Discussion of development of legal framework for environmental control.

CIVIL ENGINEERING (CE)

Institute of Technology

122 Civil and Mineral Engineering, 625-5522
M. Semmens, 150 Civil and Mineral Engineering, 625-9857

CE 5212. TRANSPORTATION PRODUCTIVITY AND ENERGY CONSERVATION. (4 cr; prereq #)
Measuring transportation productivity and energy consumption; application of control theory for improving transportation productivity; simulation of energy-conservation policies and effect of such policies on transportation ridership and economics through time; transportation use and energy consumption in relation to urban and rural structures; case studies.

CE 5401. WATER RESOURCES ENGINEERING. (4 cr; prereq IT or grad student, 3400 or #; 3 lect and 3 lab hrs per wk)
Introduction to water resources engineering including flow in conduits, pumps, open channels and culverts; introduction to flow measurements, hydraulic structures and systems approach to water resources engineering.

CE 5405. HYDROLOGY AND HYDROLOGIC DESIGN. (4 cr; prereq IT or grad student, 5401 or #; 3 lect and 3 lab hrs per wk)
Hydrologic cycle, precipitation, evaporation, infiltration, runoff analysis, flood routing, statistical procedures in hydrology, urban hydrology, introduction to mathematical models of medium and large watersheds, application of hydrology to design of outlet works and flow control structures.

CE 5425. GROUNDWATER MECHANICS. (4 cr; prereq IT or grad student, 3400 or #)
Basic equations. Shallow confined and unconfined flows, two-dimensional flow in the vertical plane, and transient flow. Flow from rivers and lakes toward wells. Determination of streamlines and pathlines in two and three dimensions. Introduction to containment transport. Elementary computer modeling.

CE 5426. COMPUTER MODELING OF GROUNDWATER FLOW. (4 cr; prereq IT or grad student, 3400 or #)
Principles of Analytic Element Method, Boundary Integral Equation Method, Finite Element Method, Finite Difference Method. Applications of these four methods to field problems using existing computer programs. Derivation and interpretation of basic equations for contaminant transport in groundwater. Implementation of transport mechanisms in the various computer models.

CE 5500. ANALYSIS AND DESIGN OF WATER SUPPLY SYSTEMS. (4 cr; prereq 3400 or #, IT or grad student)
Planning and engineering design considerations in developing water supply systems for urban centers. Supply quality, storage, treatment, distribution, and cost analysis.

CE 5501. ANALYSIS AND DESIGN OF WASTEWATER SYSTEMS. (4 cr; prereq 3400 or #, IT or grad student)
Planning and engineering design considerations in developing waste disposal systems for urban centers. Volumes and quality of waste streams, treatment and ultimate disposal of domestic and industrial wastewaters, and storm water runoff. Environmental effects, cost, and political aspects of ultimate disposal.

CE 5505. WATER QUALITY ENGINEERING. (4 cr; prereq IT or grad student or #)
Chemical and physical properties of natural waters, introduction to aquatic biology, and ecological considerations of element cycling of natural carbon, nitrogen, phosphorus, oxygen, and anthropogenic chemical species (pesticides, PCBs, heavy metals). Physical and chemical processes of water treatment.

CE 5506. ENVIRONMENTAL WATER CHEMISTRY. (4 cr; prereq IT or grad student, Chem 1006 or #; 3 lect and 1 rec hrs per wk)
Composition of natural waters and wastewater; chemical processes affecting distribution of pollutants and water quality parameters in natural waters; methods of evaluation to determine fate of organic pollutants.

CE 5507. TECHNIQUES OF WATER AND WASTEWATER ANALYSIS. (4 cr; prereq 5500, 5501, 5506 or #, IT upper div student or grad)
Methods of sampling and examining natural waters and wastewaters; technique used in analysis of general water quality parameters, nutrients, major and minor ions, and natural and synthetic organic matter, with emphasis on modern analytical procedures. Composition of natural waters and wastewater; chemical processes affecting distribution of pollutants and waters; methods of evaluation to determine fate of organic pollutants.

CE 5510. SOLID AND HAZARDOUS WASTE MANAGEMENT. (4 cr)
Analysis and design of engineered systems for collection, transportation, processing, and disposal of solid and hazardous waste materials. Waste characteristics affecting management options, discussion of relevant regulatory legislation.

CE 5515. WATER AND WASTEWATER MICROBIOLOGY. (4 cr; prereq Chem 1005, Math 1231)
Analysis of role of microbes in environmental degradation and pollution control. Organism growth and selection in wastewater treatment systems. Pathogenic organisms in water supply. System control using microbial based indicators.

CE 5540. ANALYSIS OF GROUNDWATER-SOIL POLLUTION ABATEMENT TECHNOLOGY. (4 cr; prereq 5501, 5401 or #)
Fate of chemicals in groundwater and soils will be analyzed and modeled. Transport, dispersion, chemical-biological transformations and accumulation will be considered. Models will be used to study in situ clean-up of groundwater and aquifers and simulate time dependent changes in pollutant concentration.

CE 8406. SEMINAR: ADVANCED HYDROLOGY. (1 cr)
Weekly seminar by staff, students, and guest speakers.

CE 8419. WATER RESOURCES SYSTEMS SIMULATION. (4 cr prereq 5401 or #)
Computer simulation of water resource systems, including hydrology systems stream flow and quality systems, economic systems and sociopolitical systems using deterministic and stochastic approaches.

CE 8425. ADVANCED GROUNDWATER MECHANICS. (4 cr; prereq 5425 or #)
Conforma mapping techniques for two-dimensional steady groundwater flow. The hodograph method. Problems involving a free boundary and horizontal drains. Boundary value problems. Application of boundary integral equation techniques.

CE 8430. LAKE AND RESERVOIR HYDRODYNAMICS. (3 cr; prereq #)
Overview of hydrodynamic phenomena, analysis of density stratification, energy and momentum transfer through a water surface, wind effects of stratification and circulation, standing of progressive waves, stratified flow, density currents, selective withdrawal, mixing.

CE 8500. PHYSICAL AND CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT. (3 cr; prereq 5500, 5501, or #)
Theoretical principles underlying physical and chemical processes for water and wastewater treatment including sedimentation, flotation, adsorption, precipitation, and disinfection.

CE 8501. PHYSICAL AND CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT - PART II. (3 cr; prereq 5500, 5501, 5506 or #)
Theoretical principles, design considerations, and performance of processes not covered in CE 8500. Coagulation flocculation, filtration, membrane processes, gas transfer, sludge dewatering, mixing, and other processes commonly used in water pollution control.

CE 8502. BIOLOGICAL AND CHEMICAL PROCESSES FOR WASTEWATER TREATMENT. (3 cr; prereq 5501 or #)
Theoretical principles underlying chemical and biological wastewater treatment processes including aerobic and anaerobic biological processes for carbon and nitrogen removal, aeration, and chemical processes for phosphorus and nitrogen removal.

CE 8505. AQUATIC CHEMISTRY FOR ENVIRONMENTAL ENGINEERS. (4 cr; prereq Chem 5506 or #)
Application of principles of physical chemistry to quantification of chemical processes in aquatic systems. Natural waters as equilibrium and dynamic systems. Ionic equilibria; protolysis, complexation, solubility, and redox equilibria. Precipitation and mineral dissolution kinetics. Aqueous metal species in electrolyte solutions.

CE 8506. AQUATIC CHEMISTRY FOR ENVIRONMENTAL ENGINEERS. (4 cr; prereq 8505 or #)
Natural interactions with rock and soil, precipitation and atmospheric fallout; industrial and domestic sources. Nature of aqueous metals in term of electrolyte solutions, hydrolysis reactions, complexation, chelation, redox, solubility, and precipitation. Interactions at solid-solution interfaces in terms of phenomenological and general models for adsorption. Hydrodynamic, biological, and chemical factors affecting distribution, transport and removal from aqueous phase. Computer techniques emphasized.

CE 8550. ANALYSIS AND MODELING OF AQUATIC ENVIRONMENTS. (4 cr; prereq #)
Introduction to hydrologic transport and water quality simulation in natural water systems. Mixed cell models, advection, turbulent diffusion and dispersion in one- and two-dimensional systems. Chemical and biological kinetics in water quality models. Applications to temperature, dissolved oxygen, primary productivity, and other water quality management problems in rivers, lakes, and reservoirs. Deterministic versus stochastic models. Water quality dynamics.

CE 8551. SEMINAR: MODELS OF AQUATIC ENVIRONMENTS. (1-5 cr; prereq 8550)
Case studies of specific aquatic streams and lake systems.

CE 8560. SEMINAR: SPECIAL TOPICS IN ENVIRONMENTAL ENGINEERING. (1 cr; prereq #)
Selected environmental engineering topics discussed by students, staff members, and guests.

COMMUNICATION DISORDERS (CDis)

College of Liberal Arts

110 Shevlin Hall, 624-3322
W.D. Ward, 2630 University Ave. S.E., 627-4694

CDis 5704. NOISE AND MAN. (4 cr; prereq 5301 or #)
Temporary and permanent effects of steady, intermittent, and impulse noise on hearing and health. Annoyance and community noise. Noise measurement, reduction, and control; ear defenders and their limitations. Hearing conservation programs; preemployment testing and monitoring audiometry.

CONSERVATION BIOLOGY (CB)

Graduate School

307 Johnston Hall, 625-3490
Francie Cuthbert, 320 Hodson Hall, 624-1756

CB 8452. CONSERVATION BIOLOGY: GENETIC AND DEMOGRAPHIC ISSUES. (3 cr; prereq intro genetics course or #)
new Seminar on current conservation biology issues; genetic, demographic, and environmental analysis and management of populations; ecosystem conservation; case studies of species conservation strategies.

ECOLOGY, EVOLUTION, AND BEHAVIOR (EEB)

College of Biological Sciences

109 Zoology, 625-4466
Franklin H. Barnwell, 109 Zoology, 625-4466

EEB 3001. INTRODUCTION TO ECOLOGY. (4 cr; open to jrs and above but not to biology majors)
Basic concepts in ecology; the organization, development, and functioning of ecosystems; population growth and regulation. Human impact on ecosystems.

EEB 3101. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS. (4 cr; §3001; not open to biology majors; prereq Math 1231)
Description and analysis of the spatial and temporal interactions between populations in ecosystems; processes affecting populations; transformations of energy and materials in the biosphere. Lectures and recitations.

EEB 5008. QUATERNARY ECOLOGY. (4 cr; prereq Biol 5041 or 5841 or #)
Impact of changes in the physical and biological environment during the Quaternary period on plants and animals. Changes in evolutionary rates, geographical distributions, community composition and fluctuations in population sizes. Impact of prehistoric human culture on the environment, including ecosystem-level changes recorded in sedimentary sequences. Recent climatic changes. General principles of analysis and methods of investigation and interpretation.

EEB 5014. ECOLOGY OF PLANT COMMUNITIES. (5 cr; prereq Biol 5041 or 5841, 1 qtr statistics or #; offered when feasible)
Methods of describing, sampling, and classifying plant communities; theory of their structure and development, and of the stability of the interactions among their constituent populations. Field trips to examine local vegetation types; analysis of quantitative data.

EEB 5016. ECOLOGICAL PLANT GEOGRAPHY. (5 cr; prereq Biol 5041 or 5841, PBio 3201 [formerly Bot 3201] or PBio 3201 or #; offered when feasible)
Vegetation regions of the world and North America in detail; ecological principles of plant distribution; interpretation of regional and temporal patterns in distribution of vegetation and taxonomic groups. Field trips to floristic regions of Minnesota.

EEB 5051. ANALYSIS OF POPULATIONS. (4 cr; §8001; prereq Biol 5041 or 5841 or #)
Factors involved in the regulation, growth, and general dynamics of populations. Data needed to describe populations, population growth, population models, and regulatory mechanisms.

EEB 5052. THEORETICAL POPULATION ECOLOGY. (4 cr; prereq Biol 5041 or 5841 or #)
Theories of population ecology, including models of growth and regulation of single populations, and of interactions between populations, including competition, predation, mutualism; emphasizes assumptions and rationales of models and their predictions for dynamics, stability, diversity of communities.

EEB 5122. PLANT/ANIMAL INTERACTIONS. (4 cr; prereq Biol 1106 or 3011, 1103 or 3012 plus 10 credits in biological sciences or #)
Herbivority, pollination, seed dispersal. Implications of interaction for plants and animals at organismal, population, and community levels. Coevolution.

EEB 5129. MAMMALOGY. (5 cr; §FW 5129; prereq Biol 1106 or 3011 or #)
Recent families and orders of mammals of the world and of genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.

EEB 5132. HERPETOLOGY. (5 cr; prereq Biol 1106 or 3011 or #)
Distribution, classification, and evolution of amphibians and reptiles of the world. Physiological, morphological, and behavioral aspects of adaptive trends. Laboratory and lecture.

EEB 5134. INTRODUCTION TO ORNITHOLOGY. (5 cr; prereq Biol 1106 or 3011)
Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips scheduled.

EEB 5136. ICHTHYOLOGY. (4 cr; prereq 15 cr incl Biol 1106 or 3011)
Biology of fishes including development, systematics, anatomy, physiology, and ecology.

EEB 5601. LIMNOLOGY. (4 cr; §Geo 5601; prereq Chem 1005 or #)
Description and analysis of the events in lakes, reservoirs, and ponds, beginning with their origins and progressing through their physics, chemistry, and biology. Interrelationships of these parameters and effects of civilization on lakes.

EEB 5606. ECOLOGY OF FISHES. (3 cr; prereq Biol 1106 or 3011, EEB 5136 plus 10 cr in the biological sciences; offered when feasible)
Ecological requirements of fishes with emphasis on nongame species, habitat, food, interactions among species, and behavioral, anatomical, and physiological adaptations. Fishes in the aquatic ecosystem with emphasis on fresh waters.

