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NATIONAL
LABORATORY**

LOCKHEED MARTIN

**Environmental Sciences Division
Annual Progress Report
for Period Ending
September 30, 1994**

**Environmental Sciences Division
Publication No. 4407**

**MANAGED BY
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

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**Environmental Sciences Division
Annual Progress Report for Period Ending
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Preface

This progress report summarizes the research and development activities conducted in the Environmental Sciences Division (ESD) of Oak Ridge National Laboratory during fiscal year (FY) 1994, which extended from October 1, 1993, through September 30, 1994. The report is structured to provide descriptions of current activities and accomplishments in each of the division's major organizational

units. Following the sections describing the organizational units are sections highlighting ESD Scientific, Technical, and Administrative Achievement awards and listing information necessary to convey the scope of the work in the division. An organizational chart of staff and long-term guests who were in ESD at the end of FY 1994 is located in the final section of the report.

Abbreviations and Acronyms

AAAS	American Association for the Advancement of Science
ACC	Air Combat Command
ACS	American Chemical Society
AEM	analytical electron microscopy
AFS	American Fisheries Society
AGU	American Geophysical Union
AIBS	American Institute of Biological Sciences
AL	action level
AMP	Artificial Magma Program
ANS	Advanced Neutron Source
ARM	Atmospheric Radiation Measurement
ARS	Agricultural Research Service
ASA	American Society of Agronomy
ASCE	American Society of Civil Engineers
ASLO	American Society of Limnology and Oceanography
ASTM	American Society for Testing and Materials
AWIS	Association for Women in Science
AWRA	American Water Resources Association
BFDP	Biofuels Feedstock Development Program
BMAP	Biological Monitoring and Abatement Program
BOREAS	Boreal Ecosystem-Atmosphere Study
BSCP	Background Soil Characterization Project
BWID	Buried Waste Integrated Demonstration
CAAA	Clean Air Act Amendments
CDIAC	Carbon Dioxide Information Analysis Center
CD-ROM	compact disk, read-only memory
CEB	Center for Environmental Biotechnology
CENR	Committee on Environment and Natural Resources
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CL	confidence limit
CLP	Contract Laboratory Program
CMP	computer model package
CMS	Clay Minerals Society
COMPMECH	compensatory mechanisms in fish populations
CPBR	Consortium for Plant Biotechnology Research
CRADA	cooperative research and development agreement
CSRS	Cooperative State Research Service
CSSA	Crop Science Society of America
CV	coefficient of variation
CVI	coastal vulnerability index
DAAC	Distributed Active Archive Center
DNA	deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid

DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE-HQ	DOE Headquarters
DOE-ORO	DOE Oak Ridge Operations
EA	environmental assessment
EBMUD	East Bay Municipal Utilities District
ECAS	Environmental Compliance Assessment System
ECG	Environmental Compliance Group
EDTA	ethylenediaminetetraacetate
EFPC	East Fork Poplar Creek
EIS	environmental impact statement
EMAP	Environmental Monitoring and Assessment Program
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EPSCOR	Experimental Program to Stimulate Competitive Research
ER	Environmental Restoration
ERMD	Environment and Resource Management Division
ERWM	Environmental Restoration and Waste Management
ES&H	Environmental Safety and Health
ESA	Ecological Society of America
ESD	Environmental Sciences Division
FERC	Federal Energy Regulatory Commission
FIFE	First ISLSCP Field Experiment
FY	fiscal year
GCRP	Global Change Research Program
GCTE	Global Change and Terrestrial Ecosystems
GE-CRD	General Electric Cooperate Research and Development
GEMS	Genetically Engineered Microorganisms
GIS	geographic information system
GLoED	Global Emissions Database
GREENTIE	Greenhouse Gas Technology Information Exchange
GSA	Geological Society of America
GWA	Ground Water Association
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSEA	Health, Safety, Environment, and Accountability (Organization) (Y-12)
IAEA	International Atomic Energy Agency
ID	integrated demonstration
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IGBP	International Geosphere-Biosphere Programme
IMS	Information Management System
INEL	Idaho National Engineering Laboratory
INRA	Institut National de la Recherche Agronomique
IPCC	Intergovernmental Panel on Climate Change
ISLSCP	International Satellite Land Surface Climatology Project
ISV	in situ vitrification

IUFRO	International Union of Forest Research Organizations
LDR	land disposal restrictions
LMRP	Lower Mokelumne River Project
MASE	Mercury Air-Surface Exchange project
MMES	Martin Marietta Energy Systems, Inc.
MOU	memorandum of understanding
MRT	modified ring test
NAACP	National Association for the Advancement of Colored People
NADP	National Atmospheric Deposition Program
NAEP	National Association of Environmental Professionals
NAFTA	North American Free Trade Agreement
NALMS	North American Lake Management Society
NAPAP	National Acid Precipitation Assessment Program
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NBS	National Biological Survey
NCDC	National Climatic Data Center
NCIMB	National Collections of Industrial and Marine Bacteria
NCMS	National Center for Manufacturing Science
NDP	numeric data package
NEPA	National Environmental Policy Act
NGWA	National Groundwater Association
NIEHS	National Institute of Environmental Health Sciences
NIGEC	National Institute for Global Environmental Change
NOAA	National Oceanic and Atmospheric Administration
NOM	natural organic matter
NPDES	National Pollutant Discharge Elimination System
NPP	net primary production
NPPC	Northwest Power Planning Council
NPS	National Park Service
NRC	National Research Council
NRDA	Natural Resource Damage Assessment
NRICGP	National Research Initiative Competitive Grants Program
NSF	National Science Foundation
O&G	oil and grease
OBES	Office of Basic Energy Sciences
OHER	Office of Health and Environmental Research (DOE)
OPA	Office of Program Assessment
ORAU	Oak Ridge Associated Universities
OREIS	Oak Ridge Environmental Information System
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRHAGS	Oak Ridge Reservation Hydrology and Geology Study
OTD	Office of Technology Development
OU	operable unit
PAH	polycyclic aromatic hydrocarbon

PC	personal computer
PCB	polychlorinated biphenyl
PCFB	Pressurized Circulating Fluidized Bed
PCR	polymerase chain reaction
PEIS	programmatic environmental impact statement
PFC	perfluorocarbon
PRC-AS	PRC Academy of Sciences
PSA	Phycological Society of America
QA	quality assurance
QC	quality control
RAPD	randomly amplified, polymorphic DNA
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RIHMI-WDC	All-Russian Research Institute of Hydrometeorological Information-World Data Centre
RMO	Resource Management Organization
ROVE	Regional Ozone Vegetation Effect
SAMAB	Southern Appalachian Man and the Biosphere
SBIR	Small Business Innovation Research
SEIS	supplemental environmental impact statement
SETAC	Society of Environmental Toxicology and Chemistry
SHADES	Sharing Adventures in Engineering and Science
SI	site investigation
SLB	signature lipid biomarker
SNF	spent nuclear fuel
SRA	Society for Risk Analysis
S/S	stabilization/solidification
SSP	Subsurface Science Program
SSSA	Soil Science Society of America
SVE	soil vacuum extraction
SVOC	semivolatile organic compounds
SWSA	solid waste storage area
TCE	trichloroethylene
TDEC	Tennessee Department of Environment and Conservation
TIE	Technology Information Exchange
TNT	2,4,6 trinitrotoluene
TPH	total petroleum hydrocarbons
TRAC	Teacher Research Associates
TRC	total residual chlorine
TRU	transuranic
TSS	total suspended solids
TTP	Technical Task Plan
TVA	Tennessee Valley Authority
UEFPC	Upper East Fork Poplar Creek
UMBS	University of Michigan Biological Station
UN	United Nations
USAP	U.S. Antarctic Program
USAREUR	U.S. Army, Europe

USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
U.S.S.R.	Union of Soviet Socialist Republics
UV-B	ultraviolet-B
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area grouping
WATtec	Welding and Testing Technology Exhibition and Conference
WETF	West End Treatment Facility
WFO	work for others
WHPP	Waste Handling and Packaging Plant
WIPP	Waste Isolation Pilot Plant
WM	waste management
WOC	White Oak Creek
YNP	Yellowstone National Park

Research Overview

The mission of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) is to understand and evaluate how the development and use of energy affect the environment. To accomplish this mission, ESD staff conduct basic and applied research, assess environmental impacts of projects and policies, develop and demonstrate environmental technologies, and support education activities.

ESD emphasizes interdisciplinary research and addresses all aspects of energy-related environmental issues, from initial identification of problems to implementation of solutions and evaluation of their success. We practice a comprehensive approach that applies theoretical concepts to environmental problems and that uses applied experience to further theoretical developments. Our key products include all forms of scientific communication, demonstrations of environmental technologies, and participatory educational opportunities. We will build on our staff's history of accomplishment, which has positioned ESD as one of the nation's leading environmental research organizations.

The division engages in basic and applied research for a diverse list of sponsors. While the U.S. Department of Energy (DOE) is the primary sponsor, ESD staff also perform research for other federal agencies, state agencies, and private industry. The division collaborates with federal agencies, universities, and private organizations in achieving its research objectives and hosts numerous visiting investigators from these organizations.

ESD also has an extensive education program, providing opportunities for

research participation and other educational activities in environmental sciences while meeting division programmatic objectives. These activities range from precollege offerings to undergraduate, graduate, and postgraduate opportunities.

Given the diverse interdisciplinary specialization of its staff, ESD provides technical expertise on complex environmental problems and renders technical leadership for major environmental issues of local, national, and global concern. This progress report highlights many of ESD's accomplishments during fiscal year (FY) 1994.

Earth and Atmospheric Sciences Section

Staff of the Earth and Atmospheric Sciences Section engage in basic and applied research and conduct demonstration projects directed toward understanding and controlling the physical and chemical mechanisms that influence the movement of material through the lithosphere, hydrosphere, and atmosphere. The major areas of emphasis involve geochemistry, geology, geophysics, environmental chemistry, mathematical modeling, soil science, hydrology, atmospheric chemistry, oceanography, and environmental engineering. The scope of the studies includes field characterization, testing and demonstration, laboratory experiments, and mathematical and computer modeling.

The section strives to maintain a balance between basic and applied studies. Staff address issues that lead to an understanding of the impact of energy technologies on the environment.

The common theme of most section activities is the study of waste materials and by-products from energy production, and activities span major portions of the energy cycle. Staff of the Earth and Atmospheric Sciences Section are heavily committed to investigating many of the issues that are critical in addressing the cleanup of DOE facilities to bring them into environmental compliance. Staff have developed innovative waste treatment technologies, including bioremediation of organic contaminants and mercury, as well as oxidation and venting of organic contaminants that occur in soils and groundwater. Other major areas of emphasis are modeling of the global carbon cycle, atmospheric chemistry of trace metals, and application of high-performance computing to earth science problems.

Activities in the section are conducted at a variety of sites. Much of the work is performed on the Oak Ridge Reservation (ORR), but numerous other DOE sites are also involved, including Portsmouth, Ohio; Paducah, Kentucky; and Kansas City, Missouri. Field work often is conducted in Colorado, Nevada, and the Great Smoky Mountains National Park.

Ecosystem Studies Section

Research in the Ecosystem Studies Section focuses on characterizing the structure and functional relationships of regional landscapes and terrestrial and aquatic ecosystems, communities, and populations. The information is then used to predict the responses of these regions and ecosystems to both natural and human-induced disturbances. Major research areas include theoretical ecology, biogeochemical cycling, hydrosystems, resource analysis, and the physiological ecology of terrestrial plants.

The development of ecological theory is an important underpinning of research in ESD. Staff of the Ecosystem Studies Section develop simulation and mathematical models to describe and predict the behavior of ecological systems. Currently, research in landscape ecology and individual-based population modeling is emphasized.

Research on biogeochemical cycling focuses on Walker Branch Watershed, where investigations are conducted on the relative importance of hydrogeochemical transport and biogeochemical cycling in the regulation of productivity in forests and streams. Other research investigates the effects of atmospheric deposition in high-elevation red spruce forests. In addition, a project funded by the National Science Foundation focuses on mechanisms regulating spatial gradients in nutrient cycling and stability in stream ecosystems. Important to such research on biogeochemical cycling is the use of light, stable isotopes to study ecological processes.

In other biogeochemical studies, researchers are studying distributions of stable isotopes and radioisotopes in the Arctic to assess potential nuclear pollution resulting from activities of the former Soviet Union, as well as to study Arctic Ocean chemistry.

Research on the physiology of terrestrial plants focuses on the effects that pollutants such as ozone, acid deposition, and nitrogen oxides have on terrestrial systems. A current research emphasis is on investigations into the effects of increased atmospheric CO₂ on forests. Researchers in the Ecosystem Studies Section are also tracing the fate of nuclear waste that is disposed of in arctic seas.

Hydrosystems researchers in the section analyze environmental issues associated with hydropower development and assess the compatibility of water allocation strategies with the maintenance of fisheries resources and other important water uses within river basins. Researchers doing resource analysis develop and improve methodologies for evaluating a broad range of issues related to the sustainable development of natural resources, including such alternatives as the large-scale implementation of biofuels technologies.

In addition, researchers in the section are involved in important interactions with the Tennessee Valley Authority, the Great Smoky Mountains National Park, the Southern Appalachian Man and the Biosphere Program, several institutes of the Russian Academy of Sciences, the Korean Ocean Research and Development Institute, The University of Tennessee, and many other universities. Major research sponsors include the DOE Environmental Sciences Division, the DOE Office of Health and Environmental Research, the DOE Biofuels Feedstock Development Program, the U.S. Department of Agriculture Forest Service, the U.S. Environmental Protection Agency, the Office of Naval Research, the Electric Power Research Institute, the National Science Foundation, the Federal Energy Regulatory Commission, and the Martin Marietta Energy Systems, Inc., Environmental Restoration Program.

Environmental Analyses Section

The Environmental Analyses Section focuses on interdisciplinary analysis and assessment of environmental problems. In this context, the section develops problem-solving tools, such as methodologies, databases, and information

and policy analyses. The environmental issues addressed cover a range of spatial scales, from individual sites and regional landscapes to the continent and the globe. Various sponsors obtain technical assistance for the development of environmental management and regulatory policies, and technical information and analyses produced by the section also serve in a broader capacity—as a resource for the scientific and technical community.

Researchers in the section prepare impact analyses for DOE, the Federal Energy Regulatory Commission, the Nuclear Regulatory Commission, and the U.S. Department of Defense as part of the agencies' compliance with the National Environmental Policy Act (NEPA). Section staff also conduct regulatory analysis and environmental compliance activities in support of such sponsors as the DOE Office of Environmental Guidance, the DOE Office of Environmental Audit, the DOE Office of NEPA Oversight, the Hazardous Waste Remedial Actions Program, and the U.S. Air Force. Other members of the section develop methods for quantitative assessment of environmental risks; apply these methods to local, regional, and national environmental problems; and guide regulatory agencies on the uses of environmental risk assessment.

For the DOE Office of Energy Research, members of the Environmental Analyses Section provide information, data, and analytical capabilities essential to performing comprehensive, resource-intensive regional- and global-scale evaluations of increases in radiatively active trace gases in the atmosphere ("greenhouse" gases) and the potential effects of such increases on environmental and societal resources. The largest

function in this area is to operate the Carbon Dioxide Information Analysis Center, in support of the DOE Global Change Research Program, and the World Data Center-A for Atmospheric Trace Gases, which is a component of the International Council of Scientific Unions' World Data Center System.

Environmental Biotechnology Section

The Environmental Biotechnology Section performs basic and applied research on the mechanisms that influence the response of biological systems to contaminants, the effects that receiving systems have on the availability and distribution of materials to which they are exposed, and the modifications of biological systems to enhance degradation or immobilization of contaminants. Experimental, observational, and simulation studies are conducted at different levels of biological organization, from the subcellular and biochemical levels to the ecosystem level. Researchers investigate the roles of molecular, biochemical, and physiological processes in regulating the bioaccumulation of contaminants and assess the adverse environmental effects of these contaminants.

Section activities center on the ecological response of ORR streams to waste management and cleanup activities and on the development of capabilities for predicting the direct and indirect effects of contaminants released into the environment. Research addresses the sources of acute and chronic toxicity in wastewaters and ORR streams and includes the development of innovative in situ and laboratory tests to quantify and assess toxicity.

Other areas of research include the transport, fate, and biogeochemistry of contaminants in the aquatic environment, particularly in the off-site environs. In addition, section staff fulfill data management responsibilities for environmental restoration projects conducted at Energy Systems facilities and participate in a major effort to combine molecular biology and traditional microbiological tools to investigate the degradation of contaminants in groundwater.

Biofuels Feedstock Development Program

The Biofuels Feedstock Development Program's goal is to develop and demonstrate environmentally acceptable and commercially viable biomass supply systems based on energy crops. The program emphasizes perennial energy crops, both woody and herbaceous, suitable for use in the major crop-producing regions of the United States. A national program supported by DOE's Office of Transportation Technologies, the Biofuels Feedstock Development Program includes cooperators in the private sector and at universities, DOE laboratories in addition to ORNL, and other government agencies.

Resource assessment, environmental analysis, economic studies, and basic physiology and genetic research for the program are performed largely within ESD and ORNL. Research on specific crops, including scale-up plantings and regional or site-specific environmental research, is primarily conducted by cooperators and subcontractors at organizations such as universities and the U.S. Department of Agriculture. The Biofuels Feedstock Development Program's energy crop

development efforts are closely coordinated with the National Renewable Energy Laboratory's research on advanced biomass conversion technologies.

In FY 1994, the Biofuels Feedstock Development Program had six major research and analysis components—Model Wood Energy Species; Model Herbaceous Energy Species; Environmental Research; Systems Integration and Analysis; Scale-up, Feasibility, and Demonstration; and Energy Crops Data and Information Management. The Tennessee Valley Authority sponsored the development of energy crop supply curves for the Tennessee Valley and other regions. Other program efforts included participation in the International Energy Agency's biomass production activities, cooperation with the Office of Science and Technology Policy on biomass energy assessments, and participation in the National Biofuels Roundtable sponsored by the Electric Power Research Institute and the National Audubon Society.

Environmental Information Analysis Program

The Environmental Information Analysis Program supports large, integrated environmental database projects with extensive data analysis components. The management of research data has become a vital component of modern observational and theoretical science. The significant global change projects of the 1990s—such as the DOE Atmospheric Radiation Measurement (ARM) project; the DOE Computer Hardware, Advanced Mathematics, and Model Physics project; and the National Aeronautics and Space Administration's (NASA's) comprehensive Earth Observing System Program—have large data management components that are vital to their success. The ability to intelligently manage and analyze

substantial environmental data sets is one of the division's historically unique capabilities.

The program currently consists of the Carbon Dioxide Information Analysis Center, which supports DOE's Global Change Research Program and operates the World Data Center-A for Atmospheric Trace Gases as part of the International Council of Scientific Unions' World Data Center System; the ARM Archive, which supports the DOE ARM project; the NASA Distributed Active Archive Center, which supports NASA's Earth Observing System Program; and the Oak Ridge Environmental Information System, which supports the data needs of local restoration efforts at DOE facilities in Oak Ridge.

Environmental Restoration Program

ESD's Environmental Restoration Program is a multidisciplinary effort that draws on staff from all the research sections. Nationwide, DOE has initiated a massive undertaking to assess the nature and extent of contamination resulting from its past operations and to clean up, or remediate, the contaminated soils, bedrocks, and waters that pose risks to human health and the environment.

ESD staff play key roles in addressing the environmental restoration needs at ORNL, the Oak Ridge Y-12 Plant, the Oak Ridge K-25 Site, the Portsmouth Gaseous Diffusion Plant in Ohio, and the Paducah Gaseous Diffusion Plant in Kentucky, as well as in the surface-water system downstream from the Oak Ridge facilities.

ESD staff are involved in diverse environmental restoration activities. Many tasks are field oriented, requiring

geologic, hydrologic, and aquatic ecologic staff; others are laboratory based or use ORNL's high-speed computational systems.

The challenges associated with the Environmental Restoration Program at Oak Ridge are immense, perhaps greater than those at any other DOE facility in the country. Not only have myriad types of materials (e.g., radionuclides, organic compounds, hazardous metals) been released to the environment during the past 50 years, but virtually all disposal methods were used. Furthermore, the underlying geologic and groundwater systems at Oak Ridge are the most

complex of all the DOE sites, and rainfall is abundant here: thus, the environmental restoration needs at Oak Ridge are great.

Fortunately, the environmental restoration efforts can draw on the long history of basic environmental research that resides in ESD, for the technical questions that must be answered to effectively remediate the environment are not ones that can simply be answered by conventional technologies. Largely because of ESD's coupling of basic and applied research, the environmental restoration effort in ESD has grown significantly in recent years.

Significant Accomplishments

During FY 1994, ESD reported numerous technical accomplishments, the most significant of which are listed here.

- A staff member was invited to be a keynote speaker at the Sixth Commission of European Communities Natural Analogue Working Group meeting in Santa Fe, New Mexico. The group meets biannually to discuss the use of natural analogue studies to improve performance assessments of geological repositories for nuclear waste.
- Participants in an ORNL ESD workshop concluded that melts generated by in situ vitrification provide unique opportunities to advance the understanding of magmas and magmatic processes and justify the development of a proposal to seek funding for a new research initiative at ORNL.
- Scientists completed an analysis of a sediment core in the Russian portion of the Black Sea. Results showed that ^{134}Cs and ^{137}Cs contamination in the upper 4-cm layer is unequivocally related to the Chernobyl accident. Estimates of sedimentation dynamics are being used to delineate the age of phytoplanktonic molecular markers preserved in the anoxic sediments of the Black Sea, including the potential measurement of DNA damage resulting from ultraviolet radiation over historical time frames.
- Sensors were suspended from a helicopter to collect magnetic, electromagnetic, and radiometric data over the entire Oak Ridge Reservation (ORR). The goals were to detect unknown waste sites, to better characterize known waste sites, and to image geologic structures that might influence contaminant transport, such as faults, fractures, or lithologic contacts.
- Researchers tested the micrometeorological gradient similarity method to measure air-surface exchange rates for vapor-phase mercury to determine the processes controlling biogeochemical cycling of important trace gases. Methods to estimate air-surface exchange rates were developed. Members of the Mercury Air-Surface Exchange Project team are testing the gradient similarity method for application to mercury vapor in the first-ever application of a tower-based micrometeorological method for mercury fluxes, indicating a strong soil emission of mercury. This method will prove useful for other important tropospheric species for which real-time sensors are not available, such as reduced sulfur gases.
- A staff member estimated the effects of ozone and climate variables on the growth of large trees in an undisturbed forest environment by using a sensitive dendrometer system to obtain serial measurements of seasonal variations in stem expansion rate.
- Researchers characterized the recycling of nutrients along streams on Walker Branch Watershed. As a result of characterization activities, researchers developed (1) a solution technique that is both more efficient and easier to interpret than previous methods and (2) a technique for determining the parameters of nutrient transfer and dispersion. The new

techniques will make it possible to compare a variety of stream characteristics.

- In collaboration with the University of Maine, ESD scientists developed methods for quantifying biodiversity in large geographic regions. The U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program and Biodiversity Research Consortium are providing funding for the research.
- A staff member edited an Ecological Society of America book entitled *Biodiversity of the Southeastern United States: Aquatic Communities*, in which current knowledge on the structure and function of major aquatic ecosystems in the Southeast is integrated and summarized. The book received an award of excellence in an international technical publications competition as well as the award for outstanding book of the year in the biological sciences (conferred by the Association of American Publishers).
- Researchers reviewed the current water quality modeling approach for nitrogen in the Chesapeake Bay watershed and recommended that a nitrogen module be added to the Hydrologic Simulation Program to improve nitrogen flux estimates from forested areas. They reviewed literature on nitrogen in forests, held a workshop, identified data for model parameterization, and prepared recommendations. Research was funded by the EPA Environmental Research Laboratory, Athens, Georgia.
- Researchers completed baseline ecological risk assessments for two operable units on ORR; for the

Portsmouth, Ohio, facility; and for the Paducah, Kentucky, facility.

- Researchers conducted a review and analysis of the term "adverse ecological impact" from various regulatory and legal perspectives for the National Acid Precipitation Assessment Program.
- ESD staff developed a comprehensive guide to existing regulatory requirements for groundwater remediation during cleanup activities mandated by the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act.
- ESD provided the lead and technical support for seven environmental assessments at U.S. Air Force Air Combat Command installations.
- Staff created two Environmental Compliance Assessment System manuals summarizing all applicable U.S. environmental regulations and corresponding German standards for the U.S. Army, Europe.
- Staff from ESD and the Health Sciences Research Division collaborated in developing the Ecological Risk Assessment Database, which contains information on the toxicity of ~150 organic and inorganic chemicals to aquatic and terrestrial biota. The values may be used for identifying contaminants of potential concern at contaminated sites.
- ESD researchers were asked by the DOE Office of NEPA Oversight to coordinate a review of, and to comment on, the technical adequacy of the programmatic environmental impact

statement for the combined Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Program. This is a controversial subject with high visibility and high priority at DOE.

A multidisciplinary team of 16 experts from five ORNL divisions assembled to review the two-volume draft environmental impact statement and six detailed appendices of site-specific information and analyses totaling ~3000 pages.

- Staff completed a videotaped version of the training course "Natural Resource Trusteeship and Ecological Evaluation Requirements" for the DOE Office of Environmental Guidance. The videotape provides an overview on Natural Resources Damage Assessment (NRDA) and integrates NRDA concerns into the Remedial Investigation/Feasibility Study process.
- ESD staff developed a RCRA orientation course for DOE and for DOE contractor personnel. The course covers RCRA waste identification and listing, manifesting, record keeping, waste accumulation, permitting, corrective action, and land disposal restrictions; it also includes practice exercises throughout. It fills a void between courses that cover strictly overview material and courses that address only single topics in great detail.
- A staff member was appointed to the organizing committee for the Conference on Genetic and Molecular Ecotoxicology sponsored by the National Institute of Environmental Health Sciences. The goal of the conference is to bring together a small

group of experts in genetic ecotoxicology, ecological genetics, and molecular biology to develop a vision for research in genetic ecotoxicology in the 1990s.

- A multidisciplinary team of 29 technical staff members from ESD, other ORNL divisions, and several environmental consulting firms designed and implemented a comprehensive sampling and analysis plan for sediment and water that will be used to assess off-site risks to human health and the environment. This activity was audited by the DOE Oak Ridge Operations Office, which commented favorably on the plan and recognized the effectiveness of the team.
- ESD researchers are participating with Oak Ridge Y-12 Plant staff in a cooperative research and development agreement with the National Center for Manufacturing Science (NCMS). In collaboration with NCMS partners at Ford Motor Company, General Motors, and Texaco, the researchers will develop and demonstrate approaches to improving in situ bioremediation of contaminated aquifers.
- A staff member was appointed to the Advisory Committee for The University of Tennessee Center for Environmental Biotechnology (CEB). CEB is an intercollegiate, interinstitutional research center for training and research in the development and effective use of microorganisms for the destruction and control of hazardous wastes and environmental contaminants. The purpose of the Advisory Committee is to develop a strategic plan for research and curriculum development.

- ESD staff developed the ORR Ecological Monitoring and Assessment Program to evaluate impacts from DOE activities to wide-ranging species.
- The Carbon Dioxide Information Analysis Center (CDIAC) published four numeric data packages. Topics included long-term climate data from the former U.S.S.R., oceanic carbon chemistry data, carbon emissions from land use change, and data for assessing the vulnerability of the U.S. Gulf Coast to sea-level rise.
- CDIAC published *Trends '93: A Compendium of Data on Global Change* (the third report in the *Trends* series).
- Researchers updated the CDIAC database on emissions of CO₂ from fossil-fuel combustion and cement production to include emissions through 1991. These estimates show that global emissions rose to an all-time high of ~6.19 gigatons of carbon in 1991. These emission estimates are critical to global carbon cycle studies and quantify the major anthropogenic source of CO₂ to the atmosphere.
- In June 1994, DOE Headquarters approved the implementation of the Oak Ridge Environmental Information System (OREIS). The approval fulfilled a milestone for the DOE Oak Ridge Operations Office and authorized the release of OREIS as a production system.
- Staff members began to incorporate National Pollutant Discharge Elimination System (NPDES) and ambient air compliance and surveillance data into OREIS. User services provided training in five modules to 132 (cumulative) users, gave technical assistance to users via the OREIS Helpline, and generated numerous data products (e.g., maps).
- Researchers designed, developed, and released (July 1994) a local Information Management System tailored to ORNL Distributed Active Archive Center (DAAC) data and the needs of the ORNL DAAC user community.
- The ORNL DAAC researchers worked with the Boreal Ecosystem-Atmosphere Study (BOREAS) in preparation for receiving and distributing data from the BOREAS project, including participating in BOREAS Intensive Field Campaigns.
- The first increment of the Atmospheric Radiation Measurement (ARM) Archive's mass storage system is operational and can store ~5 terabytes of data. The final version of this system, expected to be operational in late FY 1995, will be capable of storing >100 terabytes of data.
- Staff members have stored >60 gigabytes of data in >340,000 files in the ARM Archive. These files are available via a graphical user interface that allows users to request files based on the instrument package that generated the data and a date range of interest.
- As part of a study to investigate the transport, fate, and effects of contaminants released from the DOE ORR, ESD staff have been managing and conducting the Clinch River-Watts Bar Reservoir Remedial Investigation. For the lower Watts Bar Reservoir, ESD staff completed an assessment of the nature and extent of contamination