EEB 5607. ECOLOGY OF ANIMAL PLANKTON. (4 cr; prereq Biol 5041 or 5841, EEB 5601 or #; offered when feasible)
Biology of animal plankton, including distribution of zooplankton in lakes, ecosystem functions such as grazing and remineralization, determination of production, physiological responses to contaminated environments, and important aspects of behavior.

EEB 5608. ECOSYSTEMS: FORM AND FUNCTION. (3 cr; prereq 5601 or Biol 5041 or 5841 or equiv)
Nature and development of terrestrial wetland and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.

EEB 5613. ASSESSING THE ECOLOGICAL EFFECTS OF POLLUTION. (4 cr; prereq Biol 5041 or 5841 or equiv, Chem 3301, 3302)
Assessment of effects upon species and ecosystems, methodological problems, initial phases of investigating a new pollutant, problems of prediction.

EEB 5621. LIMNOLOGY LABORATORY. (2 cr; §Geol 5621; prereq EEB 5601 or Geol 5601 or #)
Principal techniques for obtaining information about environmental conditions in lakes and streams. Procedures for measuring the abundance and population dynamics of aquatic organisms, with special emphasis on plankton, field instruments, sampling devices, chemical analyses, microscopy and analysis of data. One Saturday field trip.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

EEB 5814su. PLANT COMMUNITY ECOLOGY. (5 cr; limited to 20 students; prereq course in ecology; offered when feasible)
Communities represented in Itasca Park and vicinity, with emphasis on vegetation. Patterns of distribution of the communities, their interaction with the environment, and their dynamic relationships. Methods of community description and analysis.

EEB 5817s,su. VERTEBRATE ECOLOGY. (5 cr; prereq course in ecology, Δ)
Field studies on populations and their relationships to local environments; habitat analysis and ecological research methods. All students will work as a team investigating factors influencing the distribution and abundance of selected vertebrates in various habitats. This is a research-oriented course supplemented with lectures and field trips.

EEB 5834s,su. FIELD ORNITHOLOGY. (5 cr; prereq course in general biology including study of zoology; Δ)
Emphasis on the breeding season, biology, behavioral ecology of birds in the Itasca region. Field trips taken to a variety of habitats to learn bird identification and observe and practice techniques for conducting field studies. Laboratory sessions investigate family distinctions and species identification. Individual field projects. Designed primarily for students with fisheries and wildlife management interests. (Lab charge required)

ECONOMICS (Econ)

College of Liberal Arts

1035 Management and Economics, 625-6353
Christina Kelton, 1035 Management and Economics, 625-6353

Econ 5611w. RESOURCE AND ENVIRONMENTAL ECONOMICS. (4 cr; prereq 3101 or equiv, 1 qtr calculus; not offered 1989-90)
Exhaustible resources and the theory of optimal depletion. Renewable resources and the theory of optimal use. Will resource scarcity limit growth? Natural resources and natural environments. Environmental pollution and economic efficiency.

ELEMENTARY EDUCATION (Elem)

College of Education

125 Peik Hall, 625-6372
Pat Williamson, 125 Peik Hall, 625-4044

Elem 5348w. WORKSHOP: OUTDOOR SCIENCE EDUCATION. (3 cr; prereq elementary teaching experience, A-F only; also offered Summer 1991 through Extension)
Classroom and fieldwork activities dealing with models, materials, and methods in the outdoor setting; consideration of broad topics such as ecological relationships, cyclic processes, and change as well as more specific topics such as rocks and minerals, plants and animals, and stargazing.

ENTOMOLOGY (Ent)

College of Agriculture

219 Hodson Hall, 624-3636
David W. Ragsdale, 416 Hodson Hall, 624-3636

Ent 1005. ECONOMIC ENTOMOLOGY. (4 cr; prereq Biol 1009 or #)
Brief introduction to structure and classification of insects; management of insect populations; life histories, habits, and recognition of insect pests of livestock, orchards, field crops, vegetables, and ornamentals.

Ent 3005. INTRODUCTORY ENTOMOLOGY. (5 cr; prereq Biol 1009 or equiv)
General morphology, life histories, habits, and classification of insects.

Ent 5040. INSECT ECOLOGY. (3 cr; prereq Biol 5041 or EBB 5122 or #)
Synthetic analysis of the causes of insect diversity and of fluctuations in insect abundance. Focus on abiotic, biotic and evolutionary mechanisms influencing insect populations and communities.

Ent 5210. INTEGRATED PEST MANAGEMENT. (5 cr; prereq 1005 or #)
Management of insect, mite, and weed populations through integration of various methods and techniques.

Ent 5250. FOREST ENTOMOLOGY. (4 cr; prereq any two courses among the forestry, zoological, botanical, biological and/or agricultural sciences)
Lectures and laboratory concerning ecology and population management of forest insects, with heavy emphasis on tree factors and biological control.

Ent 5320. ECOLOGY OF AGRICULTURE. (4 cr; prereq two 3000 or above level courses in agronomy, horticulture or animal science, and two 3000 or above level courses in entomology, plant pathology or soil science or #)
Ecological perspective on post-industrial agriculture. Discussions on the origins of agriculture and comparison of the function and ecology of contemporary and extinct agricultural systems.

Ent 5600su. FIELD ENTOMOLOGY. (5 cr; prereq introductory biology; offered SSI at Itasca)
Insect fauna in various natural habitats of the park and surrounding areas. Includes field trips and collection and identification of insects, as well as studies of general morphology, life histories, and habitats of local species.

Ent 5610. AQUATIC ENTOMOLOGY. (5 cr; prereq 3005 or 5600 or equiv or #; given at Itasca)
Identification and biology of aquatic and littoral insects in all stages.

Ent 8240. COLLOQUIUM IN INSECT ECOLOGY. (3 cr; prereq 5040 or #)
Dispersal, distribution, abundance, natural control and related problems.

Ent 5280. LIVESTOCK ENTOMOLOGY. (3 cr)
Biology and management of arthropods that affect livestock production systems.

ENVIRONMENTAL AND OCCUPATIONAL HEALTH (PubH)

School of Public Health

1155 Mayo Memorial Building, 626-0900
Susan LaTendresse, 1260 Mayo, 626-0900

PubH 5151f. ENVIRONMENTAL HEALTH. (3 cr; prereq #; evening Extension course)
Methods for promoting human health and comfort by controlling environment.

PubH 5152. ENVIRONMENTAL HEALTH. (2 cr)
General principles of environmental health relating to macro and micro environments and products consumed or used by people.

PubH 5153. CASE STUDIES IN ENVIRONMENTAL HEALTH. (2 cr; prereq EH student and concurrent registration in PubH 5152 or #)
new Current applications of environmental health principles and practices. Relation of past didactic work to real-life problems encountered by environmental health professionals.

PubH 5155. ISSUES IN ENVIRONMENTAL AND OCCUPATIONAL HEALTH. (2 cr; prereq PH or grad student, or #)
new The field, the current issues, and the principles and methods of environmental and occupational health protection. Independent field visits to observe, review and analyze environmental/occupational health programs are required.

PubH 5158. HEALTH RISK EVALUATION. (3 cr; prereq EH majors or #)
General principles of health risk assessment and management; environmental pollutants; public domain and workplace, legislation and regulations.

PubH 5161. ADMINISTRATION OF ENVIRONMENTAL HEALTH PROGRAMS. (3 cr; prereq EH student or #)
new Administrative organization of environmental health activities.

PubH 5171. ENVIRONMENTAL MICROBIOLOGY. (4 cr; prereq MicB 3103 or #)
Survival, dissemination, monitoring, and significance of microorganisms in the environment; application of principles to environmental health problems.

PubH 5181. AIR POLLUTION. (4 cr; prereq 2 yrs chemistry, calculus, general physics or #)
Overview of current air pollution problems; sources; chemistry of air pollutants and polluted atmospheres; potential human health effects; air pollution control technology; laws regulating air pollution.

PubH 5184. AIR ANALYSIS. (3 cr; prereq 5211, #)
Laboratory and field exercises involving air flow calibration, dynamic calibration of field equipment for analysis of air contaminants, respirable mass sampling, dust counting and sizing, and instrumentation for measuring physical environmental stresses.

PubH 5185. FIELD INSTRUMENTATION. (1 cr; prereq 5211)
new Laboratory experience with the instruments used by industrial hygienists in the performance of field evaluations of occupational exposures to toxic agents. Sampling strategy.

PubH 5186. ENVIRONMENTAL CHEMISTRY. (3 cr; prereq general chemistry and organic chemistry or #)
Chemistry of atmosphere, water and soil; environmental behavior and fate of pollutants.

PubH 5191. OCCUPATIONAL SAFETY. (2 cr)
new Occupational safety procedures; environmental controls to reduce injuries on and off the job. Safety program development and administration. Summer - Graduate Occupational Health and Safety Institute.

PubH 5192. OCCUPATIONAL SAFETY. (3 cr)
new Provides information on the development of occupational safety programs essential to the health and safety of the worker and integral to public health in general.

PubH 5194. INJURY PREVENTION IN THE WORKPLACE, COMMUNITY AND HOME. (3 cr)
new Analysis of injury problems affecting the public in the workplace, community, and home; strategies for the prevention and control--an epideimologic approach.

PubH 5195. SEMINAR: SAFETY IN THE WORKPLACE. (1 cr)
new Safety problems in the workplace; hazard analysis and prevention and control of injuries to workers.

PubH 5196. PROBLEMS: SAFETY IN THE WORKPLACE. (2 cr; prereq OH student, grad, or MPH student, or #)
new An interdisciplinary approach to systematize and analyze data relevant to the hazards in the workplace. A forum format provides the opportunity for students to further synthesize and evaluate their findings.

PubH 5197. TOPICS: INJURY PREVENTION IN THE WORKPLACE, COMMUNITY, AND HOME. (1-3 cr; prereq #)
new Selected projects: provides an opportunity for students to pursue projects relevant to injury problems.

PubH 5201. RADIATION PROTECTION AND MEASUREMENT. (2 cr)
Ionizing radiation sources, detection and measurement, protection principles, health implications.

PubH 5202. RADIATION LABORATORY. (1 cr; prereq 5201 or concurrent with 5201)
Laboratory for 5201.

PubH 5211. INDUSTRIAL HYGIENE ENGINEERING. (3 cr)
Concepts and techniques used in occupational health; emphasis on evaluation of potential hazards and preventive techniques.

PubH 5213. ERGONOMICS IN OCCUPATIONAL HEALTH. (2 cr)
Provides a basis for understanding injury risk of lifting, material handling and repetitive motion activity in occupational environment. Topics include: biomechanics, strength testing, back and wrist injury, and strategies for reducing the risk of injury.

PubH 5215. APPLIED OCCUPATIONAL TOXICOLOGY. (3 cr; prereq 5261 or #; not offered 1990-91)
Basic toxicology and physiology with emphasis on environmental contaminants. Inhalation toxicology of the work environment and air pollution.

PubH 5218. FIELD PROBLEMS IN OCCUPATIONAL HEALTH. (3 cr; prereq 5211, #)
new Guided evaluation of potential occupational health problems; recommendations and design criteria for correction if indicated.

PubH 5219. SEMINAR: OCCUPATIONAL HEALTH. (1 cr; prereq OH student)
new Interdisciplinary discussions of current occupation health issues. Summer - Graduate Occupational Health and Safety Institute.

PubH 5233. BIOLOGICAL SAFETY. (2 cr; prereq #)
Topics include: assessment of risk; primary barriers, laboratory design criteria, safety devices and equipment; personnel practices; sterilization and decontamination; laboratory animals; and shipping and disposal of biohazardous agents.

PubH 5239. MICROBIOLOGY OF THE HUMAN ENVIRONMENT: SEMINAR. (1 cr; prereq #)
new Topics of current research interest on infectious disease and injury prevention through environmental intervention.

PubH 5242. ENVIRONMENTAL HEALTH ASPECTS OF GROUNDWATER SYSTEMS. (2 cr)
Groundwater geology, quality, and treatment; well design, construction and maintenance; special references to public and environmental health problems.

PubH 5243. WATER AND HEALTH. (3 cr)
Occurrences, health effects, and treatment of physical, chemical and biological agents in transmission of waterborne diseases.

PubH 5253. INTRODUCTION TO HAZARDOUS WASTE MANAGEMENT. (3 cr)
Review of roles of public and private sectors as generators, disposers and regulators of hazardous wastes. Includes definitions, sources, transportation, handling, treatment, recovery, disposal, and public health implications.

PubH 5254. HAZARDOUS WASTE MANAGEMENT. (1 cr)
new Overview of problems and possible solutions. Technical, political, social, economic and regulatory factors are included.
Summer - Graduate Occupational Health and Safety Institute.

PubH 5261. GENERAL ENVIRONMENTAL TOXICOLOGY. (3 cr)
Application of basic biochemical, anatomical, and physiological principles to environmental toxicology; assessment of potential health hazards; approaches to solution of toxic problems.

PubH 5262. METABOLISM AND DISTRIBUTION OF XENOBIOTICS. (3 cr; prereq 5261 or #)
new In depth examination of mechanisms and regulation of zenobiotic metabolism; kinetic models for distribution of toxicant and metabolites; receptor-mediated toxicity.

PubH 5266. RISK ASSESSMENT AND MANAGEMENT. (1 cr)
new General principles and practices, including data extrapolation techniques, model selection, public preference analysis, contextural analysis and equity analysis.

PubH 5267. ENVIRONMENTAL AND OCCUPATIONAL TOXICOLOGY. (3 cr; not open to students with subspecialty in toxicology)
new Basic principles of toxicology (absorption, distribution, metabolism, excretion, and site of action); tissue specificity of chemical injury.
Summer - Graduate Occupational Health and Safety Institute.

PubH 5268. SEMINAR: TOXICOLOGY AND HUMAN POPULATIONS. (1 cr)
new Students present data from the literature pertaining to the scientific evaluation of epidemiological studies that deal with human exposure to toxic agents.

PubH 5271s. OCCUPATIONAL EPIDEMIOLOGY. (3 cr; prereq basic epidemiology and biostatistics)
Basic principles and concepts in ascertaining health effects in the workplace; review and discussion of strategies for identifying excess risk, evaluating strengths and weaknesses of research techniques, assessing bias and confounding.