- and the risks those contaminants pose to human health and the environment.
- Staff members on the Background Soil Characterization Project team provided data to make informed decisions based on characterization of natural background soil concentrations of organics, inorganics (metals), and radionuclides found on ORR. Standards for cleanup of potentially contaminated soils on ORR will be based on concentrations above those established as background in this project for typical soil constituents.
 - Researchers found that the red cedar (*Juniperus virginiana*) is favorable for its use in monitoring long-term trends in environmental chemistry. Such trees provide two exposure routes: foliar absorption alone and combined foliar-root uptake for mercury released from the Oak Ridge Y-12 Plant. Trees growing on low-mercury soil within 30 km of the facility revealed sharp, well-defined peaks in mercury centered in the mid-1950s.
 - ESD researchers conducted an evaluation of the site-specific relationship between waterborne inorganic mercury concentrations and methylmercury accumulation in fish. Results will be used by the Oak Ridge Y-12 Plant to assist the Tennessee Department of Environment and Conservation in establishing discharge limits on mercury in the NPDES permit for the facility. The recommended mercury criterion was based on (1) protection of biota in the receiving stream, (2) protection of human health from ingestion of fish containing mercury, and (3) technical achievement of the limit with current treatment and remediation technologies.
 - The Energy Systems Groundwater Program took the first step toward evaluating the network of streamflow and rainfall gages on ORR and determining if significant gaps exist in the information being collected. Maps and summary tables will prove useful to everyone engaged in rainfall-runoff investigations and related work. In particular, identification of the current network in a published format can eliminate duplication of effort and provide a basis for designing a cost-effective gaging network for the entire ORR as well as enhance data sharing.
 - Scientists conducted laboratory experiments to evaluate in situ chemical oxidation for remediating contaminated groundwater and soil. Results indicate that volatile organic compound reductions as great as 98% can be achieved using chemical oxidation. In situ chemical oxidation with H_2O_2 and $KMnO_4$ is applicable to many of the contaminated sites found in the DOE complex; it appears to be an effective and inexpensive treatment technique that can be used to help restore many of those sites.
 - Researchers completed a 5-year study on the impact of ambient ozone on mature forest trees. Results showed that current levels of ozone exposure can significantly reduce stem growth. Ozone reduces a tree's ability to control water loss; high temperatures and low levels of soil moisture amplified this effect, suggesting that future climate changes may enhance the effects of ozone on forests.
 - Staff generated a time-series estimate of CO_2 emissions from fossil fuel consumption, cement production, and gas flaring during the past year.

Generated annually, these emission estimates quantify the major anthropogenic sources of CO₂ to the atmosphere and are critical to global carbon cycle studies.

- Using literature published during the past 25 years, a staff member compiled a database on the growth response of forests to atmospheric CO₂ enrichment. A topic of debate, the capacity of long-lived woody perennials to sequester carbon in a future, higher-CO₂ world is a key component to understanding how forests interact with the global carbon cycle. Although several extensive databases had been compiled to address a similar concern within the agricultural research community, no such database had existed for forests.
- In March 1994, ESD hosted the Oak Ridge Conference on Global Environmental Change in collaboration with the National Institute for Global Environmental Change and the U.S. Forest Service Southern Global Change Program. The workshop brought together global change researchers from ORNL, the U.S. Forest Service, the National Oceanic and Atmospheric Administration, and more than a dozen universities. Topics included forest response to climate change; responses of wetlands, lakes, and oceans; aerosols, atmospheric trace gases, and climate; climate and vegetation modeling; and education, economics, and policy.
- Researchers completed the harvest of 30 white oak saplings that had been growing in increased concentrations of atmospheric CO₂ for 4 years—the longest any forest tree species has been exposed to CO₂ enrichment.

Researchers are compiling a data set on root and shoot responses that will be used in global carbon models to assess future global change scenarios.

- A staff member was appointed by the Sustainable Biosphere Initiative of the Ecological Society of America to serve as chairman of the Scientific Review Committee. The purpose of the committee is to cooperate with EPA in evaluating federally funded projects that address the response of natural habitats to global climate change.
- Researchers installed a throughfall displacement experiment at the stand level at Walker Branch Watershed. This stand-level manipulation of throughfall (i.e., rain) will provide the opportunity for mechanistic studies of ecosystem and plant-level responses to changing climatic conditions.
- Researchers developed and successfully tested a system for controlling temperature in open-top CO₂-exposure chambers. This system will enable researchers for the first time to evaluate how the stresses associated with climate change might be alleviated or compensated for in a CO₂-enriched atmosphere.
- Researchers conducted physiological studies of lowland and highland switchgrass grown in three climates. Results show that rates of photosynthesis vary between lowland and upland varieties and that seasonal variation in climate effects these differences. At all sites, under high moisture conditions lowland switchgrass had the higher photosynthetic rates, while under drought conditions highland switchgrass had the higher rate of photosynthesis.

- Biofuels Feedstock Development Program (BFDP) staff developed regional information on production costs and productivity of switchgrass and hybrid poplar for a biomass energy assessment coordinated by the Office of Science and Technology Policy. The information was used by EPA and the U.S. Department of Agriculture to develop supply curves for biomass feedstocks.
- A BFDP scale-up project in Minnesota reached a milestone with the planting of 1000 acres of hybrid poplar in a single year. The project, which includes plantings ranging in size from 25 to 160 acres on 13 different farms, is developing information on the cost and effectiveness of operational-scale crop management practices.
- A collection of silver maple germ plasm developed by the BFDP project at Southern Illinois University has proven to be a valuable genetic resource for other projects. Plant materials from the collection were supplied to researchers at the University of Maine for cold-hardiness studies and to researchers at Iowa State University for studies on heat and drought stress.
- Scientists discovered that a discrepancy exists between observations and carbon cycle model predictions for the global bomb-radiocarbon inventory. This discrepancy can be attributed to inadequacies in the carbon cycle model currently in use.
- ESD staff coordinated the review of population models used in evaluating the options for managing endangered Columbia River Basin salmon stocks.

Section Activities 1

Earth and Atmospheric Sciences

Introduction

Staff in the Earth and Atmospheric Sciences Section of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) conduct basic and applied research on interdisciplinary problems related to the broad field of earth sciences. Most of the section's research focuses on managing energy-related waste materials. Field, laboratory, and computer-based investigations support these efforts. Research is directed toward understanding the factors that control the movement of materials through the solid earth, the hydrosphere, and the atmosphere. Major sponsors include the U.S. Department of Energy (DOE) (the Office of Health and Environmental Research; the Office of Technology Development; Environmental Restoration; Defense Waste and Environmental Restoration; the Oak Ridge Y-12 Plant; the Paducah, Kentucky, and Portsmouth, Ohio, gaseous diffusion plants; and other national laboratories), the Tennessee Valley Authority, the U.S. Geological Survey, the Electric Power Research Institute, and the U.S. Environmental Protection Agency (EPA).

Atmospheric and Geochemical Processes

The Atmospheric and Geochemical Processes Group performs basic research designed to quantify and to understand the processes that influence the transport, transformation, deposition, and fate of materials released into the environment. This research encompasses the fields of atmospheric, marine, freshwater, and soil

sciences. Primary areas include the atmospheric chemistry and deposition of trace metals, air-surface exchange and its role in biogeochemical cycling, and processes controlling the transformation and mobility of radionuclides and other contaminants in aquatic and soil systems.

During FY 1994, staff of the Atmospheric and Geochemical Processes Group completed several significant objectives. Researchers characterized the speciation of mercury in contaminated soils near Oak Ridge, finding that the projected costs of remediation could be significantly reduced. Staff developed a pioneering method for micrometeorological measurements of mercury vapor fluxes over soils, surface waters, and vegetation at background sites; open-literature publication of these results has established the significance of natural remission of mercury to the atmosphere. Researchers also demonstrated that annual rings in red cedar trees faithfully record historical atmospheric mercury releases from known point sources, thus allowing for assessment of historical air exposures. For a joint U.S. and Russian study, scientists in the Atmospheric and Geochemical Processes Group analyzed arctic sediments for radionuclides resulting from waste disposal activities of the former Soviet Union to assess the impact of the radionuclides on arctic food chains.

Earth Systems Modeling

The Earth Systems Modeling Group develops, applies, and evaluates mathematical models used in addressing local-, regional-, and global-scale environmental issues. Current research emphasizes the development of new models and the examination and

integration of disparately scaled existing models to comprehensively address global carbon dynamics. This work is designed to increase understanding of the global carbon cycle and to forecast the effects that changes in atmospheric carbon emissions will have on global climate and ecological resources during the next century. Group interests also include quantification of the implications of model uncertainties for model performance. Sensitivity and uncertainty analyses are conducted to evaluate performance and to place model forecasts in the context of global risks. Earth systems modelers use an innovative synthesis of techniques to address problems in mesoscale, regional, and global modeling.

The Earth Systems Modeling Group seeks to improve our understanding of the Earth's major dynamic systems, climate, and the global biogeochemical cycles through the development and analysis of comprehensive earth systems models. The group's research objectives address major issues within the U.S. Global Change Research Program. These objectives include clarifying the relationship between fossil fuel emissions and changes in atmospheric greenhouse gas concentrations, analyzing means of decreasing greenhouse gas emissions or compensating for emissions by increased elimination from the atmosphere, and assessing ways in which climatic change resulting from greenhouse gas increases can affect the carbon cycle and its control of atmospheric CO₂ concentration. The group also addresses interactions between the global biogeochemical cycles and the potential impacts of global environmental change on terrestrial ecosystems. DOE and EPA fund group projects. Group members participate in activities of the International Geosphere-Biosphere Programme and assessments of the

Intergovernmental Panel on Climate Change.

During FY 1994, the Earth Systems Modeling Group completed a number of major tasks. Researchers analyzed how plant growth response to increases in atmospheric CO₂ influence estimates of atmospheric releases of carbon that result from changes in land use. Group members developed (1) a spatially explicit global terrestrial model of carbon cycling and (2) an oceanic radiocarbon inventory for model testing. In addition, a book entitled *Greenhouse Puzzles* was completed.

Energy Systems Groundwater Program

The Groundwater Program Office provides coordination for all groundwater activities at the three DOE facilities managed by Martin Marietta Energy Systems, Inc., in Oak Ridge, Tennessee, and the DOE gaseous diffusion plants in Paducah, Kentucky, and Portsmouth, Ohio. The Energy Systems Groundwater Program's primary objective is to develop a consistent approach to ensure that applicable state or federal environmental laws and relevant DOE orders are satisfied and that the environment and the health of the public are protected. The Groundwater Program Office, working through groundwater coordinators at each of the three Oak Ridge sites as well as at the Paducah and Portsmouth sites, provides management support to achieve these goals.

The Oak Ridge Hydrology Support Program offers technical expertise in the broad areas of hydrology and geology to the three Energy Systems plants in Oak Ridge and the Paducah and Portsmouth gaseous diffusion plants. Two principal groups make up this program. The first consists of hydrologists

who advise the groundwater programs on groundwater and surface water issues related to environmental restoration and regulatory compliance. The second group is directed toward understanding fundamental hydrogeologic principles related to groundwater flow and remediation in fractured rock systems such as those that dominate the Oak Ridge Reservation (ORR).

Environmental Engineering

The Environmental Engineering Group performs basic and applied research related to environmental restoration and waste management. This research involves process modeling, bench-scale and pilot-scale field experimentation, and full-scale field experimentation and demonstration activities. Current emphasis includes research on processes controlling the measurement, behavior, and treatment of contaminants in waste deposits and in contaminated soil and groundwater systems. Staff conduct research on environmental monitoring technologies and assessment strategies, spatial modeling of contaminant distributions, process modeling of physicochemical treatment systems, and in situ treatment by physicochemical and biological processes. Research is also directed toward the development of critical enabling technologies, including in situ recirculation systems, fracture emplacement methods, and mixed-region subsurface reactors. Increasing efforts are placed on field-scale research and on the demonstration of emerging environmental restoration technologies at sites across the United States and abroad.

Geology and Geophysics

The Geology and Geophysics Group addresses field-based geologic and geophysical aspects of waste management. Principal emphasis is on the elucidation of geologic principles that are important in

quantifying groundwater flow and the characterization and evaluation of waste disposal sites. New and continuing research projects are directed toward two broad-based goals: (1) the development of noninvasive geophysical techniques for investigating waste management areas and (2) the evaluation of geologic properties of fractured sedimentary rocks that control groundwater flow and contaminant transport. In addition, staff continue to expand the geologic and geophysical database by providing support for ongoing site-specific investigations.

Airborne geophysical studies consist of a helicopter-based aerial survey of ORR and development of model airplane capabilities for reconnaissance studies. FY 1994 aerial survey activities concentrated on ground truthing, developing applications for characterizing karst features, and acquiring high-resolution data in a smaller portion of ORR. Model airplane photographic capabilities were demonstrated during this fiscal year, and staff are continuing to develop the capability acquiring magnetic data. Surface geophysical investigations are targeted toward evaluating optimal methods and instrumentation. FY 1994 activities included a test to determine the most appropriate source for seismic investigations in shale units on ORR, an evaluation of different geophysical techniques to characterize karst features, and the application of low-frequency ground-penetrating radar in different hydrologic settings. Subsurface borehole investigations included the successful application of borehole geophysics to determine the integrity of well casing and continued characterization work to identify groundwater flow paths and hydrogeologic properties.

The purpose of geologic investigations conducted by staff is to understand rock matrix properties that control contaminant

storage, to define hydrologically important fracture parameters, and to define spatial changes in fracture networks. These studies are both laboratory and field based and take advantage of a growing ORR database of core information and borehole geophysical and hydrologic data. Matrix porosities are being evaluated and calibrated through a combination of laboratory, geophysical, and petrographic measurements. In FY 1994, we started concentrating on the factors that control development and measurement of shale porosity.

Fracture studies identify lateral and vertical changes in the fracture characteristics, evaluate the origin of the networks in terms of rock properties and geologic history, and examine hydrologic fracture behavior. In FY 1994, staff conducted a surface fracture mapping study that showed a change in fracture characteristics from other parts of ORR. Fracture connectivity and spacing in sedimentary rocks was examined in a study that integrates core, borehole geophysical, and hydrologic data from multiport instrumented wells. Laboratory studies are directed toward determining fracture toughness measurements of competent rock units on ORR. This work will be used to determine physical properties, primarily elastic moduli, of the aquifers on ORR.

In FY 1994, we completed an effort to translate our regional geologic mapping data into digital form. The data are now available for investigations as a geographic information system layer. In addition, portions of our subsurface borehole data have been incorporated into three-dimensional visualization software.

Results of our studies are being integrated into conceptual and numerical groundwater flow models. In addition, the results provide the framework for developing

conceptual and analytical models for transport of dense nonaqueous-phase liquids in sedimentary rocks.