PubH 5274. PRINCIPLES IN OCCUPATIONAL EPIDEMIOLOGY. (2 cr; prereq bachelor's degree, registration in special occupational health symposium)
new Basic concepts in epidemiology and principles and methods related to evaluation of health effects of occupational exposures.
Summer - Graduate Occupational Health and Safety Institute.

PubH 5275. EPIDEMIOLOGY AND THE LAW. (1 cr)
new Basic principles and methods of epidemiology and use of epidemiologic studies in legal proceedings.
Summer - Graduate Occupational Health and Safety Institute.

PubH 5281. TOPICS IN OCCUPATIONAL MEDICINE. (2 cr)
new This course will review the major clinical, administrative, and preventive issues in occupational medicine. Disease mechanisms, descriptive epidemiology, and public health aspects of the common occupational health problems will be covered.
Summer - Graduate Occupational Health and Safety Institute.

PubH 5576. THE POLITICAL PROCESS IN PUBLIC HEALTH. (3 cr)
new Preparation for assuming leadership in health policy arena. Emphasis on policy development; political, legislative, and regulatory processes; and political strategies in public health.

PubH 5590. THEORY AND PRACTICE OF OCCUPATIONAL HEALTH NURSING. (1-4 cr)

new Introduction to major concepts and issues in occupational health and safety. Students identify a conceptual framework for working with aggregate populations of workers. Correlated field experience included.

PubH 5592. PLANNING EMPLOYEE HEALTH SERVICE PROGRAMS AND CORPORATE COST CONTAINMENT. (3 cr)

new Trends in health care cost containment will be examined for implications for planning and financing of health care for employees and their families. The role and functions of consultants and managers within insurance, industry and health care will be analyzed relative to programs in industry. Students will evaluate a health care cost containment program.

PubH 8185. ANALYSIS OF TOXICANTS. (3 cr; prereq #)

new Application of principles of analytical chemistry to analysis of toxic chemicals in tissues and fluids, environment, workplace, and environmental health research: survey of instrumental methods (gas and liquid chromatography, mass spectrometry, and atomic and molecular spectroscopy); interpretation of results; analytical quality control.

PubH 8191. RESEARCH: INJURY PREVENTION IN THE WORKPLACE, COMMUNITY, AND HOME. (3-6 cr; prereq #)

new Provides opportunity for students to develop independent and comprehensive research efforts relevant to injury problems.

PubH 8261. MOLECULAR TOXICOLOGY. (3 cr; prereq 5261 or #)

new Toxic actions and mechanisms of environmental chemicals: emphasis on current research in selective toxicity.

PubH 8269. SEMINAR IN TOXICOLOGY. (1 cr; prereq 5262 or #)

new Evaluation of toxicological studies. Students present data from the literature of their own research.

EXTRACTIVE METALLURGICAL ENGINEERING (MetE)

Institute of Technology

Civil and Mineral Engineering
105 Walter Library, 624-2006
M. T. Hepworth, Mineral Resources Research Center, 56 East River Road, 625-6354

MetE 5800. MINERAL PROCESSING I. (4 cr; prereq IT upper division; 4 lect hrs per wk)

new Introduction to unit operations of mineral and waste processing. Size reduction, classification, separation, and auxiliary operations. Application of physical and chemical principles to mineral and waste processing problems.

MetE 5801. MINERAL PROCESSING II. (4 cr; prereq IT upper division; 3 lect and 3 lab hrs per wk)

new Chemical, physical, and engineering aspects of flotation, tickening and filtration.

MetE 5901. PRINCIPLES OF METALS EXTRACTION. (4 cr; prereq IT upper division; 3 lect and 1 rec hrs per wk)

new Overall evaluation of a) pyrometallurgical, hydrometallurgical, and electrometallurgical extraction of metals from their concentrates, e.g., extraction of Cu, Ni, Pb, Zn, Mg, A., Ti, ironmaking and steelmaking, b) metal melting and recycling.

FISHERIES AND WILDLIFE (FW)

College of Natural Resources

200 Hodson Hall, 624-3600
WILDLIFE: F. Cuthbert, 320 Hodson Hall, 624-1756
FISHERIES: G.R. Spangler, 132 A Hodson Hall, 624-9229

FW 1001. ORIENTATION IN FISHERIES AND WILDLIFE. (1 cr; S-N only)

Survey of technical requirements and training of fishery and wildlife technicians and scientists; introduction to fields of work, problems and career outlets.

FW 1002. WILDLIFE: ECOLOGY, VALUES AND HUMAN IMPACT. (3 cr)
new Controversial issues involving specific wildlife management principles and techniques. Designed for students without natural science background who are interested in wildlife management issues.

FW 1101. ETHICS AND VALUES IN RESOURCE MANAGEMENT. (3 cr)
Coverage of various aesthetic, economic and ecological values of wildlife and fisheries resources. Class discussions will be directed at understanding the process and ethics of resource management.

FW 3052. INTRODUCTION TO FISHERIES AND WILDLIFE. (3 cr)
Introduction to general ecological principles applied to management of fish and wildlife populations and their habitats; survey of legislation, agencies and policy affecting vertebrate populations; natural history of important Minnesota game and nongame vertebrates.

FW 3167. TECHNIQUES OF FOREST WILDLIFE MANAGEMENT. (2 cr; offered at Cloquet)
Biology and management of important forest wildlife species; methods of evaluating forest wildlife populations and habitats.

FW 3600. FISHERIES AND WILDLIFE FIELD TECHNIQUES. (5 cr; FW 3052; given at Itasca)
An introduction to a variety of field techniques and skills; planning and implementing field projects; data collection and analysis using microcomputers; written reports and a field journal.

FW 5129. MAMMALOGY. (5 cr; §EBB 5129; prereq Biol 1106 or 3001 or #)
Recent families and orders of mammals of the world and genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.

FW 5455. AQUACULTURE. (4 cr; prereq Biol 1009, 1103, 1106 or equiv, Chem 1001-2 or 1004-5 or equiv or #; offered alt yrs)
Role of aquaculture in resource management and world food production; institutional and economic considerations; principles of husbandry of aquatic organisms; interactions between fish metabolism and water quality; nutrition and energetics; fish health and genetics.

FW 5459. ENVIRONMENTAL PHYSIOLOGY OF FISHES. (3 cr; prereq Biol 5041 and EBB 5136 or equiv)
Examination of environmental factors such as temperature, oxygen, salinity, toxic substances and food; effects on fish physiology with an emphasis on bioenergetics.

FW 5460. POLLUTION IMPACTS ON AQUATIC SYSTEMS. (3 cr; prereq Biol 5041, EEB 5601 and Chem 1004, 1005, 3301, 3305 or #)
new Pollution assessment approaches, biological effects, fate and flow of contaminants in aquatic systems, and major types of pollutants will be described.

FW 5570. AVIAN CONSERVATION AND MANAGEMENT. (4 cr; prereq grad or #)
new Current problems in avian conservation and management, with emphasis on non-game, wetland, and game birds.

FW 5601. ASSESSMENT AND MANAGEMENT OF VERTEBRATE POPULATIONS. (5 cr; prereq 1101, 3052 and FR 1201)
Conceptual models of populations, description of population characteristics and computer-assisted estimation of population parameters for the purpose of management. Students select either a fisheries or a wildlife laboratory.

FW 5603. ECOLOGY AND MANAGEMENT OF FISH AND WILDLIFE HABITATS. (4 cr; prereq 5601 or #)
Management of habitats for birds and mammals as developed from the environmental interactions and requirements of these animals. Emphasis is on regional settings and practices. Lab will include team projects and demonstrations.

FW 5604. FISHERY AND WILDLIFE MANAGEMENT. (4 cr; prereq 5601 or #)
Fundamental concepts and applications of fisheries management; pond and reservoir fisheries; lake and stream investigations; rehabilitation; lake fisheries management; warm-water and trout stream management.

FOREST RESOURCES (FR)

College of Natural Resources

115 Green Hall, 624-3400
Alan Ek, 204 Green Hall, 624-3400

FR 1001. FOREST RESOURCES ORIENTATION. (1 cr)
new Information about curricula offerings, areas of emphasis, CLE requirements, and summer job and internship programs.

FR 1200. INTRODUCTION TO FOREST RESOURCES. (3 cr)
Multiple forest resources and their management. History, policy, and current issues in forest resources. Lectures and laboratory.

FR 1201. CONSERVATION OF NATURAL RESOURCES. (3 cr)
Development of thought on natural resource conservation in the United States. Renewable resources and their management problems; resource conservation and environmental management related to basic ecological principles.

FR 1202. FARM AND SMALL WOODLANDS FORESTRY. (3 cr for non-forestry majors, 2 cr for majors [3 cr with paper]; prereq for majors 1100 or ¶1100)
Status and problems of the small woodland owner. Factors influencing tree growth. Cutting practices for and marketing products of small woodlands. Establishment and care of plantations, shelterbelts, and windbreaks. Field trips.

FR 1203. INTRODUCTION TO MINNESOTA'S NATURAL RESOURCES. (3 cr; §1201; for non-forestry students)
Ecological, social, and economic implications of Minnesota's soil, water, forest, wildlife, and other resources are studied in field exercise and group discussions at nature centers and natural areas. Environmental teaching techniques for the elementary indoor classroom.

FR 3100. IMPORTANT FOREST PLANTS. (1 or 2 cr; prereq Biol 1103; given at Itasca)
Identification of forest plants as related to forest types.

FR 3101. FIELD FOREST ECOLOGY. (3 cr; prereq Chem 1001 or Chem 1004; given at Itasca)
Field examination of succession, soils, silvical characteristics, tree classification, stand structure, and the ecology of regeneration.

FR 3102. SOUTHERN FOREST RESOURCE TOUR. (1 cr; prereq jr or sr or #; offered alt yrs)
One-week tour of selected southern forest industries and public forest management agencies. Walnut production, southern pine silviculture, hardwood utilization, various mill tours. Discussions, paper.

FR 3103. METEOROLOGY AND CLIMATOLOGY FOR RESOURCE MANAGERS. (2 cr; prereq Phys 1001, Phys 1005 or #)
Fundamentals of meteorology and climatology as applied to wildland resource management.

FR 3104. FOREST ECOLOGY. (3 cr; prereq Itasca session)
Ecological concepts and principles as a basis for silvicultural practice. The forest as an ecosystem.

FR 3201. FIELD FOREST MEASUREMENTS. (1 cr; prereq Math 1008; given at Itasca)
Introduction to land survey, tree and stand measurement, and basic forest sampling techniques.

FR 3225. DIRECTED STUDY EXPERIENCE. (1-5 cr; prereq #)
Opportunity to pursue experiences not available under independent study or extra credit registration. The student develops, in consultation with the adviser for the project, a prospectus, and completes progress reports on his or her project.

FR 3232. MANAGEMENT OF RECREATIONAL LANDS. (3 cr; prereq #)
Recreational use of the forest and associated land and water. Policy problems arising from recreational demands.

FR 3250. ROLE OF RENEWABLE NATURAL RESOURCES IN DEVELOPING COUNTRIES. (2 cr; also offered as FR 5200)
International perspective on important resource issues, including integration of natural resource, social, and economic considerations. Overviews of issues and case studies.

FR 3300. ELEMENTS OF SURVEYING. (2 cr; prereq Math 1008 or high school trigonometry; given at Cloquet Forestry Center 1 week prior to fall quarter)
Basic concepts of elementary plane surveying for use in natural resource assessment. Introduction to public land and boundary surveys and geographic information systems. Lectures and labs.

FR 5100. SILVICULTURE. (3 cr; prereq Itasca session, 1100)
Introduction to silvics, forest regeneration and site preparation techniques, intermediate silvicultural practices, and silvicultural systems.

FR 5101. FIELD SILVICULTURE. (3 cr; prereq 5100; given at Cloquet)
Regeneration surveys, plantation inspection, site preparation, and reforestation prescription. Practice in marking for thinning and determining effect on stands. Compartment examination and prescription. Written and oral reports.

FR 5103. ADVANCED FOREST TREE BIOLOGY. (3 cr; prereq FR 3104)
Current applications and research in forest tree biology.

FR 5104. FOREST ECOLOGY. (3 cr; prereq one course in biology or #)
new Ecological concepts and principles as a basis for conservation and management of forest ecosystems.

FR 5106. SENIOR SILVICULTURE SEMINAR. (2 cr [3 cr with research paper]; prereq senior, FR 5100, or #; A-N only)
Students prepare, present, and critique seminars on silvicultural topic of interest. Guest speakers.

FR 5110. FORESTRY APPLICATIONS OF MICROCOMPUTERS. (3 cr; prereq Stat 3011 and AgEt 3030 or equiv)
Use of microcomputer software to solve forestry problems, applications programming, working of hardware components. Hands-on access to microcomputers as well as lectures.

FR 5114. FOREST HYDROLOGY. (3 cr; prereq Itasca session, 3103, Geo 1001 or #)
Introduction to the hydrologic cycle and hydrologic processes. Effects of forest management activities on water yield, storm flow, and water quality.

FR 5115. FOREST HYDROLOGY, FIELD APPLICATIONS. (2 cr; prereq 5114 or #; given at Cloquet)
Use of hydrologic instrumentation to measure precipitation, streamflow, infiltration capacity, soil moisture, air temperature, evaporation, and selected water quality constituents. Collection and interpretation of hydrologic information to evaluate forest-use impacts on water quantity and quality.

FR 5120. INTRODUCTORY TREE PHYSIOLOGY AND GENETICS. (4 cr; prereq Chem 1001 or 1004, 10 cr Biol)
Genetic variation in forest trees, underlying causes, use. Tree growth, nutrition, and water relation. Environmental and internal regulation of growth. Plant biochemistry and photo-chemistry. Physiology related to silviculturally and ecologically significant phenomena.

FR 5126. SILVICULTURE: SOIL-SITE RELATIONSHIPS. (2 cr; prereq 1122, 5100; given at Cloquet)
Field examination of forest soils and their relationship to site productivity and forest management.

FR 5140. APPLICATION OF SILVICULTURE IN NORTH AMERICAN FOREST TYPES. (3 cr; prereq FR 5100 or #)
Current regeneration methods and intermediate stand treatments. Economic and biological principles. Primarily lectures. Student presentations, discussion of current literature, and field trips may also be included, depending on enrollment.

FR 5152. FOREST GENETICS. (3 cr; prereq sr or #)
Genetic variation of forest tree species and underlying principles; application of plant breeding principles to forestry.

FR 5153. ADVANCED FOREST HYDROLOGY. (4 cr; prereq 3220, 5114 or #)
Current hydrologic problems in the management of forested watersheds. Analytical methods to evaluate effects of vegetation management on the quantity and quality of runoff. Lecture and laboratory.

FR 5160. PRACTICUM IN FOREST BIOLOGY AND MEASUREMENTS. (3 cr; prereq grad only; given at Itasca)
Plant identification, plant dynamics, land survey, tree measurement.

FR 5200. AERIAL PHOTO INTERPRETATION. (3 cr)
Types, characteristics, procurement, preparation, viewing, and interpretation of color, black-and-white, and color infrared aerial photographs; basic aerial photography; introduction to mapping; applications to resource surveys.

FR 5212. NATURAL RESOURCES INVENTORY. (3 cr; prereq Itasca session, AgET 3030 or equiv computer programming course with FORTRAN or BASIC language, Math 1142 or Math 1211, Stat 3011 or Stat 5021)
Measurement of stand variables, forest products, forest growth and yield. Elementary statistics. Sampling methods for estimating characteristics of natural resources and resources use for management decision making. Lecture and laboratory.

FR 5215. FOREST FIRE MANAGEMENT. (2 cr; prereq FR 1100, Itasca session, 3103, 5100, or #)
Concepts, principles, and techniques of fire control and use in wildland management.

FR 5216. SPECIAL TOPICS IN FOREST FIRE MANAGEMENT. (cr ar; prereq FR 5215 or #)
Independent study in selected aspects of forest fire management.

FR 5217. FIELD TECHNIQUES FOR PRESCRIBED BURNING. (1 cr; prereq FR 5215 or #)
Field exercises in prescribed burn planning and execution.

FR 5218. FIELD TECHNIQUES FOR FOREST FIRE CONTROL. (1 cr; prereq FR 5215 or #)
Supervised experience in presuppression and suppression activities.

FR 5220. REMOTE SENSING, FOREST RESOURCES INVENTORY. (4 cr; prereq FR 5200, 5212; given at Cloquet)
Use of aerial photographs in property boundary location; interpretation and classification of forest vegetation types. Application of sampling methods for estimating natural resources and resource use for management decision making.

FR 5221. PLANT MOLECULAR EVOLUTION. (3 cr; prereq Biol 5003 or GCB 3022 or GCB 5022; equiv to PBiol 5221)
new Experimental molecular techniques applicable to evolutionary studies. Molecular methods of quantifying genetic diversity. Statistical methods for phylogenetic reconstruction. Application of RFLPs to the study of morphological evolution. Evolution of organellar gonomes. Evolution of multigene families. Role of transposable elements in plant evolution. DNA sequence evolution. Molecular aspects of development as related to plant evolution.

FR 5226. FOREST ECONOMICS AND PLANNING. (5 cr; prereq FR 5212, AgEc 1030 or #)
Conduct and interpretation of economic analysis, forest planning concepts, principles and techniques of forest regulation.

FR 5231. RANGE MANAGEMENT. (3 cr; prereq Biol 1103 or #)
Important range plants; range livestock; range management methods and improvements; public grazing land administration; relationship of livestock grazing to wildlife, forest, watershed, and recreation management on public and private range lands.

FR 5233. PRINCIPLES OF OUTDOOR RECREATION DESIGN AND PLANNING. (4 cr; prereq 5232 or #; same as LA 5010)
For advanced students associated with design, management, and planning of recreational facilities. Planning and design principles related to recreational land use and development; parks campsites, water areas, highways, summer and winter recreational facilities.

FR 5236. FOREST RECREATION PLANNING. (1 cr; prereq 5232; given at Cloquet)
Recreation area and site planning, examples and managerial concerns. Field work and presentation.

FR 5240. NATURAL RESOURCE POLICY AND ADMINISTRATION. (3 cr; prereq sr in forestry or #)
Basic concepts of political and administrative processes in development of natural resource policies and programs. Policy processes, agenda setting, political decision rules, strategies for achieving agreement, participants in policy development, public means of implementing policies and case examples.

FR 5248. HARVESTING AND ENGINEERING. (3 cr; prereq CE 3100; given at Cloquet)
An introduction to harvesting systems, relationship to forest management, and preparation and administration of timber sales. Fundamentals of location, construction, and maintenance of forest roads.

FR 5250. ROLE OF RENEWABLE NATURAL RESOURCES IN DEVELOPING COUNTRIES. (2 cr)
International perspective on important resource issues, including integration of natural resource, social, and economic considerations. Overviews of issues and case studies. Term paper, other requirements.

FR 5253s. FOREST BIOMETRY. (3 cr; prereq 5212, Stat 5022 or #; offered alt even yrs)
Topics in forest measurements, sampling, inventory, and the modeling and analysis of forest growth and change.

FR 5255s. FOREST RESOURCES SURVEY DESIGN. (3 cr; prereq FR 5212, Stat 5022 or #; offered alt odd yrs)
Advanced forest measurements, sampling, and survey design concepts and practices.

FR 5257. RECREATION LAND POLICY. (3 cr; prereq 5232 or #)
Policy issues affecting the use and management of lands devoted entirely or in part to recreational objectives.

FR 5259. ANALYSIS OF OUTDOOR RECREATION BEHAVIOR. (3 cr; prereq 5232, RRM major or grad student or #)
Development of environmental framework for understanding recreation behavior. Contributions of several disciplines, current cultural trends, management implications.

FR 5262. REMOTE SENSING OF NATURAL RESOURCES. (4 cr)
Introduction to remote sensing for natural resource inventories, land use analyses, and environmental monitoring activities; photographic, thermal, multispectral, and radar sensing procedures; airborne and satellite systems; visual and computer-assisted analysis techniques; oriented toward an interdisciplinary audience.

FR 5264. QUANTITATIVE TECHNIQUES IN FOREST MANAGEMENT. (3 cr; prereq FR 5212, 5226 or #)
Forestry applications of quantitative techniques in allocation and other decision-making problems. Mathematical programming, simulation, and other techniques.

FR 5269. INTERDISCIPLINARY SEMINAR I. (4 cr)
Resource and community development analysis, implications for resource allocation. Selected speakers, readings, and discussion topics. Diverse disciplinary contributions reflected.

FR 5270. INTERDISCIPLINARY SEMINAR II. (4 cr)
Development of ability to identify and analyze resource development problems. Student participation as team members; guest speakers. Diverse disciplinary contributions reflected.

FR 5401. SENIOR TOPICS. (ar cr; prereq sr in forestry or #)
Independent study in a field of interest to the student. Work must be planned with a forestry faculty member.

FR 5403. FUNDAMENTALS OF NATURAL RESOURCE EDUCATION. (3 cr; offered through Extension)
Intended for elementary school teachers. Study of soil, water, forest, and wildlife resources of Minnesota and the biological principles and ecological implications of management.

FR 5406. FORESTRY WORKSHOP FOR TEACHERS. (3 cr)
Forest ecosystems and forest management studied in lecture and laboratory sessions conducted in a forest environment. In field exercises, techniques and materials are developed for teaching principles of forestry in indoor and outdoor classrooms. Tours to forest and wildlife research and management units and utilization locations, and discussions of contemporary forestry issues by guest lecturers. Offered at Cloquet Forestry Center (1 week) in June.

FR 5408. FORESTRY IN THE URBAN ENVIRONMENT. (3 cr; prereq student teacher, teacher or #)
Study of forest ecosystems and forest management in lecture and laboratory sessions. Field exercises emphasize techniques and materials useful for teaching principles of forestry in indoor and outdoor classrooms; forest areas in the Twin Cities used for field exercises. Special uses and problems of the urban forest. Discussions and presentations by guest lecturers on contemporary forestry issues.

FR 5412. ADVANCED REMOTE SENSING. (4 cr; prereq FR 5262 or #)
Working knowledge of quantitative remote sensing. Both theoretical basis and practical aspects, including energy-matter interactions, radiation measurements and sensors, and digital analysis.

FR 5458. WATER QUALITY MANAGEMENT: ECOSYSTEM APPROACHES. (4 cr; prereq Chem 1005, 3103 or #)
Anthropogenic influences on aquatic ecosystems. Influences include forest management, point and non-point pollution, and acid rain. Fishery impacts.

FR 5500. URBAN FOREST MANAGEMENT. (3 cr; prereq 5100 or #)
Discussion and development of basic concepts. Introduction to terminology and principles of urban tree inventory, propagation, and care; management case studies; equipment operation and costs.

FR 5700. COLLOQUIUM IN FOREST BIOLOGY. (1-2 cr; prereq varies with topic or #)
Colloquium on specialized topics in forest biology and silviculture.

FR 8100. RESEARCH PROBLEMS: SILVICULTURE. (ar cr)

FR 8101. RESEARCH PROBLEMS: FOREST TREE PHYSIOLOGY. (ar cr)

FR 8102. RESEARCH PROBLEMS: FOREST TREE GENETICS. (ar cr)

FR 8103. RESEARCH PROBLEMS: FOREST HYDROLOGY. (ar cr)

FR 8105. ADVANCED FIELD SILVICULTURE. (3 cr; prereq FR 5101, #)
Selected current problems and research in silviculture. Plant-soil relationships with particular reference to forest soils. Methods of forest soil investigations in the field and laboratory.

FR 8106. TOPICS IN SILVICULTURE--FOREST SOILS. (ar cr; prereq FR 5100 and 5 cr in soils or #)

FR 8200. RESEARCH PROBLEMS: FOREST MANAGEMENT. (ar cr)

FR 8201. RESEARCH PROBLEMS: FOREST ECONOMICS. (ar cr)

FR 8202. RESEARCH PROBLEMS: FOREST MEASUREMENTS. (ar cr)

FR 8203. RESEARCH PROBLEMS: FOREST RECREATION. (ar cr)

FR 8204. RESEARCH PROBLEMS: FOREST POLICY. (ar cr)

FR 8205. RESEARCH PROBLEMS: REMOTE SENSING. (ar cr)

FR 8206. ADVANCED MANAGEMENT OF RECREATIONAL LANDS. (3 cr; prereq FR 5233, EBB 3004 or #)
Relationship of people as recreationists to the natural environment. Principles of manipulation of plant and animal communities for outdoor recreation objectives. Lectures, readings, discussions, reports, field trips.

FR 8207. ECONOMIC ANALYSIS OF FORESTRY PROJECTS. (3 cr; prereq #)
Public and private forestry projects; analysis of commercial profitability and application of benefit-cost analysis; preparation of feasibility studies; case studies.

FR 8210. RESEARCH METHODS IN FORESTRY. (1 cr)
Procedures for writing study plans and grant proposals. Each student will prepare study plan or grant proposal.

FR 8211. SEMINAR: NATURAL RESOURCE POLICY ISSUES. (3 cr)
Identification and analysis of major international, national, and state issues of importance to natural resource management. Review of literature, case studies, and guest speakers.

FR 8213. TOPICS IN WILDLAND HYDROLOGY. (3 cr; prereq 5114, CE 5405 or #; offered alt yrs)
Lecture and discussion of current literature on the water resources of wildlands (non-urban, non-agricultural lands).

FR 5121. TREE PHYSIOLOGY LABORATORY. (1 cr; prereq 5120 or #)
Laboratory study of aspects of tree biology. Emphasis on design and conduct of experiments.

FR 5130. GEOGRAPHIC INFORMATION SYSTEMS IN NATURAL RESOURCE ANALYSIS. (2 cr; prereq grad or #)
Provides an introduction to the application of Geographic Information Systems (GIS) to natural resource and regional planning studies. Theory and technical points covered, emphasis on applications. Hands-on experience on microcomputer. Case study is performed, including map digitizing, data processing, and generation of map products.

FR 5241. NATURAL RESOURCE MANAGEMENT: POLITICAL AND ADMINISTRATIVE PROCESSES. (3 cr; prereq FR 5240 or #)
Advanced concepts of political and administrative processes important to the development of natural resource policies and programs. Issue creation and agenda setting theories, incremental decision-making styles, role of analysis and analytical information, actions of major policy participants (e.g., courts, legislatures, interest groups, media), program planning, budgeting and staffing, and evaluation of natural resource case studies.

GENETICS AND CELL BIOLOGY (GCB)

College of Biological Sciences

250 Biological Sciences Center, 624-3003
Kathleen Peterson, 233 Snyder Hall, 624-9717

GCB 3002. HUMAN GENETICS, SOCIAL AFFAIRS. (3 cr [4 cr with paper], §3022 or §Biol 1101, §Biol 5003; for students in programs not directly related to biological sciences)
Human genetics; study of individuals, families, populations, and races with respect to differences in intelligence, behavior, disease, and other matters of social concern.

GEOGRAPHY (Geog)

College of Liberal Arts

414 Social Sciences, 625-6080
R. Skaggs, 568 Social Sciences, 625-6643

Geog 1401. PHYSICAL GEOGRAPHY. (5 cr; §NSci 1501)
Distribution patterns of climate, relief, vegetation, and soils, regional differences in problems of physical development.

Geog 1425. INTRODUCTION TO METEOROLOGY. (4 cr; §Soil 1262)
(Same as Soil 1262) The atmosphere and its behavior. Atmospheric composition, structure, stability, and motion; precipitation processes, air masses, fronts, cyclones and anticyclones; general weather patterns, meteorological instruments and observation; plotting and analysis of maps; forecasting.