Groundwater Hydrology

The Groundwater Hydrology Group addresses technical problems related to the preservation and restoration of groundwater quality. Staff activities include application of complex numerical models to simulate multiphase flow of fluids in porous and fractured systems, design and operation of groundwater-monitoring systems, characterization of large-area hydrologic properties, use of artificial tracers and natural groundwater chemistry to study transport processes, and studies of interactions with surface water and groundwater. The primary strength of the group lies at the interface between modeling and field activities. Field work is directed at understanding flow mechanisms in complex subsurface systems. Research topics include the effects of fracture flow systems on the dynamic storage and release of pollutants, development of innovative drilling and sampling methods, and direct measurement of rates of recharge by means of groundwater dating with ^3H and ^3He . Modelers within the groups are adapting the extensive ensemble of ORNL groundwater models to massively parallel computers and exploring new modeling techniques on these computers.

Soil Science

The Soil Science Group conducts applied and basic research in the characterization and management of soils and sediments. Much of the research centers on understanding how contaminants interact with soils and wastes in a subsurface environment. Because the soils and sediments contain many of the pollutants released when DOE waste management practices of the past were used, the Soil

Science Group expends considerable effort in developing methods to characterize, decontaminate, and control the fate of these contaminants. Soil scientists interact with environmental engineers, hydrologists, and aquatic and terrestrial ecologists in defining the magnitude of the problems with respect to the transport and fate of a large spectrum of inorganic and organic pollutants in the environment.

Recent projects include the development of a large database characterizing the concentrations of anthropogenic constituents potentially in the natural soils surrounding the Oak Ridge DOE facility. The purpose of the study is to determine background levels of these constituents in soils so that contaminating events can be properly identified. Other projects involve the development of methods to remove uranium from contaminated soils through the use of selective leaching processes and the containment of contaminants in soils through the use of in situ vitrification processes. Also during FY 1994, a report on background soil characterization for ORR was completed; soil characterization of uranium in soils at the Oak Ridge K-25 Site, the Portsmouth Gaseous Diffusion Plant, and the Fernald, Ohio, facilities was completed; and bench- and pilot-scale studies revealed that 80 to 95% of the uranium in Fernald soils can be removed with carbonate-based extractions.

Subsurface and Surficial Geochemistry

Research in geochemistry emphasizes the understanding of processes that control the transport, fate, and transformation of elements in subsurface and surficial geological environments. This understanding is used in developing and applying interpretive models of element behavior to solve energy-related problems.

Complementary field, laboratory, and computational research efforts are undertaken to evaluate strategies for the effective use of energy resources, the future disposal of wastes, and environmental restoration at existing contaminated sites.

This research incorporates principles from the disciplines of aqueous geochemistry, biogeochemistry, computer science, geology, hydrology, isotope geochemistry, limnology, radiogeochemistry, and soil chemistry. Research efforts focus on biotic and abiotic transformations of contaminants in natural waters, soils, and sediments; characterization of contaminants in active and inactive waste disposal areas; colloid mobility; contaminant transport in unsaturated, heterogeneous soils; hydrogeochemical aspects of the local groundwater system; in situ vitrification for the stabilization of contaminated soils; sorption of trace metals onto natural materials; and trace element transport and cycling in river, lake, and coastal zone environments.

In FY 1994, measurements of the concentrations of transuranium isotopes were made in Waste Area Grouping (WAG) 4 groundwaters. Identification of the specific isotopes will aid in tracing contaminants to their sources in WAG 4 and in assessing risks and planning for any required remedial actions. Also during the year, staff organized and conducted a workshop to evaluate the use of in situ vitrification (ISV) technology to produce large silicate melts that would serve as analogs for natural magmas for the study of magmatic properties and processes. In preparation for the treatability study of ISV at the formerly used Waste Seepage Pit 1, "remote" surveys were conducted in FY 1994 to obtain both the dimensions of the original pit and the current distribution of radioactivity. In addition, researchers

initiated investigations into the kinetics and mechanisms governing the oxidation state of organically chelated ^{60}Co , which has migrated from waste burial sites on the Oak Ridge Reservation.

Surface Water Hydrology

The Surface Water Hydrology Group addresses problems related to flow and water quality in water systems affected by industrial activities and waste disposal, and the group compares research results with measurements in unaffected watersheds. Staff characterize and quantify contaminant transport in contaminated drainages on ORR by investigating mechanisms of flow, sediment production, sediment transport, and contaminant movement. Group members study interactions between groundwater and surface water by analyzing the occurrence and chemical signature of seeps and springs and their roles in surface water production. Investigations include developing water budgets and modeling watershed hydrology, with an emphasis on streamflow production in fractured-rock terrains.

During FY 1994, the work performed by the Surface Water Hydrology Group mainly focused on environmental restoration issues at ORNL. The group conducted surveys of springs and seeps on the ORNL site to determine the distribution and quality of contaminant inputs to the White Oak Creek drainage system that have leaked from closed low-level radioactive disposal facilities.

Sampling of tributaries during storms showed patterns of partial dilution of contaminants; the patterns reflected the mechanisms of runoff generation. In turn, the results are leading to better understanding of the roles of precipitation, geology, and terrain in mobilizing and transporting contaminants. A flood-monitoring system was fully activated and three large storms were intensively sampled for sediments and sediment-bound contaminants. This sampling information is being used along with innovative sediment transport modeling to estimate off-site movement of contaminants and resulting risk to human health brought about by extreme storms. The group continued to use diverse surface water and groundwater data to improve an innovative risk-based methodology to guide and evaluate monitoring to WAG 6. The monitoring system emphasizes the measurement of major contaminant releases, identifies contaminants that exceed risk-based concentration levels, and proves to be cost-effective.

Our new project includes (1) the application of a topographically based hydrologic model to simulate streamflow from the basic hydrogeological land units on ORR and (2) the merging of the results to yield improved hydrological predictions on a large scale. This approach may provide a new method for addressing large-scale heterogeneities found in the Valley-Ridge geological province.

Technical Summaries

1 Comprehensive Survey Identifies Major Dry-Weather Sources of Contaminants to Upper East Fork Poplar Creek

M. A. Bogle and R. R. Turner

Staff members of ORNL's Environmental Sciences Division participated in a comprehensive sampling effort (four rounds of dry-weather surface-water sampling) to characterize the movement of mercury and other contaminants into Upper East Fork Poplar Creek (UEFPC), which runs through the Oak Ridge Y-12 Plant site. This effort focused on sampling 29 active building outfalls located below the North-South Pipe, 9 outfalls or trunklines in the Exclusion Area, and 3 in-stream locations.

The sampling locations spanned the length of the creek from the site furthest upstream at the west end of the Y-12 Plant to the oil skimmer at the east end. In-stream sites were used as checkpoints for monitoring flow and contaminant mass balance. Water samples were collected and analyzed for mercury, polychlorinated biphenyls, pesticides, metals, volatile and semivolatile organics, radiological contaminants, and anions.

To identify major sources of contaminants in the creek and to assess outfall contributions to the total creek load during dry weather conditions, researchers took flow measurements and water samples concurrently. An analysis of flow data indicated that 83% of the average flow at the site furthest downstream (i.e., the oil skimmer) could be attributed to inputs

from the sampled outfalls. Inputs for two of the contaminants of most concern, mercury and uranium, were associated with outfalls serving buildings in the areas where mercury formerly was used. Mercury entered the creek at the rate of 15 g/d; ~60% of this came from three outfalls draining two buildings in the Exclusion Area. An additional 25% came from two outfalls serving Building 9201-2. Mass balance calculations for mercury indicate a loss of mercury in the lower reaches of UEFPC; this loss could result from biotic uptake or volatilization. Almost 70% of the uranium load came from two outfalls associated with a single building in the Exclusion Area. Depending on the sampling round, from 70 to 95% of the uranium load at the oil skimmer could be attributed to outfall inputs.

Results of this survey are helping researchers decide which locations and contaminants should be sampled in the future (in wet weather as well as dry weather); in addition, they are providing data necessary for evaluating and prioritizing possible remedial actions, especially for mercury contamination.

2 Beryllium-7 Inventories Are Used to Estimate Particle Settling Rates in the Bering Sea

L. W. Cooper, I. L. Larsen, and J. M. Grebmeier

Beryllium-7 (half-life 53.3 d) is produced in the upper atmosphere by cosmic ray spallation of nitrogen and oxygen. The radionuclide is particle-reactive and, following wash-out from the atmosphere into the ocean, is associated with organic production and particulate deposition to

the sea floor. Because of its short half-life, ^7Be decays before reaching the deeper portions of the sea.

An extensive survey of Bering Sea continental shelf sediments in June 1993 showed that ^7Be became undetectable when bottom depths exceeded 100 m. Based on the average life of an

individual ^7Be atom (half-life/ $\ln 2 = 77$ d), a net particle settling velocity of 1 to 2 m/d can be estimated. This particle settling velocity is consistent with independent estimates of particle flux in the Bering Sea based on sediment trap deployment and sediment oxygen utilization.

Determination of particle settling velocities is important for estimating carbon fluxes to continental shelf and slope sediments as well as for identifying regions of particle focusing and accumulation.

3 Airborne Geophysical Survey of the Oak Ridge Reservation Is Conducted

W. E. Doll and J. E. Nyquist

During December 1992 and January 1993, sensors suspended from a helicopter were used to collect magnetic, electromagnetic, and radiometric data over the entire Oak Ridge Reservation. The data acquisition technique was an adaptation of methods used in the mineral-prospecting industry. The goals were to detect unknown waste sites, to better characterize known waste sites, and to image geologic structures that might influence contaminant transport, such as faults, fractures, or lithologic contacts.

Data were acquired at lower elevations (100 ft) and smaller flight-line spacings (150 ft) than in mining applications, and contractor processing steps were modified to enhance smaller man-made targets that are typically filtered out of exploration data. Because the sensitivity of airborne sensors to environmental targets is unknown, data were collected at four test sites. Test data from Waste Area Grouping 6 were acquired to determine sensor response to a variety of targets

Jackie Grebmeier and Steve Kimble (The University of Tennessee) use a haps core to recover undisturbed sediments from the sea floor. The cores will be sectioned and sent to ORNL for gamma spectroscopy. Researchers will use the resulting data to analyze potential radionuclide contamination from sources in the former Soviet Union.

whose constitution and position were well characterized. Airborne data were collected over Solid Waste Storage Area (SWSA) 4 for comparison with earlier surface measurements. The sensitivity to individual 55-gal drums and to tree cover and topography was evaluated by placing groups of one to eight decoy drums at SWSA 7 and at the Preferred Advanced Neutron Source site.

Some of the processed data received to date are very encouraging. The magnetic data were particularly abundant at waste sites and near buried metals, although sensors recorded a smaller response to lithologic contacts between limestones and shales. Most electromagnetic data were from lithologic contacts and changes in soil moisture. To enhance targets of interest for site characterization work, further processing will be applied and techniques for improving resolution of airborne geophysical methods will be tested.

4 Natural and Anthropogenic Radionuclides Are Used to Interpret Black Sea Sedimentation Dynamics

*I. L. Larsen, J. M. Grebmeier,
L. W. Cooper, L. R. Shugart, and
K. Shimkus¹*

Analysis of a sediment core collected in March 1993 from a water depth of 300 m in the Russian portion of the Black Sea revealed ¹³⁴Cs and ¹³⁷Cs contamination in the upper 4-cm layer that was unequivocally related to the Chernobyl nuclear reactor accident that occurred in April and May 1986. The presence of ¹³⁴Cs provided a tool to distinguish 1960-era atmospheric fallout cesium from Chernobyl-derived cesium and to

determine the degree of sediment mixing due to bioturbation. At this location ~25% of the underlying 1960-era sediment is mixed into the upper layer of more recently (1980 era) deposited sediment. The presence of atmospherically derived ⁷Be (53.3 d half-life) in the top 1-cm layer of sediment at a 300-m water depth suggests a water column particle settling rate of ~4 m/d (~0.005 cm/s).

On the basis of this particle settling rate and sea water viscosity, an average particle settling diameter of 0.05 mm was estimated; measuring confirmed this diameter. Analysis of ²¹⁰Pb inventories revealed a sediment accumulation rate of ~0.36 cm/year. These estimates of sedimentation dynamics are being used to delineate the age of phytoplanktonic molecular markers preserved in the anoxic sediments of the Black Sea, including the potential measurement of DNA damage resulting from ultraviolet radiation over historical time frames.

¹*Southern Branch of P. P. Shirshov Institute of Oceanology, Russian Academy of Science, Gelendzhik, Russia.*

5 The Micrometeorological Gradient Similarity Method Is Tested to Measure Air-Surface Exchange Rates for Vapor-Phase Mercury

*S. E. Lindberg, K.-H. Kim, P. J. Hanson,
J. Owens, and T. P. Meyers¹*

To determine the processes that control biogeochemical cycling of important trace gases, scientists are developing methods of estimating air-surface exchange rates. Because micrometeorological methods yield area-averaged fluxes over undisturbed

surfaces, they hold important advantages over chamber approaches.

The Mercury Air-Surface Exchange (MASE) Project is testing the gradient similarity method for application to mercury vapor in the first-ever application of a tower-based micrometeorological method for mercury fluxes. The method involves quantification of time-averaged concentration gradients (~ 1 h) of mercury and related trace gases (i.e., CO_2 and H_2O) over the surface of interest. Values for these gradients are combined with direct measurements of the fluxes of CO_2 , H_2O , and heat, measured by fast-response sensors and eddy correlation to compute fluxes of mercury. To measure air concentrations with the high precision and accuracy necessary for quantifying small concentration gradients over forest canopies and soils, scientists designed a sampler employing 12 replicate mass flow controllers.

During spring 1993, tests were made to determine whether meaningful concentration gradients over mercury-contaminated soils in Oak Ridge could be measured. The mercury-concentration gradients and fluxes behaved as predicted from first principles: (1) all gradients indicated a strong soil emission of mercury; (2) the concentrations decreased logarithmically with height, similar to the wind-speed profile; (3) the gradients decreased with increasing atmospheric turbulence; and (4) mercury fluxes increased with soil temperature. These data provide confidence in the approach, and measurements have begun over background soil and canopy sites in Walker Branch Watershed, near Oak Ridge.

Preliminary results indicate that mercury gradients are very small (a small

percentage of the mean concentrations) and are bidirectional, which suggests that the cycling of mercury in forests may be strongly influenced by re-emission. Gradients over soils are influenced by soil temperature, turbulence, and soil moisture, whereas those over the canopy are influenced by stomatal conductance, leaf wetness, and turbulence. The methods developed will prove useful for other important tropospheric species for which real-time sensors are not available, such as reduced sulfur gases.