Geog 3343. LAND USE AND STATE GOVERNMENT. (4 cr; prereq 3344)
How individuals choose to use land in the United States; the state's role in such choices. Descriptions of American landscapes as outcomes of decisions.

Geog 3344. LAND USE AND THE FEDERAL GOVERNMENT. (4 cr)
Analysis of how individuals choose to use land in the United States, emphasizing the statutory and regulatory framework for decisions. Description of American landscapes as outcomes of decisions.

Geog 3345f. ENERGY AND MINERALS. (4 cr)
Sources, production, circulation, and consumption of power, metals, and nonmetallic minerals. Problems of exhaustion, substitution, pollution, costs, trade, and policy. National and local case studies.

Geog 3421. CLIMATOLOGY. (4 cr; prereq 1401 or #)
World distribution of climatic elements; methods of arranging climatic data; climatic classifications and world distributions of climatic types; general circulation; climatic change and climatic fluctuations.

Geog 3431. INTRODUCTION TO PLANT AND ANIMAL GEOGRAPHY. (4 cr; not open to biology majors)
World distribution of plants and animals; biological and ecological background; the geographical picture; the paleoecological record.

Geog 3441f. LANDFORM GEOGRAPHY. (4 cr)
The role of landforms in the distribution of resources; processes of landform origin and change; map interpretation of landforms; complex environmental history of the Quaternary period and its contribution to a complicated pattern of landforms, with emphasis on North America.

Geog 3451. GEOGRAPHY OF SOILS. (4 cr; §Soil 5512)
Distributions of soil-forming processes and soil types; soil differences in small areas; soil constraints on human activities in different places; regional differences in soil problems and management techniques--farming, forestry, construction, agri-business, suburbanization, homesteading.

Geog 5344. HISTORICAL GEOGRAPHY OF RESOURCE USE IN THE UNITED STATES. (4 cr; prereq 3101 or 3344 or grad)
Selected topics in the development of the American landscape; how resources have been used.

Geog 5424. APPLIED CLIMATOLOGY. (3 cr; §Soils 5424; prereq Geog 3421 or Soils 5420 or #)
Application of climatic principles and data to selected problems in environmental management and agriculture.

Geog 5444. GEOGRAPHY OF WATER RESOURCES. (4 cr; prereq two courses in physical geography or #)
Distributional aspects of the magnitude, quality, and dynamics of water resources. Aesthetic, recreational, and material production uses of water; consequences of human actions in the hydrosphere, especially in fresh water.

Geog 8340. SEMINAR: LAND USE PLANNING. (3 cr; prereq #)

Geog 8344. SEMINAR: PUBLIC LAND POLICY IN MINNESOTA. (1 cr; prereq #)

Geog 8345. SEMINAR: PUBLIC LAND POLICY IN MINNESOTA. (3 cr; prereq 8344)

Geog 8420. SEMINAR: CLIMATOLOGY. (1-3 cr; prereq #)
Detailed study of selected topics. Topics vary from year to year; examples include modeling, climatic variability, predictability, severe local storms, drought, and energy balance.

GEOLOGY AND GEOPHYSICS (Geo)

Newton Horace Winchell School of Earth Sciences

Institute of Technology
106 Pillsbury Hall, 624-1333
H.O. Pfannkuch, 2D Pillsbury Hall, 624-1620

Geo 1001f,w,s. PHYSICAL GEOLOGY. (4 cr; 4 lect hrs)
A nonmathematical introduction to earth, its internal structure; processes that shape its surface; theory of plate tectonics; action of streams, glaciers, waves, wind, and groundwater; limnology; fossil fuels and mineral deposits; environmental geology; planetary geology; and the geology of Minnesota.

Geo 1005w. GEOLOGIC PERSPECTIVES ON ENERGY. (4 cr; 4 lect hrs per wk)
Introduction to the geologic aspects of energy resources, conventional and unconventional. History of energy use, distribution and amounts of known and potential reserves, environmental aspects and implications of U.S. consumption patterns.

Geo 1012f. INTRODUCTION TO COMPARATIVE PLANETOLOGY. (4 cr)
A nonmathematical introduction to comparative planetology. Topics include the origin and evolution of the solar system, composition, structure, and dynamics of planetary interiors, planetary surfaces, oceans and atmospheres; plate tectonics, the origin of the elements, climate, Earth resources, the biosphere, the life cycle of stars, vulcanism, and measurement of geologic time.

Geo 1021f,w,s. INTRODUCTION TO GEOLOGY LAB: GEOLOGY OF MINNESOTA. (1 cr; prereq 1001 or ¶1001 or #; one 2-hr lab)
Ten laboratory exercises based on the geology of Minnesota. These labs will introduce students to the bedrock, glacial history, topography, mineral resources, and environmental geology of the state through the use of appropriate minerals, rocks, topographic and geologic maps.

Geo 1111s. INTRODUCTORY PHYSICAL GEOLOGY. (5 cr; prereq high school or college chemistry or #; 3 lect hrs, 1 rec hr, and two 2-hr labs per wk)
For prospective majors and others desiring a more intensive course.

Geo 1601w. OCEANOGRAPHY. (4 cr; 3 lect and 1 lab hrs per wk)
How various processes in the ocean interact; analogies between the oceans and Lake Superior and smaller lakes in Minnesota. Topics include marine biology, waves, tides, chemical oceanography, marine geology and human interaction with the sea. Lab work includes study of live marine invertebrates and manipulation of oceanographic data.

Geo 3401w. INTRODUCTORY MINERALOGY. (5 cr; §5004, 5404; prereq 1001 or 1111 or #, 1 term college chemistry, Math 1221; 3 lect and 6 lab hrs per wk)
Crystallography, crystal chemistry, and crystal physics. Physical and chemical properties, crystal structures, and chemical equilibria of the major mineral groups. Laboratory includes crystallographic, polarizing microscope, X-ray powder diffraction exercises, and hand specimen mineral identification.

Geo 5004w. MINERALOGY. (4 cr; §3401; not open to geology, geophysics, and geological or mineral engineering majors; prereq Math 1221, 1 term college chemistry, and #; 3 lect and 6 lab hrs per wk; offered when demand warrants)
For description, see 3401.

Geo 5108w. ADVANCED ENVIRONMENTAL GEOLOGY. (4 cr; prereq geology core courses 1111 through 5201 or equiv or #)
Human impact on the geological environment and the effect of geology; geologic processes on human life from the point of view of ecosystems and biogeochemical cycles. Geologic limits to resources and carrying capacity of the earth. Land use planning, environmental impact assessment, ecogeologic world models. Field project.

Geo 5201s. STRUCTURAL GEOLOGY. (5 cr; prereq 3401; 3102; IT: upper division major in Geo, Geophys, GeoE, MinE; CLA: jr or sr Geo major; or #)
Primary and secondary structures of rocks, mechanics and modes of deformation, introduction to field methods in geology. Field trips.

Geo 5251. GEOMORPHOLOGY. (4 cr [5 cr with term project]; prereq 1001, Math 1111 or #; 3 lect, 2 lab hrs per wk; lab often used for field trips; offered when demand warrants)
Study of the origin, development, and continuing evolution of landforms in various environments. Environmental implications are emphasized. Topics include weathering, slope and shore processes, fluvial erosion and deposition, wind action, tectonics, and impact phenomena.

Geo 5261. GLACIAL GEOLOGY. (4 cr [5 cr with term paper or map lab]; prereq 1002 or 3112; offered when demand warrants)
Formation and characteristics of modern glaciers; erosional and depositional features of Pleistocene glaciers; history of Quaternary environmental changes in glaciated and nonglaciated areas. Field trips.

Geo 5601f,w. LIMNOLOGY. (4 cr; §EBB 5601; prereq Chem 1005 or equiv)
Description and analysis of events occurring in lakes, reservoirs, and ponds, beginning with their origins and progressing through study of their physics, chemistry, and biology. Emphasis on interrelationships of these parameters and on effects of civilization on lakes.

Geo 5611s. GROUNDWATER GEOLOGY. (4 cr; prereq 1001 or 1111, Math 1231, 1 qtr physics and chemistry or #)
Origin, occurrence, and movement of groundwater viewed in the context of the hydrologic cycle. Characteristics of aquifer systems. Exploratory investigations. Hydrogeologic units and boundaries of regional systems. Analysis of surface water groundwater interaction, recharge. Quality and chemistry of groundwater supplies. Contaminant hydrology.

Geo 8262. QUATERNARY PALEOECOLOGY AND CLIMATE. (4 cr; prereq 5261 or #; offered when demand warrants)
Principles of stratigraphic pollen analysis. Pleistocene and Holocene vegetation and climatic history as interpreted from pollen diagrams from different parts of the world. Paleoclimatic interpretation of ocean-sediment cores.

Geo 8602w. ADVANCED LIMNOLOGY. (3 cr; prereq 5601 or equiv, #; offered 1987-88 and alt yrs)
Detailed study of selected problems in limnology using current and classical literature. Term paper required.

Geo 8612. ANALYTICAL GEOHYDROLOGY. (3 cr; [4 cr with term paper]; prereq Math 3221, CE 3400 or #; offered when demand warrants)
Microphysics of flow through porous media; geological factors in aquifer performance; equations for groundwater flow; analysis of pumping tests; potential theory in groundwater flow; computer and analog models of aquifers; groundwater basin analysis; contaminant fate and transport through aquifers.

Geo 8617. TRANSPORT PHENOMENA IN NATURAL POROUS MEDIA. (2 or 3 cr; prereq CE 3400 or Chem 5520 or equiv or #; 2 lect hrs per wk and term project ar; offered when demand warrants)
Microscopic flow parameters, momentum, mass and energy transport through porous media, rate processes, coupled processes and nonequilibrium thermodynamics, geologic controls of natural flow systems in porous media and aquifers.

HISTORY OF SCIENCE AND TECHNOLOGY (HSci)

Babbage Institute for History of Information Processing

103 Walter Library, 624-5050
Arthur Norberg, 103 Walter Library, 624-5050

HSci 3331/5331. TECHNOLOGY IN AMERICAN CULTURE. (4 cr)
Technology in America with emphasis on its impact on society and culture. Traces the growth of American technology in its cultural and intellectual context from colonial period to present.

HUMANITIES (Hum)

College of Liberal Arts

314 Ford Hall, 624-5553
W. John Archer, 358 Ford Hall, 624-3830

Hum 3366. LANDSCAPE AND IDEOLOGY, 1600-1875. (4 cr; § Hum 3663)
new The cultural construction of "nature" as concept and as environment. From Puritan "garden in the wilderness" to 18th-century "natural" landscape garden and 19th-century transcendentalism. Attention to the role of agriculture, religion, philosophy, aesthetics, property relations, travel, and exploration.

INTERDEPARTMENTAL STUDY (ID)

College of Liberal Arts

225 Johnston Hall, 624-5701
Mary Lymer, 225 Johnston Hall, 624-5701

ID 3525-3526. GARBAGE, GOVERNMENT, AND THE GLOBE.
(4 cr winter, 4 cr spring; Extension course)
new Garbage—yours, mine, ours—affects not only our economy, politics, environment, and health but also the lives of untold future generations of humans and other species. The problem of garbage does not lend itself to narrow disciplinary approaches, but calls for cooperation among many fields. Reflecting this need for boundary crossing, this two-quarter course offers an interdisciplinary approach to learning about messy, real-world problems. Faculty from the Institute of Technology, the Carlson School of Management, and the Colleges of Agriculture, Biological Sciences, and Liberal Arts join students in examining topics such as the movement of toxic materials through the environment; the management of solid wastes, especially those generated by incinerators, power plants, municipal water treatment plants, etc.; the philosophic grounding of environmental exploitation in the ethics of humanism; the physical, chemical, and biological aspects of soils in environmental planning and conservation decisions; and the effect of environmental problems on economic competitiveness and domestic and international corporate operations. The sequence will include lectures, films, visiting speakers, and field trips. Students must enroll in both quarters. Enrollment is by application only; contact Susan Henderson in 202 Wesbrook Hall (625-6361). No prerequisite for 3525; 3525 for 3526.

ID 3970. DIRECTED STUDIES. (3-15 cr per qtr; prereq OSLO [Office for Special Learning Opportunities] approval, Δ)
Individual readings and research on topics that cross departmental lines.

JOURNALISM AND MASS COMMUNICATION (Jour)

College of Liberal Arts

111 Murphy Hall, 625-9824
P. Tichenor, 35 Murphy Hall, 625-7261

Jour 5133. INTERPRETIVE REPORTING ABOUT SCIENCE.
(4 cr; prereq 3121 or #, Δ; offered 1989-90)
Role of journalistic communication in science; scientist-journalist relationships; communicating results of scientific investigations to public, specialized audiences, industry.

LANDSCAPE ARCHITECTURE

College of Architecture and Landscape Architecture

205 North Hall, 625-8285
David Pitt, 205 North Hall, 625-7099

LA 1021. HISTORY OF ENVIRONMENTAL DEVELOPMENT: ARCHITECTURE. (4 cr; Arch 1021; 4 lect hrs per wk)
Introduction to the philosophy and principles of architecture and landscape architecture as an art; survey of environmental history from the ancient periods through the medieval age.

LA 1022. HISTORY OF ENVIRONMENTAL DEVELOPMENT: LANDSCAPE ARCHITECTURE. (4 cr; Arch 1022; prereq 1021; 4 lect hrs per wk)
Continuation of 1021 from the Renaissance through the modern eras; focuses on forces and individuals that shaped the form of architecture and landscape architecture in the 19th and 20th centuries in America and Europe.

LA 1023. HISTORY OF ENVIRONMENTAL DEVELOPMENT: PLANNING. (4 cr; Arch 1023; prereq 1022; 4 lect hrs per wk)
Introduction to urban planning. Survey of the rise and history of cities as centers of civilization. Collaboration among various disciplines for creating better urban environment and improving the quality of human life in cities.