¹*Atmospheric Turbulence and Diffusion Division, National Oceanic and Atmospheric Administration, Oak Ridge, Tennessee.*

6 A Discrepancy Exists Between Observation and Carbon Cycle Model Prediction for the Global Bomb-Radiocarbon Inventory

T.-H. Peng

Measurements of stratospheric radiocarbon resulting from aboveground nuclear testing in the 1950s and the early 1960s do not match predictions of a carbon cycle model used to quantify dilution of the radiocarbon. The ratio of atmospheric ^{14}C to C has steadily declined since reaching nearly twice its pre-nuclear value just after implementation of the ban on aboveground testing of nuclear devices. This decline is largely the result of dilution of bomb-test radiocarbon, a dilution that occurs through isotope exchange between atmospheric CO_2 and terrestrial and oceanic carbon.

A carbon cycle model has been used to quantify the dilution of bomb-test atmospheric ^{14}C as it mixes with oceanic and terrestrial carbon. The model

atmosphere is constrained to follow the observed history of the time that excess bomb radiocarbon takes to decline in the troposphere.

Research shows that, after the implementation of the ban on atmospheric testing in 1963, the model's inventory of bomb-test ^{14}C atoms kept growing but at an ever-decreasing rate, finally leveling off at a near-constant value in the late 1980s. The obvious explanation is that the growth in inventory is driven by the downward mixing of excess ^{14}C atoms stored in the stratosphere. The model suggests that as of 1964, about one-third of the bomb-test ^{14}C remained in the stratosphere and that it was released to the troposphere with an e-folding time of about 7 years.

By contrast, measurements carried out in the stratosphere suggest that, as of 1964, the excess was closer to one-quarter of the total bomb-test ^{14}C and that the e-folding time for its decline was 3 ± 1 years. This anomaly cannot be attributed solely to an inadequacy in the model's representation of the terrestrial biosphere. Rather, it must reflect an inadequacy either in the oceanic part of the model or in the measured stratospheric inventories.

7 Global Maps of Carbon Dioxide Emissions from Fossil Fuel Consumption and Cement Manufacture Are Created

R. J. Andres¹ and G. Marland

Tables of global and national estimates of CO_2 emissions from fossil fuel consumption and cement manufacture are not in a convenient form for some climate-modeling studies. To address this need,

ESD researchers created 1° latitude by 1° longitude (1×1) maps of CO_2 emissions for 1950, 1960, 1970, 1980, and 1990.

National estimates of carbon emissions were then combined with 1×1 maps of political units and human population density to create the new 1×1 carbon emissions maps. The human population density map has an effective resolution of the country or state level. The resolution translates to the CO_2 emissions 1×1 maps because population density was used to distribute within-country CO_2 emissions. Latitudinal distributions of emissions were also calculated.

The maps show continual growth over most of the world; increased growth rates are particularly notable in major urban areas. As Asian countries increase their energy consumption to support their growing economies and populations, a slow equatorial shift in the bulk of the emissions is also seen. The maps will become part of the Global Emissions Inventory Activity, which is part of the International Geosphere-Biosphere Programme.

¹*Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee.*

8 Recent Carbon Dioxide Emissions Estimates from Fossil Fuel Consumption Show Slowing Global Growth Rate

G. Marland, R. J. Andres,¹ and T. A. Boden

Each year, a time-series estimate of annual CO_2 emissions from fossil fuel consumption, cement production, and gas flaring is generated by ESD staff. The emission estimates are critical to global

carbon cycle studies and quantify the major anthropogenic source of CO₂ to the atmosphere. The estimates are derived using methods developed by Marland and Rotty,² energy statistics compiled by the United Nations (UN), hydraulic cement production estimates published by the U.S. Bureau of Mines, and gas-flaring data furnished by the UN and DOE's Energy Information Administration.

Global, regional, and national CO₂ emission estimates have recently been calculated for 1950–1991. These estimates show that global emissions rose to an all-time high of ~6.19 gigatons of carbon in 1991. Only 1.5% higher than the 1990 level, this estimate maintains a recent declining trend in the global growth rate of CO₂ emissions. If the Kuwait oil fires had not emitted 130 million metric tons of carbon to the atmosphere as CO₂, the global estimate for 1991 would have been less.

Regionally, North America and Eastern Europe continue to be the largest emitters despite recent declines, while the developing regions are contributing greater percentages to the global share. In 1950 North America, Western Europe, and Eastern Europe accounted for 89.2% of global CO₂ emissions. In 1991 these regions contributed 59.5% of global CO₂ emissions.

Nationally, the United States continues to be the world's largest emitter (1.35 gigatons of carbon in 1991) despite two successive years of small decline. Emissions from the former U.S.S.R. declined 12% from 1988 to 1991. The three largest emitters, the United States, the former U.S.S.R., and

the People's Republic of China, contributed 48.8% of the world's 1991 CO₂ emissions.

¹*Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee.*

²G. Marland and R. M. Rotty, "Carbon Dioxide Emissions from Fossil Fuels: A Procedure for Estimation and Results for 1950–82," *Tellus* 36(B), 232–61.

9 Active Streamflow and Rainfall Gaging Sites for ORR Are Summarized

D. D. Huff, D. M. Borders,¹ and B. K. Thompson¹

The Tennessee Department of Environment and Conservation DOE Oversight Division is concerned about the adequacy of current streamflow and rainfall-gaging activities on and near the Oak Ridge Reservation (ORR). The issue is whether the current long-term data acquisition strategy is sufficient to support site remediation assessment on the ORR, including implementation of rainfall-runoff-solute transport models.

Because no central point of contact was responsible for maintaining a current status summary for all streamflow and rainfall gaging on ORR, DOE directed the Energy Systems Groundwater Program Office to contact representatives from each of the site Environmental Restoration Program offices, the site compliance organizations, the Biological Monitoring and Abatement Program, DOE contractors, and research and development projects to assemble a comprehensive synthesis of activities. This is viewed as the first step toward evaluating the nature of the network of gages on ORR and determining whether significant

gaps exist in the information being collected.

On the basis of a comprehensive survey, 36 active streamflow-gaging sites and 16 active rainfall-gaging sites were known to be operational on ORR in early October 1993. Using the current Geographical Information Systems map base, ESD researchers prepared two maps of ORR. The first provides the locations of the stream-gaging sites together with main roads, streams, and topographic contours; the second, locations of active rainfall-gaging sites. Each map has a set of identifier numbers that relate each location to a table that summarizes the type of installation, data attributes collected, period of record, and organization responsible for maintaining the data.

An indication of expected longevity of the data collection project is also given. Clearly, the number and density of streamflow and rainfall gages is determined by specific study objectives that differ depending on the scale of the focus. One scale would support rainfall and runoff modeling; it is basin-wide for major drainages on ORR (e.g., White Oak Creek drainage). Another scale involves individual remediation sites within the major drainages; it is also evident in the assortment of gaging sites. The major basin scale is likely most appropriate for long-term record keeping, and the data obtained should provide a framework for site-specific characterization studies, for which the duration of the record will seldom exceed a few years.

The maps and summary tables should prove useful to those engaged in rainfall-runoff investigations and related work. In particular, identification of the current network in a published format can eliminate duplication of effort, enhance

data sharing, and provide a basis for the design of a cost-effective gaging network for the entire ORR.

¹*The University of Tennessee, Knoxville.*

10 In Situ Chemical Oxidation of Contaminated Groundwater and Soil Is Investigated

D. D. Gates, R. L. Siegrist, S. R. Cline, and D. S. Marshall

Laboratory experiments to evaluate in situ chemical oxidation as a method of remediating contaminated groundwater and soil are under way. Aqueous chemical oxidants such as hydrogen peroxide (H_2O_2) and potassium permanganate ($KMnO_4$) are being studied to determine their ability to oxidatively degrade volatile organic compounds (VOCs), such as trichloroethylene, perchloroethylene, and trichloromethane, and semivolatile organic compounds (SVOCs), such as naphthalene, pryene, and phenanthrene. Preliminary findings indicate that VOC reductions of up to 98% can be achieved using chemical oxidation.

In the laboratory, chemical oxidants are added to artificially contaminated soil slurries in custom-fabricated, zero-headspace extraction vessels. Ensuring that the reaction vessels are gas-tight minimizes contaminant losses due to volatilization and facilitates independent evaluation of losses due to oxidation.

Chemical oxidation treatment efficiency is evaluated at several oxidant concentrations under a variety of operating conditions. Clean soil was obtained from four DOE sites for use in this study so that the operating conditions needed for treating sites with different soil

properties (i.e., clayey vs sandy and low vs high organic carbon content) could be determined in the laboratory before this technology is implemented in the field.

To evaluate the effect of in situ chemical oxidation on metal contaminants that are often found in areas contaminated with VOCs and SVOCs, companion studies are being conducted at The University of Tennessee, Knoxville.

Once the optimum treatment conditions for in situ chemical oxidation are determined, methods for delivering and distributing chemical oxidants to contaminated zones will be evaluated. In situ chemical oxidation with H_2O_2 and $KMnO_4$ is applicable to many of the contaminated sites found in the DOE complex; it appears to be an effective and inexpensive treatment technique that can be used to help restore many of those sites.

11 Elemental Iron Filings Are Effective in Reductive Dechlorination of TCE

L. Liang, J. D. Goodlaxson,¹ and N. E. Korte

Elemental iron was found to be effective as an abiotic, reductive reagent in the dechlorination of trichloroethylene (TCE). To determine the reaction half-time and the by-products of the reaction, batch studies were conducted. Three sources of iron filings were used in the research: Fisher Scientific; Columbus Chemical Industries, Inc.; and Master Builders, Inc.

With a solid:solution ratio of 1:5, the half-time of the reduction was between 7 and 12 h, depending on the sources of iron.

When the Fisher Scientific filings were precleaned with HCl, the reaction half-time was reduced from 7 to 5 h. The major by-product of the reaction is ethylene; dichloroethylene and vinyl chloride are minor by-products.

To confirm the TCE mass loss through the iron column by physical transfers and chemical degradations, a flow-through experiment is ongoing. Rate information will be obtained in these experiments as well. The results of the research will have direct applications for environmental restoration activities at many DOE sites.

¹*Oak Ridge Research Institute, Oak Ridge, Tennessee.*

12 Natural Organic Sorbents Offer Effective In Situ Treatment of Contaminated Groundwater

L. Liang, J. D. Goodlaxson,¹ and R. L. Siegrist

ESD researchers have found that peat offers a simple, inexpensive, and passive means of in situ treatment for contaminated seep water in the solid waste storage areas (SWSAs) at ORNL. Initial bench-scale studies using simulated seep water showed that peat is an excellent sorbent of heavy metals: in the presence of 5 g of peat per liter, Cd, Ni, Cr, and Pb were reduced by 90 to 98% at initial concentrations ranging from 0.5 to 5 mg/L.

Among the four types of peat tested, the most decomposed peat had the highest sorption capacities for heavy metals. At the concentration 10g/L, two types of peat also reduced ⁹⁰Sr in SWSA groundwater seeps from 18,000 Bq/L to 4200 Bq/L (a decrease of 77%)

and 960 Bq/L (a decrease of 95%). Kinetic experiments indicated that sorption was completed within an hour.

Because peat is inexpensive, treating contaminated seep water with peat would be cost-effective. Because the thermal combustion of spent peat will produce only a small volume of residue, storing spent

peat will pose few problems. Using peat as a reactive barrier for in situ treatment of contaminated groundwater appears to be an effective, inexpensive technique that can be used at many contaminated DOE sites.

¹*Oak Ridge Research Institute, Oak Ridge, Tennessee.*

Horizontal drilling equipment is used to install two parallel 475-ft-long horizontal wells comprised of ductile porous polyethylene pipe. The wells are essential to field experiments involving in situ recirculation and treatment of contaminated groundwater in thin aquifer zones.

13 In Situ Treatment of Mixed Contaminants in Groundwater Is Accomplished by Innovative Horizontal Flow Field and Module Methods

R. L. Siegrist, N. E. Korte, and M. T. Muck¹

Groundwater contamination by mixtures of organic chemicals and radionuclides is a significant problem within the DOE complex. The coupling of simple but robust in situ treatment processes with groundwater recirculation has great potential for treating those sites. Consequently, DOE's Office of Technology Development has funded ORNL to develop and demonstrate such a system.

Initial studies determined that current recirculation applications use vertical wells and are limited to aquifers that are relatively thick (i.e., >5 m) and have horizontal-to-vertical conductivity ratios between 1 and 10. Horizontal wells are less constrained by these restrictions, and their use extends the applicability of recirculation treatment to a broader range of hydrogeologic conditions.

Advanced microtunneling methods and materials technology originally identified in Germany with the sponsorship of DOE's International Technology Exchange Program were selected for inclusion in a field test at the DOE Portsmouth, Ohio, facility in October 1994. A continuous guidance and drilling method was used to install two 500-ft-long horizontal wells ~100 ft apart and at ~30 ft depth. The central 200-ft section of each well was laid on a bedrock surface and was composed of a unique porous polyethylene casing. The test is expected to show that the combination of the advanced materials and

installation methods will yield a horizontal recirculation system with improved performance, flexibility, and cost-effectiveness in comparison with the features of installation with conventional materials.

Development of the in situ treatment module was also initiated during 1994. Potentially useful in situ treatment processes were identified and screened by a panel of ORNL scientists. Specific processes considered were (1) simultaneous reduction and adsorption of radionuclides and the reduction of hydrocarbons by zero-valence metals (e.g., iron), (2) destruction of hydrocarbons through the use of chemical oxidants, and (3) countercurrent air stripping (cocurrent air stripping is currently used). Bench-scale testing and a field pilot test will be completed in 1994; a full-scale technical demonstration will be established at a contaminated site during 1995.

¹*Health Sciences Research Division, ORNL.*

14 In Situ Remediation of DNAPLs in Low-Permeability Media Is Studied in a Joint DOE and American Petroleum Institute Project

R. L. Siegrist, O. R. West, N. E. Korte, D. R. Smuin, A. D. Laase, D. D. Gates, L. Liang, A. V. Palumbo, J. Strong-Gunderson, B. Gu, and D. T. Davenport¹

Dense nonaqueous-phase liquid (DNAPL) compounds like trichloroethylene (TCE) and perchloroethylene are prevalent at DOE sites, and their presence in low-permeability media poses challenges for effective in situ remediation technologies.

ORNL researchers have been coordinating a joint program sponsored by DOE and the American Petroleum Institute wherein in situ remediation technologies are being tested and evaluated for both source control and mass removal of DNAPLs in fine-grained media.

The project includes technology evaluation and screening and laboratory- and field-scale testing at clean and contaminated test sites in the United States and Canada; participants include staff from numerous universities and industries (e.g., Oregon Graduate Institute, Colorado State University, University of Cincinnati, New Jersey Institute of Technology, University of California-Berkeley, University of Waterloo, BP Oil, Freeze Engineering, CH2M Hill). Progress to date has included technical workshops, preparation of 16 state-of-the-art papers, and field-scale experimentation at three sites.

At the site near Sarnia, Canada, a controlled release of 50-L nonaqueous-phase liquids (gasoline and TCE) occurred during fall 1992 within a 10- by 10-m test cell and was followed by studies of soil vacuum extraction (SVE) performance. Because researchers observed relatively low mass removal efficiency (30–40%) during two summers of SVE, they focused their current studies on the enhancement of SVE by hydraulic fracturing and dewatering and on the potential for bioremediation.

At the DOE Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, a field test was initiated during October 1994 to explore the fracture-enhanced injection and dispersal of reactive fluids such as oxidants/reductants and surfactants/nutrients in uncontaminated clay soils. At the site on Aber Road near Cincinnati, a

field study of hydraulic fracturing and heated fluid injection was initiated in late fall 1994. The results from the various facets of the project will provide the basis for designing and conducting a full-scale field test at a contaminated site during 1995.

¹*Environmental Restoration Program, ORNL.*

15 Options Are Evaluated for Treating and Disposing of Low-Level Mixed Waste Sludges at the Rocky Flats Site

R. L. Siegrist, K. S. Dickerson,¹
M. I. Morris,² and M. J. Wilson-Nichols¹

Solar evaporation ponds have been used at the DOE Rocky Flats site since the early 1950s for the disposal of process wastewater containing radioactive and hazardous materials. In 1993, sludges were removed from the existing ponds by vacuum truck and placed into about fifty-five 10,000-gal double-wall polyethylene tanks under a tent on a concrete pad for temporary storage.

During 1994, ORNL staff evaluated treatment and disposal options for the containerized sludges and prepared a report for the DOE Rocky Flats site. The sludges were characterized as low-level mixed waste containing high concentrations of dissolved salts (e.g., nitrates, sulfates) and heavy metals (e.g., nickel, cadmium) and low levels of radionuclides (e.g., ²³⁹Pu, ²⁴¹Am, ²³⁴U, ²³⁵U, ²³⁸U). The sludges exceeded land disposal restrictions for cadmium and nickel. A literature review and survey of federal facilities identified stabilization/solidification (S/S) as the most frequently implemented remedial action for pond sludges.

A query about DOE and U.S. Department of Defense sites revealed that ~75% of the sites have disposed of or plan to dispose of the treated sludges off-site rather than on-site. After taking a formal survey of more than 80 private industry vendors, ORNL researchers proposed six types of treatment technologies: S/S, chemical extraction/precipitation, polyethylene immobilization, vitrification, molten metal, and pyrolytic concentration. The project team integrated the results of the review and developed more than 20 candidate treatment and disposal systems for further evaluation. An interdisciplinary, multi-institutional team was assembled, and a systems analysis and ranking exercise was completed.

The top-ranked system was cement-based S/S. Middle-ranked systems were simple stabilization, biochemical stabilization, biodenitrification followed by cement S/S, pressure S/S, and polymer S/S. The lowest ranked systems were vitrification, microwave S/S, and plasma hearth S/S. Whereas stabilization systems appeared most feasible, additional testing and treatability studies were deemed necessary and appropriate to support design and implementation.

¹Health Sciences and Research Division, ORNL.

²Chemical Technology Division, ORNL.

16 Fracture Spacing and Connectivity Are Observed in Multiport Instrumented Wells

R. B. Dreier and G. L. Davidson¹

Characteristics of hydraulically active fractures determine groundwater flow paths and strongly influence contaminant transport on the Oak Ridge Reservation

(ORR), which is located in the Eastern Tennessee Appalachian Fold and Thrust Belt and overlies an area of folded, faulted, and moderately dipping Cambrian through Mississippian clastic and carbonate rocks. ESD researchers are conducting a study to understand the lateral and vertical changes in fracture behavior on ORR. Fourteen core holes that have been geophysically logged and instrumented with multiport systems provide detailed vertical resolution of the fractured rock groundwater system. Fracture spacing increases with depth, suggesting that fracture distribution is related to near-surface processes such as weathering and unloading.

Fractures create a connected system that shows smooth, fairly continuous vertical changes in the hydraulic head that extend to depths of 700 ft. This depth range contains the majority of borehole geophysical logging responses indicative of fractures. Below these depths the fractures are more widely spaced and likely range from being poorly connected to unconnected, leading to unpredictable and reversible vertical hydraulic head gradients. Locally, packages of strata (as much as 100-ft thick) exhibit no vertical gradient. These packages are delimited by abrupt and significant changes in head (as much as 30 ft) that probably reflect a poor hydraulic connection between hydrostratigraphic packages.

Where fractures are not observed in cores from the base of deep wells, hydraulic heads at these levels show a sharp drop, greater than 60 ft; this drop suggests that the zone is underpressured, possibly as a result of unloading. Core analysis has determined that most fractures are strike parallel, but dip-parallel fractures must occur to produce continuity in the groundwater flow paths. Continuity varies

locally, and connectivity can be qualitatively determined from hydraulic head patterns.

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17 The Modified Ring Test Is Effective in Determining the Fracture Toughness of Competent Rock Cores from ORR

P. J. Lemiszki¹ and J. D. Landes¹

Rock mechanics tests of rock cores from the Oak Ridge Reservation (ORR) provide a necessary database for mechanical modeling of the bedrock in response to past deformational events, unloading and uplift, hydrofracture injections, and hydrologic testing. Located in the southern Appalachian Valley and Ridge province, ORR is underlain by a variety of sedimentary rock types with distinct physical properties.

The modified ring test (MRT), a new technique, is a fracture mechanics extension of the Brazilian tensile-strength test. MRT provides an estimate of rock fracture toughness from core-sized samples that were once considered too small to produce reliable results. The major limitation of MRT is that it requires rock types that maintain their integrity during sample preparation; therefore it cannot be used to test friable shales.

Tests have been completed on 20 samples obtained from the JOY2 corehole in the Copper Creek thrust sheet. Sandstone samples are from the Rome Formation; dolomite samples are from the Copper Ridge Dolomite and Maynardville Limestone. Although more tests must be performed to evaluate the data statistically,

preliminary results indicate that average fracture toughnesses of sandstone and dolomite are $4.5 \text{ MPa(m)}^{1/2}$ and $3.0 \text{ MPa(m)}^{1/2}$ respectively.

In addition to testing more core samples, future work will include comparing core sample and outcrop sample test results and testing samples under confining pressure to simulate subsurface conditions.

¹*The University of Tennessee, Knoxville.*

18 Geologic Mapping Is Used as the First Step in Planning Subsurface Studies to Unravel the Complex Geology of the Oak Ridge K-25 Site

P. J. Lemiszki¹

Environmental restoration and waste management plans for the Oak Ridge K-25 Site require a complete understanding of the site geology because various aspects of the groundwater flow system are directly influenced by stratigraphic and structural characteristics of the bedrock. This study involved mapping the bedrock geology of a 52-km^2 (20-mile^2) area in and around the plant site at a scale of 1 to 12,000. Field mapping focused on (1) checking the accuracy of previously mapped stratigraphic contacts and faults, (2) dividing the bedrock into distinct stratigraphic units based on field criteria, (3) determining the geometry of map-scale folds and faults, and (4) conducting a preliminary assessment of various aspects of the local fracture system.

Results from this study led to two new hypotheses regarding the site geology that may have an important influence on the groundwater flow system. First,

macroscopic folding within the Chickamauga carbonates in the plant area suggests the existence of a thrust fault in the subsurface that detaches the overlying folds in the Chickamauga from the underlying Knox Group. The possible surface location of this fault is within the Carters Limestone where a zone of deformation occurs parallel to bedrock strike. The fault zone may be intensely fractured and may enhance local fracture permeability. Second, thrust slices of the Rome Formation that overlie the Chickamauga carbonates may be thin and have a more limited aerial extent than previously mapped. Therefore, the potential exists for contaminants to migrate through the clastics of the Rome Formation into the karstified Chickamauga carbonates. Evaluating these hypotheses will require information about the subsurface that can be acquired only through drilling and surface geophysical surveys.

The geologic map produced from this study can be used to choose the location of coreholes to intersect a combination of stratigraphic, structural, and hydrologic targets.

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19 A Statistical Approach for Optimizing the Monitoring of Temporal Changes in Groundwater Quality Is Developed for WAG 6

G. R. Moline, J. J. Beauchamp, and T. Wright¹

Applying the Data Quality Objectives process during the development of the Environmental Monitoring Program for Waste Area Grouping (WAG) 6 led to a

decision rule that bases criteria for action on changes in the summed releases of contaminants from WAG 6 in relation to releases from other WAGs that contribute to the total contaminant flux over White Oak Dam. This approach is consistent with the overall strategy for remediation of the White Oak Creek watershed; the strategy allows for prioritization of remedial activities on the basis of a WAG's relative contribution to off-site flux. Currently, WAG 6 contributes only 1–3% of the total contaminant flux over White Oak Dam; thus, it is low on the priority list for remedial action.

Studies found that contaminant releases from WAG 6 must undergo a tenfold increase to reach a magnitude comparable to the worst contributors to off-site contaminant flux. This conclusion led to the following decision rule: if total contaminant flux from WAG 6 increases by a factor of 10 over 5 years or by a factor of 2 annually, then actions will be taken, including increased monitoring and/or implementation of source control measures. In applying the decision rule to groundwater monitoring, we developed two statistical methods to provide a measure of comprehensive change that could be declared statistically significant at predetermined levels of confidence. These methods incorporate both spatial and temporal variability and utilize historical data to determine initial statistical parameters that can be updated as new data are obtained.

The first method is used for evaluating the summed changes in contaminant concentration within a population of wells during an arbitrary "out" year in comparison with the concentration during a baseline year. The second method is used for evaluating the statistical significance of

a trend in mean contaminant concentration for a group of wells. For either method, the magnitude of change that can be declared statistically significant can be

This undisturbed soil column from the Oak Ridge Reservation has been coated in wax. The vertical walls will be sealed with a rigid epoxy resin in preparation for shipment to ORNL. Soil columns are used to help determine how contaminants are transported through the subsurface.

calculated, given the pooled variance from a set of well data, the levels for Type I and Type II errors, and a sampling frequency for the set of wells. Alternatively, given the desired magnitude of change and the other statistical parameters, a minimum sampling frequency can be determined. Because the costs of sampling and analysis are known, a cost/benefit analysis can be performed to provide a direct measure of the incremental costs for increased levels of confidence and resolution.

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20 Historical Water-Level Data Provide a Means for Examining Regional Groundwater Flow

G. R. Moline and D. E. Allred¹

Historical water-level data from more than 600 wells in Melton Valley are being evaluated through the use of multivariate statistical techniques to provide a framework for understanding flow dynamics on a regional scale. This framework will provide the means for examining the spatial variability of hydrologic parameters such as hydraulic conductivity and recharge to the groundwater system, which in turn can be used to improve the calibration of the Melton Valley groundwater model and to guide decisions about well plugging and abandonment.

The objectives are to categorize the wells according to their variations in water level, to determine the spatial distribution of the different categories, and to investigate the correlations between types of water-level responses and potential controlling factors. Water levels within groundwater

wells and piezometers respond to a variety of forcing events, including precipitation, evapotranspiration, earth tides, barometric pressure changes, and anthropogenic activities. The degree of response is controlled by subsurface hydrologic characteristics as well as by the construction design of the well. When variations in well design are accounted for and when forcing events are assumed to be uniform across all well locations, then variations in water-level response reflect variations in subsurface hydrologic properties. Water-level measurements that range in frequency from monthly to daily were examined for suitability and edited to remove outliers and other nonrepresentative points.

Using a subset of daily well hydrographs as a test set, scientists developed a method for separating the low-frequency seasonal responses from the high-frequency storm responses. Statistical parameters that characterize the seasonal and storm responses were then used to cluster the wells into groups that respond similarly; as a result, nine classes emerged. Future work will focus on classifying the remaining wells in the data set, analyzing the spatial distribution of dynamic classes, and linking well responses to specific hydrologic properties.

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21 Sampling Protocols for Fractured Media Are Being Investigated

G. R. Moline and M. E. Schreiber¹

To accurately calculate contaminant flux from waste disposal sites and the subsequent risk to the environment,

researchers must have groundwater samples that are representative of in situ flow conditions at the sampling location and that take into account the spatial and temporal variability in groundwater quality. At an uncontaminated site in West Bear Creek Valley, researchers are collecting data to help determine what constitutes a representative sample in the fractured shale that is typical of the geology underlying many of the waste disposal sites on the Oak Ridge Reservation and to determine how the construction of monitoring wells and the choice of sampling methods affect the representativeness of samples.

The specific objectives are (1) to measure the spatial and temporal variability of geochemical and tracers constituents; (2) to identify discrete transport pathways and construct new monitoring wells that isolate those zones; (3) to determine the influence that the design of monitoring wells has on sample representativeness; and (4) to investigate the impact that various purge volumes have on the flow system, particularly with regard to the potential for increased mobilization of contaminants.

Injection of helium and bromide tracer was initiated in early spring 1994 to create surrogate contaminant plumes for initial characterization of flow dynamics and for later testing of sampling methods. Three new boreholes were drilled into the shallow bedrock adjacent to existing screened wells. Electromagnetic borehole flowmeter tests and point dilution tests were conducted to identify and characterize the active flow zones and to determine the appropriate placement of multilevel sampling ports.

Data obtained from screened wells and multilevel wells will be compared to

determine the impact of well design on the representativeness of samples. To examine the spatial variability in water quality, we are analyzing the geochemical and tracer composition of samples taken from discrete zones within the boreholes. Results of this study will lead to recommendations for revisions in strategies for groundwater monitoring so that researchers can obtain samples that better represent undisturbed flow conditions within active transport pathways.

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22 Attrition Scrubbing, Ultrasonic Treatment, and Oxidant Additions Enhance Uranium Removal from Contaminated Soils

M. E. Timpson, M. P. Elless, and C. W. Francis

As part of DOE's Uranium in Soils Integrated Demonstration Project, bench-scale investigations of selective uranium leaching from soils at the Fernald Environmental Management Project site, in Ohio, were conducted. Two Fernald site soils, one sampled adjacent to an old trash incinerator and another sampled adjacent to a storage pad, representing the major contaminant sources at the site, were extracted using carbonate- and citric acid-based lixiviants.

To increase the rate of uranium released from the soils, physical and chemical processes were used in combination with the two extractants; attrition scrubbing and ultrasonic dispersion were the two physical processes used. Potassium permanganate was used as an oxidizing agent to transform tetravalent uranium to the hexavalent state, because hexavalent uranium is easily

complexed in solution by the carbonate radical. Attrition scrubbing increased the rate of uranium released from both soils when compared with rotary shaking. At equivalent extraction times and solids loadings, however, attrition scrubbing proved effective only on the soil sampled adjacent to the old trash incinerator.