LA 1031. INTRODUCTION TO LANDSCAPE ARCHITECTURE. (4 cr; 4 lect hrs per wk)
Design potential of materials of the landscape; exercises in assessment of land developments and detail landscapes; the role of landscape architecture in shaping the natural and cultural environment; brief historical review of site developments.

LA 3001. ENVIRONMENTAL DESIGN: PEOPLE AND ENVIRONMENT. (4 cr; Arch 3001)
Interaction of people with the environment, using natural and social sciences and the arts as background for readings, lectures, discussions, and workshop sessions.

LA 3002. ENVIRONMENTAL DESIGN: TOOLS AND PROCESSES. (4 cr; Arch 3002; prereq 3001)
Nature and the effects of various tools and processes of environmental change, ranging from buildings and landscapes to economic policies, climate, and myths. Readings, lectures, discussions, and workshop sessions.

LA 5010. PRINCIPLES OF OUTDOOR RECREATION DESIGN AND PLANNING. (4 cr; §FR 5233; 4 lect hrs per wk)
For advanced students interested in design, management, and planning of recreational facilities. Planning and design principles related to recreational land use and development; parks, collection, storage, treatment, and disposal. Utilization of liquid and solid wastes. Non-urban water supply and quality.

LA 5105. RECREATIONAL PLANNING AND DESIGN. (6 cr; prereq 5010; 2 lect and 12 lab hrs per wk)
Analysis, development, and presentation of landscape design solutions for diverse, recreational land uses.

LA 5107. REGIONAL LANDSCAPE DESIGN. (6 cr; prereq senior or grad or #)
Emphasis on large-scale land areas. Analyzing development potential and evolving solutions for integration of such divergent land use patterns as agricultural, residential, commercial, industrial and recreational.

LA 5562. INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS. (4 cr; prereq jr, sr, or grad major in Geog or LA or #)
Basic concepts of geographic information systems structure. Theory and applications for landscape location and resource analysis, and regional planning. Location principles, data structure, and variable attributes.

LA 8330. CONCEPTS OF LANDSCAPE EVALUATION. (2 cr; prereq 8108, MLA student or #)
Studies in philosophical bases for and wide-ranging approaches to evaluating qualitative aspects of landscape. Emphasis on aesthetic factors.

LA 8390. DESIGNING THE LONG-TERM LANDSCAPE. (2 cr; prereq MLA student or #)
Problems of designing landscapes that must sustain their integrity over generations or centuries. Survey of historical examples. Design theory, principles, and strategies.

LAW SCHOOL (Law)

285 Law Building, 625-1000
Ann Burkhart, 426 Law, 625-4522

Law 5215. ENVIRONMENTAL LAW. (3 cr; offered 1990-91)
Legal aspects of major environmental problems with emphasis upon pervasive issues that reappear in various regulatory contexts: e.g., the degree to which environmental quality should be protected; who should bear the cost enhancing environmental quality; the allocation of responsibilities among courts, legislatures, and administrative agencies; the role of citizens' groups and environmental litigation.

MANAGEMENT (Mgmt)

School of Management

30 Management and Economics, 625-0027
A. Marcus, 830 Management and Economics, 624-2812

Mgmt 8019. MANAGEMENT TOPICS: BUSINESS, THE PHYSICAL ENVIRONMENT, AND NATURAL RESOURCE ISSUES. (3 cr)
(Same as BGS 8019) The impacts of business on the natural environment are very great. These impacts are both national and international in nature. Subsequent social, legal, and economic reactions to these environmental impacts may have consequences not only for an individual firm's profitability and survival, but also for global competitiveness and economic development. Solutions to environmental problems range from moral appeals and voluntary assumption of corporate responsibility to government regulation and government-imposed incentive strategies. This course will examine the reciprocal impacts of the firm and environmental/natural resource issues and will investigate various possible solutions to business-related environmental problems. It will focus on how companies cope with these issues, assessing both the role of internal corporate functions and of corporate external relations and stakeholder management.

MECHANICAL ENGINEERING (ME)

Institute of Technology

125 Mechanical Engineering, 625-0705
B.Y. Liu, 130 Mechanical Engineering, 625-6574

ME 5603. THERMAL ENVIRONMENTAL ENGINEERING. (4 cr; prereq IT student or grad, 3303 and 5342 or equiv; 4 lect hrs per wk)
Thermodynamic properties of moist air; h-W diagram for moist air; solar radiation; heat and water vapor transmission in structures; effects of thermal environments upon people, processes, and materials; thermal loads, thermal environmental control systems.

ME 5609. AIR POLLUTION. (4 cr; prereq IT student or grad, 3303 or #; 4 lect hrs per wk)
Air pollution sources, atmospheric transport, transformations and fate. Air pollution meteorology, dispersion, and models. Basic chemistry of secondary pollutant formation, aerosol growth, air pollutant visibility relationships. Standards and regulations.

ME 5712. SOLAR ENERGY UTILIZATION. (4 cr; prereq IT student or grad, 5342 or #; 4 lect hrs per wk)
History and potential of solar energy utilization; availability of solar radiation on clear and cloudy days; incident radiation on horizontal, vertical, and inclined surfaces; flat-plate and concentrating solar collectors; heating and cooling with solar energy; power generation; review of current research.

MICROBIOLOGY (MicB)

College of Biological Sciences, College of Liberal Arts, and Medical School

1460 Mayo Memorial Building, 624-6190
Palmer Rogers, 925 Mayo Memorial Building, 624-7140

MicB 3103f. GENERAL MICROBIOLOGY. (5 cr; §5105, §Biol 5013, §VPB 3103; prereq soph with C avg in courses prereq to major sequence, or jr with 10 cr chemistry and 5 cr biological sciences or #)
Morphology, physiology, taxonomy, and ecology of bacteria. Applications of fundamental principles. Lab.

MicB 5352s. APPLIED MICROBIOLOGY. (4 cr; prereq 5321 or #)
Microbial adaptation to various environments; role of microorganisms in the earth's biogeochemical cycles. Application of microbial systems to industrial processes; basic principles of fermentation technology; microbial bioconversions and product formation. Biodegradation of chemicals.

NATURAL RESOURCES AND ENVIRONMENTAL STUDIES (NRES)

College of Natural Resources and College of Agriculture

439 Borlaug Hall, 625-1244
John V. Bell, 135 Natural Resources Building, 624-6704
Terrence H. Cooper, 439 Borlaug Hall, 625-7747

NRES 1001. ORIENTATION TO NATURAL RESOURCES AND ENVIRONMENTAL STUDIES. (1 cr; S-N only)
new Information about NRES major. Discussions with faculty adviser. Employment information. Current topics in NRES. Information about facilities. Discussions with alumni.

NRES 1010. ISSUES IN THE ENVIRONMENT. (3 cr)
Interdisciplinary offerings exploring five areas of environmental concern: aspects of environmental design providing maximum compatibility of human beings with their environment, sources of water pollution and their control, disposal and control of solid wastes from agriculture, minimization of pesticide pollution of the environment, and managed use of forest resources to maintain environmental quality. A televised course involving twenty taped lectures and ten discussion periods.

NRES 1040. NATURAL RESOURCES AS RAW MATERIALS. (2 cr)
new Role of natural resources as raw materials for industry and economic development. Environmental and economic trade-offs associated with raw material gathering, processing, and use. Implications of processing technologies, energy consideration.

NRES 3001. COLLOQUIUM IN NATURAL RESOURCES AND ENVIRONMENTAL STUDIES. (1 cr)
new Round table discussions of current topics in Natural Resources and Environmental Studies.

NRES 3050. EXPERIENCE AND TRAINING IN A FIELD SETTING. (1-4 cr; prereq jr or sr standing)
new Students are required to obtain professional experience in a field setting by attending field sessions, completing a professional experience program, or volunteering for various natural resource and/or environmental programs through local, state or federal agencies. Approval by an adviser required.

NRES 3099. PROBLEM SOLVING IN NATURAL RESOURCES AND ENVIRONMENTAL STUDIES I. (1 cr; prereq sr standing or #)
new Designed to help students identify and analyze natural resources and environmental problems. Identify a problem and develop a working plan for a solution. Students participate as a team.

NRES 3100. PROBLEM SOLVING IN NATURAL RESOURCES AND ENVIRONMENTAL STUDIES II. (3 cr; prereq 3099)
new Development of a solution to the problem identified in 3099. Discussions reflect diverse aspects of the problem and assignments. Oral and written presentation. Students participate as a team.

NRES 5210. SURVEY, MEASUREMENT, AND MODELLING METHODS FOR NATURAL RESOURCES. (3 cr; prereq Math 1142, Stat 3011 and computer competency)
new Introduction to survey design, measurement concepts, and modelling methods useful in the study of natural resources and environmental issues. Emphasis on data collection and analysis.

PHYSICS (Phys)

Institute of Technology

148 Physics, 624-7375
K. Maversberger, 42 Physics, 624-6305

Phys 1071f. INTRODUCTORY METEOROLOGY. (4 cr; prereq high school algebra; 4 lect hrs per wk)
Physics of atmospheric processes. Clouds, fronts, and cyclones. Weather forecasting. Human influence on the atmosphere.

Phys 1075f. INTRODUCTORY METEOROLOGY LABORATORY.
(1 cr; S-N only; prereq 1071 or ¶1071; 2 lab hrs per wk)
Field experiments offered in conjunction with 1071.

Phys 5461. PHYSICS AND CHEMISTRY OF THE EARTH'S UPPER ATMOSPHERE. (4 cr; prereq general physics and calculus; offered when feasible)
Survey of atmosphere above 15 km; physics and chemistry of the stratosphere, mesosphere, and thermosphere; temperature and density profiles; major and minor constituents and their distributions; aspects of pollutants; reactions and rates; global variation of constituents; the energy budget of the atmosphere.

PLANT BIOLOGY (PBio)

College of Biological Sciences

220 Biological Sciences Center, 625-1234
Thomas Soulen, 220 Biological Sciences, 625-1234

PBio 1009s. MINNESOTA PLANT LIFE. (4 cr; suitable for nonmajors)
Identification of the more characteristic and conspicuous Minnesota plants, including many lower forms, with discussion of their basic distinctions, life cycles, habitat requirements, distribution, vegetation types, and ecological relations. Lectures, demonstrations, six field trips.

PBio 1012s. PLANTS USEFUL TO HUMANS. (4 cr; for majors or nonmajors)
Roles that plants play and have played in human biological and cultural development. Lectures and demonstrations.

PBio 3201s. INTRODUCTORY PLANT SYSTEMATICS. (4 cr; prereq Biol 1103 or 3012)
Systematics of the flowering plants of the world. The ecology, geography, origins, and evolution of the flowering plants; family characteristics; floral structure, function and evolution; pollination biology; methods of phylogenetic reconstruction; molecular evolution; taxonomic terms; methods of collection and identification. Two field trips.

PBio 5103f. ALGAE, FUNGI, AND BRYOPHYTES. (5 cr; prereq Biol 1103 or 3012; offered when feasible)
Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Laboratory emphasizes living material and isolation of algae and fungi into culture.

PBio 5183. WATER, MINERALS, AND TRANSLOCATION. (4 cr; §PlPh 5183; prereq 5131 or equiv)
new Membrane phenomena and osmotic properties of cells. Uptake, movement, and loss of water in plants; effects of external factors. Translocation of organic substances. Absorption, distribution, and function of inorganic elements.

PBio 5231f. INTRODUCTION TO THE ALGAE. (5 cr; prereq 10 cr in plant biology or biology or #; offered when feasible)
Structure, reproduction, and life histories of major algal divisions.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

PBio 5801su. PLAINS AND BOREAL FLORA. (5 cr; limited to 20 students; prereq course in taxonomy, Δ; offered annually)
Survey of the summer flowering plants and ferns of the state with particular reference to the local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; natural history and population biology of selected important species.

PBio 5811. FRESHWATER ALGAE. (5 cr; prereq 10 cr plant biology, biology or zoology or equiv, Δ)
new Morphology, systematics, and distribution of the local algal flora. Collection, preservation, numeration, and culture techniques; identification of field collections using appropriate technical literature. Ecological implications of species interactions, algal associations, and indicator taxa.

PLANT PATHOLOGY (PlPa)

College of Agriculture

495 Borlaug Hall, 625-8200
Philip Larsen, 495 Borlaug Hall, 625-8200

PlPa 5002f. INTRODUCTORY PLANT PATHOLOGY. (5 cr; prereq 14 cr plant sciences or #)
Introductory course in plant diseases. Lectures, laboratory and special problems.

PlPa 5007s. AIR POLLUTION AND THEIR EFFECTS ON PLANTS. (3 cr; prereq 20 cr biology incl biochemistry)
Sources, types, and forms of air pollution; air pollution and changing climate; impacts of air pollution on crops and forests; acidic rain; methods of studying air pollution effects on plants including diagnosis; air quality regulations and policies.

PlPa 5050s. FOREST PATHOLOGY. (4 cr; prereq 10 cr plant sciences or forestry)
Diseases of forest and shade trees; wood decay. Symptoms, etiology and control. Lectures, laboratory, and field work.

PlPa 5102. FUNGAL ECOLOGY. (3 cr; prereq 5 cr botany)
new Emphasis on ecological studies and identification of fungi. Lectures include topics on fungal symbioses, morphology, coevolution and applicable ecological theory. Student teams will determine species richness in an aquatic, grassland, and forest habitat.

PlPa 5105. INTRODUCTION TO THE STUDY OF FUNGI. (4 cr; prereq 9 cr botany or Biol 1002 or #)
new Structure, habits, classification, and identification of fungi.

PlPa 5106. MYCOLOGY: ASCOMYCETES - FUNGI IMPERFECTI. (4 cr; prereq 5105 or equiv or MicB 3103 or #; offered alt yrs)
new Lectures and laboratory exercises in taxonomy, identification, life histories, genetics, and ecology of fungi.

PlPa 5107. MYCOLOGY: BASIDIOMYCETES. (4 cr; prereq 5105 or equiv or MicB 3103 or #; offered alt yrs)
new Lectures and laboratory exercises in taxonomy, identification, life histories, genetics, and ecology of fungi.