Additions of potassium permanganate to the carbonate extractant resulted in significant changes in the extractability of uranium from the incinerator soil but had no effect on the removal of uranium from soil sampled adjacent to a storage pad. Ultrasonic treatments on the incinerator soil removed 71% of the uranium contamination in a single extraction. Multiple extractions of the same sample removed as much as 90% of the uranium.

23 Background Soil Characterization Project Provides Data for Remedial Action Evaluation

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The Background Soil Characterization Project (BSCP) will provide the necessary data to make informed decisions based on extensive characterization of natural background soil concentrations of organics, inorganics (metals), and radionuclides found on the Oak Ridge Reservation (ORR). Standards for cleanup of potentially contaminated soils on the ORR will be based on

concentrations above those established as background in this project for typical soil constituents.

If data from this project can be used to determine that levels of organics, metals, and radionuclides at a suspected contaminated site are no greater than those found in nature, then those constituents will not be considered contaminants of concern for that site. However, if concentrations of contaminants are greater than those found in nature, then appropriate remedial actions will be evaluated in site-specific cleanup projects to reduce the elevated concentrations to naturally occurring levels or to technically feasible levels. The objectives of the BSCP were to provide (1) fully validated and defensible data for assessing contaminated sites and (2) estimates of risk from background concentrations of naturally occurring (but potentially hazardous) substances in undisturbed soils.

The BSCP addresses the variability of concentration levels in relation to major soil types occurring in different geologic formations, soil-sampling depths (i.e., horizons) within specific soil profiles, and natural variations in soils developed in the same geologic formation. ESD was instrumental in completing this 2-year field project for the DOE Environmental Restoration Program.

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24 Convection in a Large Artificial Magma Is Observed Indirectly Through Thermal Perturbations and Cooling Rates Recorded During Crystallization of an In Situ Vitrification Melt

G. K. Jacobs, M. T. Naney, and N. W. Dunbar¹

A large (5-m³, 12,500-kg) hemispherical-shaped, high-calcium basaltic melt was created by in situ vitrification technology and allowed to cool from a crystal-free, superheated condition to a solidified rock body. The interior of the solidified rock body consists of large (1 × 5 mm) diopsidic pyroxene phenocrysts in a ground mass of small pyroxenes and anorthitic feldspars. The margin of the body contains more glass as well as pyroxenes with textures indicative of rapid cooling. The melt was well mixed by convection during its formation: tracer elements placed as point sources in the precursor soil before the melt were found to be distributed homogeneously throughout the solidified rock body.

Direct observation of the melt surface indicated convection rates of 6 m/min during active melting. Convection of the melt during cooling was evaluated using information about the size of the melt combined with data from thermocouples placed in the melt at various distances from the melt margin.

Cooling rates of -0.5°C/min were measured from 1400 to 1325°C by all thermocouples immediately following termination of heating. At 1210°C the cooling rates in the melt interior decreased to -0.25°C/min, whereas rates near the melt margin were -0.37°C/min.

Thermocouples in the melt interior recorded large, distinct thermal perturbations that started at 1325°C and that had a 10- to 20-min period with a temperature variation of 10 to 20°C. Thermocouples near the melt margin measured less distinct perturbations. The thermal perturbations in the melt interior started to dampen at 1210°C, which is near the liquidus temperature derived from the MELTS model of Ghiorso.

The thermal perturbations completely disappeared by 1160 to 1180°C, just prior to a thermal arrest at 1140°C, which indicated extensive crystallization of the melt. The MELTS-calculated crystallization history suggests that the system is 25% crystals at 1190°C. Thus, convection appeared to decrease near the liquidus and to cease as the melt approached 25% crystals.

On the basis of the observed thermal behavior, estimated convection rates were 0.25 m/min during cooling from 1400 to 1325°C, 0.1 m/min from 1325 to 1210°C, and 0.025 m/min just prior to the thermal arrest. The lack of distinct thermal perturbations and the presence of dendritic textures and more glass in the margin of the solidified rock body are consistent with a conceptual model of minimal convection, rapid crystal growth, and significant heat transfer from the margins of the melt to the surrounding soil.

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25 Subsurface Column Studies Identify the Importance of Time-Dependent Diffusion During Solute Transport

P. M. Jardine, R. O'Brien,¹ and O. Reedy²

The majority of groundwater and contaminant fluxes on the DOE Oak Ridge Reservation (ORR) occur in subsurface materials <3 m deep. These materials are characterized by fractures or networks of large pores, which are highly conductive zones, and the surrounding matrix materials, which are less conductive. Mass transport from the conductive zones to the matrix material provides a sink for contaminants entering the groundwater system. The subsequent release of this mass from the matrix back into conductive zones serves as a long-term, secondary source of contaminants to the groundwater.

The objectives of this investigation were to characterize and to quantify the mass transport processes that move contaminants between these two subsurface regions. Cylindrical columns (18 × 40 cm) of undisturbed, highly weathered shale were collected from ORR and instrumented for laboratory simulations of saturated groundwater flow. Columns were acquired parallel to the subsurface bedding planes, the primary conductors of groundwater movement.

Conservative tracer tests were performed over a range of groundwater fluxes; these conditions encompassed the range of measured in situ fluxes. Additional tracer tests involved flow interruption techniques

and the use of multiple tracers with varying diffusion coefficients. Results from the tracer tests indicate that both the amount of mass and its transfer rate into the matrix vary with changes in flux. The mass transferred into the matrix decreases with an increase in groundwater flux, whereas the transfer rate increases.

Existing numerical groundwater models do not adequately predict the observed data; this suggests that not all pertinent transport processes are included in the selected models. Flow interruption experiments confirm that the molecular diffusion of solutes is a significant transport process over the entire range of experimental fluxes. Multiple tracer tests indicate that this diffusion occurs throughout all stages of solute transport and breakthrough.

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26 Common Soil Minerals Alter the Fate and Transport of Contaminants in Subsurface Environments

P. M. Jardine and D. L. Taylor¹

Low-level radioactive waste generated at DOE facilities has traditionally involved shallow land burial as a mixed waste source. Contaminants such as ⁶⁰Co and ⁹⁰Sr are chelated with organic ligands, such as ethylenediaminetetraacetic acid (EDTA), prior to disposal. Because of complex interactions with soil minerals, chelating agents tend to alter the geochemical behavior of contaminants in subsurface environments.

ESD researchers investigated the kinetics and mechanisms of Co(II)EDTA²⁻ oxidation to Co(III)EDTA⁺ by the soil mineral Mn-oxide. The environmental significance of this reaction is that the product, Co(III)EDTA⁺, is much more stable and travels farther in subsurface environments relative to Co(II)EDTA²⁻.

Quartz sand was coated with 0.04 to 0.4% β -Mn(IV)O₂, and Co(II)EDTA²⁻ reactivity was investigated for various Mn:Co molar ratios and different MnO₂ surface coverages through batch and column techniques. The soil mineral MnO₂ exhibited catalytic capabilities such that each mole of Mn(IV) catalyzed the oxidation of significantly more than two moles of Co(II)EDTA²⁻. A loss in oxidative potential of the MnO₂ occurs, however, upon continuous reaction with Co(II)EDTA²⁻.

Evidence suggests that the oxidation of Co(II)EDTA²⁻ involves the reduction of Mn(IV) to both an aqueous Mn²⁺ species and a Mn(III)-oxide solid phase. A catalytic cycle is observed as the Mn(III)-oxide is regenerated to a Mn(IV)-oxide and as the Mn²⁺ is readsorbed and reoxidized on the solid phase. The loss of oxidative potential was shown not to result from direct surface poisoning by adsorbed Mn²⁺ but rather to apparently be caused by formation of an intermediate Mn(III)-oxide solid phase whose oxidative potential was significantly less than Mn(IV)O₂. These results suggest that the kinetics of Co(II)EDTA²⁻ oxidation to Co(III)EDTA⁺ in subsurface environments depend on the rate of Mn-oxide surface regeneration.

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27 Presence of Natural Organic Matter Decreases Sulfate Adsorption in Subsurface Environments

Z. S. Kooner¹ and P. M. Jardine

Predicting in situ, multispecies subsurface transport requires knowledge of specific geochemical interactions that occur in soil. Because of hydrologic and mineralogic heterogeneities, geochemical interactions may be spatially complex at the field scale. In this study, researchers characterized competitive surface-complexation reactions of sulfate and natural organic matter (NOM) as a function of pH on different soil types spatially distributed throughout a field facility located at ORNL. Soil samples acquired from the field site were treated to remove indigenous NOM and sulfate, and a batch technique was used to investigate competitive surface reactions of added NOM and sulfate as a function of pH.

The adsorption of sulfate onto the different soil types was a time-dependent process that reached equilibrium in 4 d. Sulfate adsorption decreased in the presence of NOM and was found to be strongly pH dependent on several soil types. The pH-dependent adsorption data were successfully represented by a surface-complexation model based on electrical double-layer theory using a single adsorption reaction between the sulfate anion and the soil surface. Model-estimated surface-complexation constants were of the order $\log K = 10$, which suggested strong sulfate adsorption.

Although the presence of NOM consistently decreased sulfate adsorption over the pH range, model-estimated

surface-complexation constants for sulfate were essentially the same in the presence and absence of NOM. The surface-complexation constants also appear to be spatially consistent throughout the field site. The stability constants obtained from this study are being used, in conjunction with other information, to parameterize a field-scale, three-dimensional, multispecies hydrogeochemical transport model.

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28 Forager Sponge Helps Remove Technetium from Groundwater

J. D. Marsh, Jr., L. Liang, M. T. Muck,¹ and D. T. Davenport²

Four forms of a new proprietary material, the Forager Sponge, have been evaluated for their effectiveness in removing technetium from groundwater. Batch experiments using ^{95m}Tc were carried out for the aluminum, acid-activated aluminum (Al-H), calcium, and hydrogen forms of the Forager Sponge. Results of a 5-d experiment showed that the Al, Al-H, and Ca forms reached equilibrium with respect to Tc removal after about 1 d, whereas the H form required 4 d to achieve equilibrium. The hydrogen form also had the highest capacity for sorption of technetium, being about 50% greater than the other forms and sorbing about 63% of the initial technetium activity after 5 d. The order of the sorption capacity was H > Al-H > Ca > Al. The sorption of technetium was also found to be a linear function of the technetium concentration up to 18 nCi/g of sponge. Saturation of the sponge was not achieved at this concentration. From these experiments, the hydrogen form of the Forager Sponge

appears to be a candidate medium for removing technetium from groundwater.

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29 Use of In Situ Vitrification to Study Natural Magmatic Processes Is Discussed During a Workshop at ORNL

M. T. Naney and G. K. Jacobs

Melts generated by in situ vitrification (ISV) technology provide unique opportunities to advance the understanding of magmas and magmatic processes and thus justify the development of a proposal to seek funding for a new research initiative at ORNL. This was the consensus of participants in a workshop conducted by ORNL ESD researchers in Oak Ridge, Tennessee, March 29–30, 1994.

Workshop participants evaluated the use of ISV technology to produce large silicate melts that would serve as analogs to natural magmas for studying magmatic properties and processes. ISV melts provide a controlled and monitored environment for testing hypotheses that cannot be tested by bench-top experiments or by studying natural systems. The scale of ISV melts is intermediate (i.e., between that of natural lava lakes and laboratory crucible experiments); melt volumes of 15 to 300 m³ are easily obtained. This approach makes possible the investigation of dynamic processes that either (1) operate on a scale too large to simulate with bench-top experiments or (2) are not amenable to direct observation or control in natural systems (e.g., degassing, convection, crystal settling).

The process produces “containerless” silicate melts; this permits the development of important analog components of natural magma systems, including partial melt zones, stoping, contact metamorphic halos, and

A laboratory technician demonstrates a laboratory-scale attrition scrubber. The attrition scrubber is used in soil washing systems to dislodge, remove, or scarify silt- and clay-sized contaminated particulate from sand-sized soil particles. Technicians have used the attrition scrubber in experiments to remove uranium from Fernald soils contaminated by uranium.

"hydrothermal" fluids. The absence of a melt container makes it possible to use standard field-scale geophysical instrumentation to study the seismic and electrical properties of the melt and the host materials. Volatile and particulate emissions from an ISV melt can be sampled by using methods that avoid reaction with, and contamination by, host rocks.

Geoscientists from across the United States who have expertise in theoretical, experimental, and field investigations attended the workshop. The 23 participants represented universities, research institutions, and national laboratories, including Pacific Northwest Laboratory, where engineering staff developed ISV techniques for applications in environmental restoration. A workshop report is being prepared.

30 Cedar (*Juniperus virginiana*) Records Historical Atmospheric Releases of Mercury

R. R. Turner and N. S. Bloom

Recent dendrochemical studies have demonstrated anatomical, chemical, and ecological attributes of red cedar (*Juniperus virginiana*) that can aid researchers in defining long-term trends in environmental chemistry. The assumption in these studies is that the elemental composition of the annual woody growth partially reflects the chemistry of the environment in which it was formed. Validation of this basic assumption for a given tree and location is difficult to obtain in the absence of an exposure history.

Use of more than 1.1×10^{10} g of elemental mercury at a federal facility in Oak Ridge, Tennessee, in the 1950s has

provided a relatively well-defined exposure history for red cedar growing in the vicinity of the facility. An estimated 2.3×10^7 g of mercury was released to the atmosphere between 1950 and 1963; ~30% of the total air release occurred in 1955. During the same period, $\sim 1.1 \times 10^8$ g was released to a stream, resulting in the contamination of a 150-ha floodplain downstream of the facility.

Red cedar are abundant in the vicinity of the facility, growing on both uncontaminated and contaminated soils. Thus, these trees provide exposure routes via foliar absorption alone and by combined foliar and root uptake.

In addition, ambient air-monitoring data for mercury are available for the past 8 years near two locations where red cedar trees occur. These data provide a unique opportunity to compare average annual mercury concentrations in wood with those in ambient air. With one exception, trees growing on low-mercury soil within 30 km of the facility revealed sharp, well-defined peaks in mercury centered in the mid-1950s. Background concentrations of mercury in red cedar appear to range from 2 to 5 ng/g, whereas peak concentrations were 500 to 1500 ng/g.

One tree, located closest to the center of mercury use at the facility, exhibited mid-1950s peaks as well as one large peak in 1966 that seemed to correspond with the decommissioning and decontamination of a large building. Trees growing in the mercury-contaminated floodplain also exhibited large (i.e., up to 7000 ng/g) mid-1950s peaks that appear to include both root and foliar uptake.

Comparison of the recent ambient air data with red cedar wood values demonstrated

that wood values correlated closely with the general trends in air values. ESD researchers have also shown that red cedar growing near other industrial sources of mercury, such as chlorine-caustic soda plants, have accurately recorded the historical atmospheric releases from nearby facilities. Once fully verified, this method could prove highly useful in analyzing historical exposure levels to atmospheric mercury.