PlPa 8003s. PLANT DISEASE THEORY III, POPULATIONS. (4 cr; prereq 5005, 5006, 5007 or #, and 8001, 8002)
Disease in populations of plants; agroecosystems, natural ecosystems, and interrelatedness of plant disease over large geographic areas. This course introduces elements of population genetics, epidemiology, and geopathology.

PlPa 8111. FUNGAL GENETICS. (4 cr; prereq GCB 3022)
new Attributes of the genetics of fungi using classical approaches, including mendelian and quantitative traits, ecological and population genetics, incompatibility systems, tetrad analysis, treterokaryosis, somatic recombination, plasmids, genetics of parasitism, and molecular genetics techniques.

POLITICAL SCIENCE (Pol)

College of Liberal Arts

1414 Social Sciences, 624-4144
Terrence Ball, 1414 Social Sciences, 624-0083

Pol 3321. ISSUES IN AMERICAN PUBLIC POLICY. (4 cr)
Major public policy issues in such areas as social welfare and education; political forces molding policy choices and impact of such choices.

Pol 5523. THE POLITICS OF THE REGULATORY PROCESS. (4 cr; prereq 1001 or equiv or #)
Operations of regulatory agencies considered in context of political and legal environment. Principles of federal administrative law, informal procedures, interest group activity, philosophy of regulation, politics and processes of deregulation.

PUBLIC AFFAIRS (PA)

Hubert H. Humphrey Institute of Public Affairs
300 Humphrey Center, 625-9505
D.E. Abrahamson, 243 Humphrey Center, 625-2338

PA 5601. LAND USE. (4 cr)
Physical, spatial basis for community and regional development. Private sector development processes. Public regulatory frameworks, guidance and interventional strategies. Integration of physical, social and economic factors in land use policy, planning and decision-making. Graduate status or written permission.

PA 5622. DEVELOPMENT MANAGEMENT SYSTEMS. (3 cr)
Integrated systems of controls and incentives to manage land development at state, metropolitan, and local government levels. Traditional planning and land use devices, tax and fee techniques, environmental regulations and innovative controls.

PA 5701, 5702. TECHNOLOGY PLANNING I AND II. (3 cr each)
Relationship of science and technology to ideological bases of our society; identification of technology's significance to the policy process; analysis of our society's institutions for governing its technologies.

PA 5711. ENERGY POLICY I. (3 cr)
Possible energy supply systems and ways energy is consumed; relatively non-technical description of physical systems, environmental and social impacts, regulatory frameworks, resource base, and relationship to energy policy options.

PA 5712. ENERGY POLICY II. (3 cr)
Energy policy options including political, economic, environmental, and other considerations.

PA 5721. ENVIRONMENTAL POLICY I. (3 cr)
Systems in the natural and physical environment. Environmental impacts of technological innovation. Associated social controversy. Legislative, judicial, regulatory responses.

PA 5722. ENVIRONMENTAL POLICY II. (3 cr)
Relationship of science and technology to ideological bases of our society; identification of technology's bases of our society, identification of technology's significance to the policy process analysis of our society's institutions for governing its technologies.

PA 8600. SEMINAR: LAND USE PLANNING. (3 cr)
Topics vary, similar to an advanced topics course.

PA 8691-99. WORKSHOP/SEMINAR: ADVANCED TOPICS IN LAND USE AND HUMAN SETTLEMENTS. (3 cr)
Advanced analysis of selected topics in land use and human settlements such as large scale planned communities, agricultural preservation, historical preservation, infrastructure planning and programming, urban transportation policy.

PA 8791-99. WORKSHOP/SEMINAR: ADVANCED TOPICS IN TECHNOLOGY, ENERGY, AND ENVIRONMENTAL POLICY. (3 cr)
Topics in technology, energy, and environment, such as hazardous waste, energy efficiency, nuclear technologies, or atmospheric carbon dioxide.

RECREATION, PARK, AND LEISURE STUDIES (Rec)

College of Education

203 Cooke Hall, 625-5300
Leo H. McAvoy, 209 Cooke Hall, 625-5887

Rec 5160w. CONSERVATION OF PARK RESOURCES. (3 cr; prereq 1520 or 5100 or Δ)
Environmental considerations in relation to recreation and leisure services; environmental and visitor management in park areas.

Rec 5250s. FINANCING LEISURE SERVICES. (3 cr; prereq 3550 or Δ)
Methods and techniques of financing operations and capital improvements in public park and recreation agencies and nonpublic community leisure services; sources of revenue budgeting procedures.

Rec 5300f. FOUNDATIONS OF OUTDOOR EDUCATION. (3 cr; prereq sr, 1520 or 5100 or #)
Investigation of the philosophical, historical, and educational foundations of outdoor education.

Rec 5310s. PROGRAMMING IN OUTDOOR EDUCATION. (4 cr; prereq 5300 or #)
Methods, materials and settings for outdoor education and environmental interpretation programs.

Rec 5350su. WILDERNESS OUTDOOR RECREATION PROGRAMMING. (4 cr; prereq 3150 or #)
Exploration of leisure and educational resources of wilderness and management of wilderness-based outdoor recreation and outdoor education programs.

RHETORIC (Rhet)

College of Agriculture

202 Haecker Hall, 624-3445

Rhet 1310. HUMANITIES: THE LAND IN AMERICAN EXPERIENCE. (4 cr)
American attitudes toward the land from colonial times to the present as expressed in social history, literature, and fine arts. Social thought and the relationship between farm and city, wilderness and countryside. The changing appearance of America.

Rhet 3375. HUMANITIES: AGRICULTURAL HERITAGE. (4 cr)
new Examination and analysis of significant events or periods affecting rural agriculture peoples as expressed in historical, cultural, and literary documents. Understanding of major values, attitudes, and philosophies related to agricultural change and development.

SOCIOLOGY (Soc)

College of Liberal Arts

909 Social Sciences, 624-4300
Robert Kennedy, 1125 Social Sciences, 624-1615

Soc 3551w,s. WORLD POPULATION PROBLEMS. (4 cr)
Population growth and natural resources, population dynamics, fertility and mortality in less developed and industrialized nations, population forecasts, policies to reduce fertility.

SOIL SCIENCE (Soil)

College of Agriculture

439 Borlaug Hall
Russell S. Adams, Jr., 439 Borlaug Hall, 625-4229

Soil 1020w. THE SOIL RESOURCE. (4 cr; §3125)
Introduction to the physical, chemical, and biological aspects of soils. Use of the soil classification system to understand the use of soil survey information for land-use planning. Concepts of soil fertility for understanding plant growth requirements. Introduction to urban soils and their management. Understanding soil's role in environmental planning and conservation decisions.

Soil 1262. INTRODUCTION TO METEOROLOGY. (4 cr)
(Same as Geog 1425) Pre-calculus introductions to nature of atmosphere and its behavior. Atmospheric composition, structure, stability, and motion; precipitation processes, air masses, fronts, cyclones and anticyclones; general weather patterns; meteorological instruments and observations; plotting and analysis of maps; forecasting.

Soil 3118f. SEMINAR: SOIL AND WATER POLLUTION AND PUBLIC POLICY. (1 cr; [may be repeated for max 3 cr]; S-N only)
Speakers from the University, the public, and state and federal agencies address a current rural soil and water environmental issue, with emphasis on policies and pertinent technical concerns. A new topic is examined each time offered.

Soil 3125. BASIC SOIL SCIENCE. (4 cr; prereq Chem 1001 or 1004)
Basic physical, chemical, and microbiological properties of soil. Soil genesis, classification, and principles of soil fertility. Lectures and laboratory.

Soil 3225. PHYSICAL SOIL MANAGEMENT AND CONSERVATION. (4 cr; prereq 3125)
Physical characteristics of soil related to plant growth and development. Soil conservation: water and wind conservation practices (rural and urban); economical, social, and policy considerations; conservation strategies. Erosion and conservation in the world.

Soil 5104. AGRICULTURAL SYSTEMS ANALYSIS AND MODELING. (4 cr; §PlPa 5104, §AgEc 5104, §AnSc 5104; prereq Math 1142 or #)
Introduction to bioeconomic modeling as preparation for interdisciplinary agricultural systems analysis. Basic concepts; deterministic and stochastic models; delays, feedback, and clockwork; data aquisition; model verification and validation; role of models for agroecosystem management.

Soil 5240. MICROCLIMATOLOGY (SOILS). (5 cr; prereq Math 1111, 10 cr physics or #)
Meteorology and climatology in relation to the soil-atmosphere interface, with emphasis on the microclimate, physical processes taking place within the microclimate, modification of the microclimate, description of meteorological instruments, and use of weather data.

Soil 5340. ORGANIC AND PESTICIDAL RESIDUES. (5 cr; prereq 1122, sr or #)
The fate of crop residues, animal wastes, sewage materials, petroleum hydrocarbons, detergents, and pesticides in soils with emphasis on the chemical, physical, and biological factors of the soil that influence decomposition or persistence.

Soil 5424. APPLIED CLIMATOLOGY. (3 cr; prereq 5140 or Geog 3421 or #)
Intended for advanced undergraduates and beginning graduate students who have a background in the principles of climatology or microclimatology. Sources of climatic data, methods of analysis, and selected set of specific applications that focus on agricultural and environmental management problems.

Soil 5550. PEATLANDS: FORMATION, CLASSIFICATION, AND UTILIZATION. (3 cr; prereq 1122 or #)
Formation, properties, and management of peatlands important to crop, forestry, and energy production in this state and worldwide. Lecture.

Soil 5560. USES AND INTERPRETATION OF SOIL SURVEY INFORMATION. (3 cr; prereq 3520 or #)
Techniques used in preparing soil maps of varying scales. Information available from soil maps and accompanying reports evaluated for use in agriculture, engineering, waste treatment, forestry, and land planning. How soil survey information can be used to the fullest extent by both lay persons and the scientific community.

Soil 5610. SOIL BIOLOGY. (4 cr; prereq 1122 and PlPa 1001 or #)
The soil environment and its biological population. Role of living organisms in the soil-plant environment and cyclic transformations of agronomic interest (carbon, nitrogen, and mineral substances). Effect of soil microflora on soil fertility and plant nutrition. Lectures and laboratory.

UNIVERSITY COLLEGE (UC)

317 Walter Library, 624-2022
Susan Stonefield, 7 Wulling Hall, 624-2004

UC 3075. INDEPENDENT STUDY. (3-15 cr; prereq Δ)
UC 3075 is an undergraduate independent study course listing available to students who wish to pursue projects that go beyond the scope of any single department or college of the University. Projects are interdisciplinary in nature or are through departments that do not have an appropriate undergraduate independent study course. Students design their own projects and work with an appropriate faculty member who supervises and evaluates their project. May be taken for 3 to 15 degree credits.

VETERINARY BIOLOGY (VB)

College of Veterinary Medicine

295K Animal Science/Veterinary Medicine Building, 624-2700
Patrick T. Redig, 295B Animal Science/Veterinary Building, 624-4969

VB 5330. WILD BIRD MEDICINE. (2 cr; prereq regis vet med, 3rd or 4th year or DVM grad student or #)
Brief summary of important aspects of clinical avian anatomy and physiology and pathology. Survey of diseases common to wild birds and surgical repair of common injuries and fractures.

PART III. SPECIAL CENTERS AND LIBRARIES

CENTERS

JAMES FORD BELL MUSEUM OF NATURAL HISTORY

College of Biological Sciences
Donald Gilbertson, Director, 10 Church Street S.E., University of Minnesota, Minneapolis, MN 55455; 624-4112

The museum features exhibits of Minnesota wildlife, the Touch and See Room, and the Jacques Gallery of natural history art. It also houses extensive research collections of birds, mammals, reptiles, amphibians, and fish. Public education programs on natural history are offered throughout the year. The Natural History Library emphasizes collections in vertebrate zoology, behavior, and basic ecology and is located in the museum.

CENTER FOR POPULATION ANALYSIS AND POLICY (CPOP)

James W. Vaupel, Director, 257 Humphrey Center, 301 19th Ave. S., University of Minnesota, Minneapolis, MN 55455; 625-9821

The Center for Population Analysis and Policy (CPOP) is an international interdisciplinary population research center founded in 1987. In addition to some fifty faculty members from a broad range of disciplines at the University of Minnesota, CPOP's research involves participants from across the United States and Europe, as well as the U.S.S.R. and China. Some of CPOP's current activities include offering weekly research seminars, sponsoring conferences, and developing a graduate program in population sciences.

CENTER FOR URBAN AND REGIONAL AFFAIRS (CURA)

Thomas M. Scott, Director, 330 Humphrey Center, 301 19th Ave. S., University of Minnesota, Minneapolis, MN 55455; 625-1551

The regents established the Center for Urban and Regional Affairs to help make the University more responsive to the needs of the larger community and to increase the constructive interaction between faculty and students, on the one hand, and between the University and those dealing directly with major public problems, on the other hand.

Specific projects of the center are selected from several broad problem areas reflecting major concerns in this region: economic development and employment, environment, housing, human services, land use management, planning and public affairs, and the diffusion of information about these topics. These problems cut across a wide and changing array of disciplines.

CURA's role is to help coordinate and stimulate projects in these problem areas. It works with the faculty and students of all academic units of the University. All CURA programs are pilot, experimental, or short term projects. The goal is to probe and evaluate, complete short-term projects, discard unsuccessful ones, and help build successful ones into the appropriate part of the academic structure. It confines itself to projects for which there is currently no other practical administrative home.

The center also publishes a newsletter, the *CURA Reporter*. Information about both the newsletter and the center may be obtained from the CURA office.

DEPARTMENT OF PROFESSIONAL DEVELOPMENT AND CONFERENCE SERVICES (CEE)

Nolte Center for Continuing Education
Steven Weiland, Director, 215 Nolte Center for Continuing Education, 315 Pillsbury Drive S.E., University of Minnesota, Minneapolis, MN 55455; 625-8040

The Department of Professional Development and Conference Services, with support from the University of Minnesota academic faculty, assists groups in developing and presenting noncredit continuing education programs.

The department has a professional staff to assist interested parties in planning, publicizing, administration, and evaluation of continuing education programs. PDCS occasionally sponsors programs for the general public in the fields of environment, urban problems, and planning. For further information contact the director.

GRAY FRESHWATER BIOLOGICAL INSTITUTE

College of Biological Sciences
David Storvick, Interim Director, P.O. Box 100, County Roads 15 and 19, Navarre, MN 55392; 471-8476

The Gray Freshwater Biological Institute is a research facility where faculty and staff members, postdoctoral fellows, and students from several disciplines conduct basic research dealing with problems of fresh water.

LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

College of Biological Sciences
Administrative Office: David Siniff, Director, 305 Zoology, 318 Church Street S.E., Minneapolis, MN 55455; 625-9165

Located at the headwaters of the Mississippi River in northern Minnesota, the field station is an ecological area where three plant regions of the United States meet. Fifty square miles of protected forest provide unique opportunities for study of varied ecosystems and of the fauna and flora with southern, northern, and western origins. Diverse lakes and wetlands provide unusual field advantages for aquatic studies. For a list of courses held at the Station, see the entry for Lake Itasca in Part I, "Courses Listed by Subject Area."

LIMNOLOGICAL RESEARCH CENTER

Newton Horace Winchell School of Earth Sciences
Institute of Technology
Herbert Wright, Director, 220 Pillsbury Hall, 310 Pillsbury Drive S.E., University of Minnesota, Minneapolis, MN 55455; 624-7005

This center conducts research on the physical, chemical, biological, and geological aspects of lakes, especially those in Minnesota. Studies of lake history are made through analyses of microfossils and of the chemical and mineral components of sediments.

An evening seminar on current problems in limnological research is presented every winter quarter. Courses and degree programs in limnology are coordinated primarily through the Department of Geology and the Department of Ecology, Evolution and Behavior.

MINERAL RESOURCES RESEARCH CENTER (MRRC)

Civil and Mineral Engineering
Institute of Technology
Malcolm T. Hepworth, Undergraduate Program Director, 56 East River Road, Minneapolis, MN 55455; 625-3344

Extractive Metallurgical Engineering, an undergraduate program within the MRRC, educates engineers to design and manage systems for recovering metals and minerals from the earth as well as from scrap and waste. The program has been developed to satisfy the needs of the mineral and process metallurgy industries, and through its research on the recycling and reuse of mining, municipal, and industrial wastes, responds to the needs of society for solutions to growing environmental problems. Students have an opportunity to participate in practical research via employment or senior projects. Examples of recent research conducted by the MRRC are: rendering municipal sludge ash environmentally safe by pelletization, removal of hazardous constituents from electric arc furnace dusts, producing salt-water resistant cements from coal waste, and extracting lead and tin from electronic printed circuit boards.

MINNESOTA GEOLOGICAL SURVEY

Newton Horace Winchell School of Earth Sciences
Institute of Technology
Priscilla Grew, Director, 2642 University Avenue, St. Paul, MN 55114; 627-4780

The Minnesota Geological Survey is engaged in a number of activities related to the environment and planning. These include developing a database of waterwell logs and groundwater data for the state of Minnesota and preparing county atlases containing geological, hydrogeological, and resource information useful for environmental planning and management.

Undergraduate and graduate students are employed by the survey as aides and research assistants. Thus the Minnesota Geological Survey is a potential source of employment and research support in geologically related aspects of the environment and planning.

The Minnesota Geological Survey maintains an inventory of topographic and geologic maps of the state, as well as publications on the state's geology and resources.

MINNESOTA LANDSCAPE ARBORETUM

Department of Horticultural Science
College of Agriculture
Peter Olin, Director, P.O. Box 39, Chanhassen, MN 55317; 443-2460

Established in 1958, the Arboretum covers 905 acres of rolling hills with native woods, marshes, a prairie, formal display gardens, and a variety of plant collections. Its programs include the Andersen Horticultural Library with 9,500 non-circulating volumes and a plant locator database with sources for more than 30,000 commercially grown plants, the Research Department which develops cold-hardy fruit and landscape plants, the Horticultural Research Center which has introduced more than 70 cold-hardy fruit varieties, and many informal classes and workshops for children and adults on horticulture, landscape design, and related areas.

MINNESOTA PUBLIC INTEREST RESEARCH GROUP (MPIRG)

Heather Cusick, Executive Director, 2512 Delaware Street S.E., Minneapolis, MN 55414 (campus office, 235 Coffman Union); 627-4035

MPIRG is a nonprofit, nonpartisan organization representing Minnesota college students and working for constructive social change to benefit all Minnesotans. MPIRG activities related to environmental issues include work on energy policy, clean air, recycling, wilderness protection, and alternative modes of transportation.

MPIRG is funded by nearly 30,000 students on nine Minnesota college and university campuses who pay a special fee for its support. It is directed by a board of elected student representatives from the participating institutions. The board holds open meetings at least once a month. All matters of organizational business--from hiring staff, to allocating $400,000 annual budget, to selecting projects for the organization--are handled by the board. Any enrolled, fee-paying student may seek election to the board. Annual elections are held in the spring.

MPIRG employs a full-time staff of twelve people including attorneys, researchers, organizers and support staff. MPIRG publishes the quarterly, *Statewatch.* MPIRG sponsors coursework on advocacy--on campus, in communities, and with the legislature. It also provides numerous internships involving research, organizing, and legislative work. Students work with MPIRG staff in coordinated programs that involve publication of research findings and recommendations for public action, active representation before government agencies, law reform through legislative action, and, where necessary, legal action through courts.

ST. ANTHONY FALLS HYDRAULIC LABORATORY

Civil and Mineral Engineering
Institute of Technology
Roger Arndt, Director, Mississippi River at 3rd Avenue S.E., Minneapolis, MN 55414; 627-4012 or 627-4010

The St. Anthony Falls Hydraulic Laboratory's focus is on fluid mechanics and water resources engineering and its relationship to the fields of water resources development, including water quality dynamics and hydropower. The Laboratory conducts research on the flow of water in streams, rivers, estuaries, lakes, and man-made pipes, channels, and reservoirs. Transport of sediment, heat, and dissolved substances, as well as natural and artificial water storage, drainage, runoff, and other hydrological processes are part of the research program. The related fields of low speed aerodynamics and wind engineering are also studied.

In its fifty-year history the laboratory staff, comprised of Civil and Mineral Engineering Department faculty, civil service employees, and graduate and undergraduate students, has conducted hundreds of studies on water-related projects locally, nationally, and internationally. Extensive documentation is available through reports and films of the research studies in the Lorenz G. Straub Memorial Library.

The laboratory provides academic and financial assistance to graduate and undergraduate students interested in water resources engineering and related programs.

UNDERGROUND SPACE CENTER

Civil and Mineral Engineering
Institute of Technology
Raymond L. Sterling, Director, 790 Civil and Mineral Engineering Building, 500 Pillsbury Drive S.E., University of Minnesota, Minneapolis, MN 55455; 624-0066

The Underground Space Center is a division of the Department of Civil and Mineral Engineering. The center was founded in November 1977 by the Minnesota Legislature in response to the growing interest in many aspects of underground space utilization.

The goals of the center are to: serve as a focal point for planning and coordination of underground space use; carry out research in areas affecting underground space use; provide an information and referral service for all aspects of

underground space utilization, and serve as a focal point for international cooperation or research and information transfer.

During the past thirteen years, research at the Underground Space Center has been conducted on a wide range of topics. Major research areas have included: planning of underground space; legal and regulatory issues; habitability of underground space; life safety in underground buildings; underground storage of food and energy; earth sheltered building technology; subsurface heat transfer; foundation construction and energy use; geomechanics; frost heave action in soils; and energy conservation retrofits to existing buildings.

The Underground Space Center offers two courses on earth-sheltered building design and underground construction engineering; these courses are listed under the Civil Engineering Department's class schedule. Energy use, planning, security, environment, building design, landscaping, building codes, financing and psychological considerations are topics, studies and discussions in these courses.

WATER RESOURCES RESEARCH CENTER (WRRC)

Patrick Brezonik, Director, 866 Biological Sciences Center, 1445 Gortner Avenue, St. Paul, MN 55108; 624-9282

The Water Resources Research Center was established in the Graduate School in 1964. The center has responsibility for promoting water resources research at the University of Minnesota and at state and private colleges with funds provided by the Federal Water Resources Research Act of 1964 (most recently re-authorized in 1984). The WRRC also promotes coordination and cooperation among the water research programs of University departments and centers and state and federal agencies throughout the state. The WRRC supports water research activities of faculty primarily through an open competitive grant proposal mechanism. Both fundamental and applied research is supported on physical, biological, economic, social, and political aspects of water resources. Projects generally are related to pressing water issues in the state, such as groundwater contamination, effects of atmospheric contaminants on surface waters, nonpoint source pollution, and impacts of climate change on Minnesota's water resources. Training of scientists for work in water resources fields is an important function of the WRRC. The majority of funds on most projects awarded by the Center are used directly for graduate research assistantships and/or for undergraduate support. In addition, some opportunities exist for student employment on projects conducted directly by the Center.

The center assists in recruiting students and in guiding them into appropriate programs of study. The center has been helpful in developing new courses in various areas of water resources and a new graduate minor program in water resources.

The WRRC publishes and distributes a quarterly newsletter called *Minnegram* as well as other informative publications to people throughout the state. The results of research projects are published in technical reports and theses, which the center distributes to scientists and water managers throughout the state and nation. To provide an opportunity for professional people and students working in water resources fields to meet and exchange information, the WRRC organizes and sponsors symposia and conferences on specific water issues. In addition, in cooperation with the Minnesota Environmental Quality Board and other state agencies, the Center sponsors a biannual conference on water resources issues and problems in the state.

LIBRARIES

UNIVERSITY LIBRARIES—TWIN CITIES

The research collections that support the courses and programs in the environment are found throughout the nineteen libraries which comprise the University Libraries. The six major library units and their respective environmentally-related collections are:

Bio-Medical Library—East Bank (Diehl Hall)

Contains environmentally-related materials in the fields of health sciences, including microbiology, pharmacology, environmental health, and genetics.

Humanities and Social Sciences—East Bank (Walter Library)

Contains environmentally-related collections in education, sport, recreation and psychology.

Humanities and Social Sciences—West Bank (Wilson Library)

Contains environmentally-related collections in a broad range of social sciences and humanities, including economics, political science, sociology, anthropology, philosophy, and history. The Map Library and the Business Reference Service are also located in Wilson. The Government Publications Library (409 Wilson Library) serves as the official U.S. Regional Depository for the State of Minnesota. It houses all federal depository documents and also has holdings of non-depository federal, municipal, and regional documents, with emphasis on the Twin Cities area.

Law Library—West Bank (Law Building)

Contains environmental law materials.

St. Paul Libraries—St. Paul Campus

Besides the St. Paul Central Library with its collections on agriculture and home economics, five libraries on the St. Paul Campus contain environmentally-related material in the fields of biochemistry, forestry, wildlife, vegetation, and veterinary medicine. These libraries are:

Biochemistry Library	(406 Biological Sciences Center)
Entomology, Fisheries and Wildlife Library	(375 Hodson Hall)
Forestry Library	(203 Green Hall)
Plant Pathology Library	(395 Borlaug Hall)
Veterinary Medical Library	(450 Veterinary Science)
Science and Technology/East Bank	(Walter Library)

Collections on chemistry, engineering, geology, mines and metallurgy, and physics contain environmentally-related information ranging from urban design to water pollution to environmental geology. There is a separate Architecture Library (160 Architecture).

In addition to strong collections, the University Libraries offer a full range of reference and research services including specialized reference assistance and computerized data base literature searching. Inquire at any library.

NON-UNIVERSITY LIBRARIES

Environmental Conservation Library (ECOL)

Minneapolis Public Library, 300 Nicollet Mall, Minneapolis, MN 55401; 372-6570

ECOL, a special collection within the Minneapolis Public Library, brings together materials from various subject fields that relate to the physical, environmental, and human impact on it. ECOL has books, periodicals, newsletters, pamphlets, bibliographies, posters, and government documents relating to such topics as air and water pollution, solid waste, wildlife, conservation of natural resources, land use planning, environmental law, energy resources, and environmental education. ECOL was designated by the Minnesota Legislature as a state center for environmental information and receives publications of many state agencies, including environmental impact statements. ECOL serves as the local public document room for U.S. Nuclear Regulatory Commission materials relating to nuclear power plants in Minnesota. A newsletter, *ECOL News*, is published twice a year and is free to the public.

A large collection of full documents and articles on microfiche are available for use and loan. Entitled Envirofiche, they are keyed to the abstract journal *Environment Abstracts*.

Minnesota Department of Health Library

Diane Jordan, Librarian, 717 Delaware Street S.E., Minneapolis, MN 55440; 623-5090

This collection has been developed with the needs of public health professionals in mind and is a specialized library with technical, as opposed to popular, literature. It is a reference collection only and extends no loan privileges except through interlibrary loan. The library subscribes to some 200 periodicals.

Minnesota Department of Public Service Library, Energy Division (formerly Minnesota Energy and Economic Development Library)

Galina Mogilyansky, Librarian, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101; 296-7952

This research library has a noncirculating collection, although some items may be borrowed through the MINITEX system. The collection contains United States and Minnesota statistics of energy use, Department of Energy reports, and approximately 100 periodicals. There is strong emphasis on energy conservation reports. The library has environmental information on electric power, nuclear power, solar energy, and coal development.

Minnesota Pollution Control Agency Library

Kathy Malec and Helena Peskova, Librarians, 520 Lafayette Road, St. Paul, MN 55155; 296-7719 or 296-6623

This collection has been developed with the needs of professional pollution control engineers in mind. It is essentially a technical library with few subprofessional materials. The library extends reference services.