31 Characterization of the Relationship Between Concentration and Discharge in WAG 4 Helps Resolve Discrepancy in the Conceptual Model of Contaminant Transport at Different Scales

D. M. Borders,¹ R. B. Clapp, and M. F. Tardiff²

Recent developments in the conceptual model of the ORNL hydrologic system have largely shifted the emphasis of monitoring and sampling from groundwater to surface water so that the characteristics of contaminant movement and discharge from waste disposal sites can be identified more effectively. However, when the conceptual model is examined at different temporal and spatial scales, a discrepancy appears in the relationship between contaminant concentration (C) and stream discharge (Q). At the tributary scale, contaminant concentrations tend to decrease as flow increases; for example, contaminants entering tributaries are partially diluted during storms. In contrast, monthly data collected at the major monitoring stations (weirs) on the White Oak Creek (WOC) watershed indicate that concentrations of contaminants (e.g., ³H, ⁹⁰Sr) increase as discharge increases; partial

dilution does not appear to occur at the larger scale.

During two storm events, researchers collected samples from the tributary draining Waste Area Grouping (WAG) 4 into WOC. The samples indicate that, for a given storm, concentrations decrease as discharge decreases. However, the wet-season storm produced higher concentrations (at higher levels of discharge) than the dry-season storm; this suggests a resolution of differences in the conceptual model at the tributary scale (i.e., storm event sampling) and the site-wide scale (i.e., monthly flow proportional sampling). Although an individual storm may exhibit the typical C-Q relationship, the average concentration for a storm in the wet season is higher than the average concentration for a storm during the dry season. Consequently, the monthly data show higher concentrations associated with higher discharges, particularly during the wet season, when the water table is elevated.

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32 Hydrologic Data for the White Oak Creek Watershed Are Summarized

D. M. Borders,¹ D. K. Reece, J. A. Watts, B. J. Frederick,¹ W. M. McCalla,² and K. S. Ziegler³

The White Oak Creek (WOC) watershed—consisting of WOC and its tributaries, White Oak Lake, and the WOC Embayment on the Clinch River—is the primary surface drainage for ORNL. WOC drains ORNL and receives

radioactive and nonradioactive effluents (treated and untreated) from ORNL activities, as well as leachates from subsurface waste storage areas in use since the early 1940s.

Streamflow has been monitored in the watershed for over 45 years; the stream network consists of small perennial and intermittent, first- to third-order streams. In addition to natural runoff and groundwater discharge, WOC and its tributaries receive waste effluents and process water discharges from ORNL facilities. These effluents and discharges represent a significant portion of the annual streamflow. Sediments within the WOC flow system have sorbed chemical and radioactive contaminants from nearby waste areas. Consequently, the WOC floodplain sediments and the White Oak Lake sediments and water contain measurable quantities of ^3H , ^{90}Sr , ^{137}Cs , and ^{60}Co .

A hydrologic data report, published for the fourth consecutive year, summarizes the hydrologic data collected on the WOC watershed and its vicinity. The collection of hydrologic data is an integral component of numerous ongoing ORNL environmental studies and monitoring programs and is designed to help (1) characterize the quantity and quality of water in the flow system, (2) plan and assess remedial action activities, (3) provide long-term data and quality assurance, and (4) support long-term measures of contaminant fluxes at a spatial scale that will provide a comprehensive picture of watershed performance commensurate with future remedial actions.

The report continues the characterization and provides the sources of data needed for long-term assessment of the

effectiveness of remedial restoration activities.

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33 Third Annual Report of Environmental Restoration Monitoring and Assessment for ORNL Is Completed

R. B. Clapp and J. A. Watts

The *Third Annual Report of Environmental Restoration Monitoring and Assessment at the Oak Ridge National Laboratory* summarizes the investigation and monitoring activities within the Environmental Restoration (ER) Program during fiscal year 1993. The report results from the cooperative effort of more than 30 contributing authors and is the product of the Waste Area Grouping (WAG) 2 and Site Investigation (SI) Program. Data collection and assessment activities are divided into four major areas: surface water, groundwater, soils and sediments, and biota. Data are presented in a watershed-wide perspective.

Because risk reduction is a primary goal of the ER Program, the data are interpreted in terms of risk to humans. The key indicator for the ER Program is the risk associated with ingesting water discharged at White Oak Dam, the outflow point for most of the ORNL site. In 1993, the risk factor was 5.4×10^{-4} chance of an excess cancer, which exceeds the U.S. Environmental Protection Agency action limit of 1×10^{-4} . The primary contaminant of concern is ^{90}Sr , followed by ^3H and ^{137}Cs . The areas where contaminant releases contributed most

to this site-wide risk factor were WAG 5, followed by WAG 1 and WAG 4 (59%, 18%, and 17% contribution, respectively).

To reduce off-site risk, the ER Program is initiating removal actions with significant involvement of ORNL's ESD staff. The WAG 2 and SI Program exemplifies the integration of applied research and environmental information collection and assessment. This third annual report and future reports will form a basis for prioritizing sites, initially selecting and finally evaluating remedial actions within the White Oak Creek watershed.

34 Rainfall-Runoff Models Fail to Simulate Extreme Floods Accurately

T. A. Fontaine

An important application of rainfall-runoff models is the simulation of peak discharge and runoff volume of extreme floods for risk analyses of dams, nuclear energy facilities, and other high-hazard structures. Runoff models also are used for analyses involving the design of hydraulic structures, flood protection, sediment transport, and research on a variety of surface water hydrology issues.

A major limitation of runoff models is that little information exists on the accuracy of these models for simulating extreme floods (used here to mean floods ranging from the 100-year event up to the probable maximum flood). To evaluate runoff model accuracy for extreme events, ESD researchers compared simulated and observed peak discharge and runoff volume for a historic 100-year flood on a medium-sized catchment. To investigate whether more sophisticated modeling results in significantly greater accuracy, the

extreme flood was simulated using two approaches: a quick analysis with a relatively simple model and an extensive analysis with a complex model.

The runoff models overestimated the peak discharge by 40 to 79% and the runoff volume by 20 to 29%. The more elaborate modeling approach used a calibrated, continuous model; it gave more accurate results but required much more effort than the simple modeling analysis. The amount of error in the simulated flood indicates the importance of including estimates of error in all modeling analyses of extreme floods and the need to develop tools to evaluate the errors on a routine basis. The uncertainty in simulated flood hydrographs potentially affects public safety, increases the cost of new construction, and limits researchers' abilities to solve many hydrologic and environmental problems.

In spite of the potential for significant error, runoff models will continue to play a critical role in the simulation of extreme floods because of the few available alternatives.

35 Dye Tracer and Point Dilution Tests Are Used to Determine Permeable Zones near the Water Table in Fractured Shales on ORR

W. E. Sanford

Information about the location and configuration of relatively permeable zones is critically important to understanding the movement of groundwater contaminants. Furthermore, the occurrence or nonoccurrence of permeable zones in the open intervals of monitoring wells will affect sampling results and their interpretation.

The current distribution of the groundwater dye Rhodamine-WT at the West Bear Creek Valley Tracer Test Site on the Oak Ridge Reservation (ORR) was used, along with point dilution tests, to examine the distribution of permeable zones near the water table. These zones typically occur at the base of the weathered zone (known as the water table interval). The dye was added as a groundwater tracer in April 1988 under natural gradient conditions.

Cores of saprolite from the Nolichucky Shale (Upper Cambrian) were recently collected to the depth of auger refusal and analyzed for dye. The analyses indicate that the greatest dye concentrations occur along the centerline of the plume in an apparently laterally continuous zone ~1.5 m thick. The direction of plume migration is parallel to the local geologic strike. The vertical distribution of dye concentrations suggests that vertical transport perpendicular to the permeable zones is diffusion dominated.

In addition, the specific flux of groundwater has been measured by point dilution testing at 0.3-m intervals within

saprolite and bedrock core holes at the tracer site. In general, the highest (1 m/d) and lowest (0.01 m/d) discharges occur in the bedrock; the highest values occur at discrete locations. In the saprolite the discharges are larger (i.e., an average of 0.16 m/d), and the permeable zones are defined by gradual changes.

These results, along with the dye distribution, suggest that most of the shallow groundwater flows through two or three permeable zones within the water table interval. The permeable intervals appear to be spaced at vertical distances of 1 to 2 m and can be traced laterally for over 30 m. A similar spacing was also observed in gamma counts from wells located near waste trenches on ORR.

The results of this study have been used to locate the sampling wells for a noble gas tracer test that was designed to demonstrate and to quantify the dynamic storage (and release) of contaminants in low-permeability zones while contaminants are transported in high-permeability zones.

This information is necessary for the accurate parameterization of the next generation of groundwater models.

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Ecosystem Studies

Introduction

Research in the Ecosystem Studies Section of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) is directed toward quantitatively characterizing the structure and functional relationships of regional landscapes and terrestrial and aquatic ecosystems, communities, and populations. This information is used to predict the responses of the regions and ecosystems to both natural and human-induced disturbances. The section focuses on complementary areas of research, including theoretical ecology, biogeochemical cycling of materials, physiological ecology of terrestrial plants, resource analysis, biofuels, and hydrosystems. Major sponsors of the section's research are the U.S. Department of Energy (DOE) Environmental Sciences Division of the Office of Health and Environmental Research, the DOE Carbon Dioxide Research Program, the DOE Biofuels Feedstock Development Program, the DOE Hydropower Program, the U.S. Forest Service (USFS), the Federal Energy Regulatory Commission (FERC), the U.S. Environmental Protection Agency (EPA), the Electric Power Research Institute (EPRI), the National Science Foundation (NSF), the National Park Service (NPS), and the Office of Naval Research. Work is also conducted in cooperation with the Tennessee Valley Authority (TVA).

Biogeochemical Cycling

Staff in the Biogeochemical Cycling Group study elemental cycling within environmental systems; the spatial and

temporal patterns of storage and fluxes of nutrients and pollutants; the role of the biogeochemical cycling of chemicals in regulating the productivity, diversity, and sustainability of natural and human-dominated ecosystems; and the development of innovative methods to measure, analyze, model, and interpret biogeochemical cycles at site-specific, regional, and global scales.

The group is currently involved in research in six areas: (1) the DOE Walker Branch Watershed project, which includes long-term studies of basic biogeochemical processes in a mixed deciduous forest catchment and a major manipulation experiment evaluating forest ecosystem response to potential changes in precipitation that result from global climate change; (2) an NSF-funded project investigating spatial gradients in nutrient cycling in streams; (3) a DOE study to evaluate hydrologic processes and the fate of precipitation-borne contaminants in arctic watersheds; (4) two Office of Naval Research studies of radionuclide contamination resulting from activities in the former U.S.S.R.; (5) studies of the dynamics of nitrogen and carbon and their storage or export from high- and low-elevation watersheds in the region; and (6) projects that monitor, predict, and assess water resources and water quality at local and regional scales.

Biomass Systems and International Studies

The Biomass Systems and International Studies Group develops and applies methodologies that assess the feasibility and implications of the development of biomass energy systems in a national and international framework. Through this

group's efforts, ORNL is recognized as an international force in transforming concepts of integrated, sustainable biomass energy systems into reality. Staff members from ESD, ORNL's Energy Division, and ORNL's Health Sciences Research Division contribute expertise in resource analysis, economic analysis, forestry, ecology, and information management. Staff manage and maintain biomass databases, evaluate the global role of biomass energy systems in reducing carbon emissions from the burning of fossil fuels, characterize the systems of energy crop production and analyze their economics, and conduct analyses of the total fuel cycle. The group also evaluates and documents the environmental risks and benefits of biomass energy systems, as well as evaluates integrated biomass energy systems in developing countries. Members of the group participate in International Energy Agency and biomass energy activities, and they develop strategies for the commercialization of biomass energy.

Hydrosystems

The Hydrosystems Group conducts applied and basic research required for the management and analysis of water resources and related natural systems. For example, researchers study how fish populations are affected by water allocation or land-use practices that influence water quality. The group's research focuses specifically on hydroelectric energy production and its environmental effects. The Hydrosystems Group specializes in the development and application of quantitative assessment techniques to solve environmental problems ranging in spatial scale from small stream segments or local levels to large river basins or national levels. In addition, the group addresses such issues as instream flow needs, fish population modeling, multiple-use trade-off analyses,

cumulative impact assessment, contaminant transport, surface water and groundwater monitoring, acidic deposition, and climate change. Research capabilities include simulation and optimization modeling, sensitivity and uncertainty analysis, geostatistical applications, geographic information systems, and scientific database management. DOE, FERC, and EPRI are the three major sponsors of the Hydrosystems Group.

Physiological Ecology

Members of the Physiological Ecology Group evaluate the effects that global climate change and environmental stress have on plant growth and vigor, and they examine the role that physiological processes play in the biogeochemical cycling of pollutants within terrestrial ecosystems. The physiological mechanisms of vegetation response to global climate change (i.e., change in CO₂ levels, temperature, precipitation) are evaluated at the seedling, whole-plant, and ecosystem levels. The group examines specific atmospheric pollutants such as ozone, acid deposition, and nitrogen oxides, as well as the effects of other changes in the chemical and physical atmospheric environment (e.g., high-energy ultraviolet radiation, also known as ultraviolet-B radiation or UV-B). Recently research has shifted toward determining the response of trees and forest ecosystems to global climate change, with emphasis on changes in precipitation, atmospheric CO₂, temperature, and high-energy ultraviolet radiation. Helping to develop nonfossil energy sources, researchers are investigating the use of physiological indicators in intensive biomass production from woody and herbaceous crops grown for the production energy feedstock.

These indicators provide an indirect assessment of stress tolerance. In

addition, research attention has focused on the effect that interactive stresses have on physiological indicators of whole-plant resource utilization. DOE, EPRI, USFS, and EPA are the primary sponsors of the work.

During FY 1994, investigators in the Physiological Ecology Group successfully completed the first full year of the Walker Branch Watershed Throughfall Displacement Experiment, which is designed to provide mechanistic studies of ecosystem- and plant-level responses to changing precipitation patterns. ESD staff and collaborators from several universities initiated further related studies at the experiment site.

At the Global Change Field Research Site, researchers in the Physiological Ecology Group established and tested a system for evaluating tree responses to increased concentrations of atmospheric CO₂ and to increased temperature. Related work focused on (1) the enhancement of photosynthesis in loblolly pine seedlings through CO₂ enrichment and (2) the chemical composition and decomposition rates of yellow poplar leaves in increased and ambient levels of CO₂. Studies sponsored by USFS provided the first direct measurements of the effects that ambient ozone has on the growth of mature forest trees. Research for the Model Herbaceous Energy Species task area of the Biofuels Feedstock Development Program revealed that an increase in ploidy levels among different populations of switchgrass did not consistently increase photosynthetic rates.

Research in physiological ecology contributed to new initiatives in modeling the global carbon cycle. The effort centered around incorporating a model of soil organic matter decomposition and a

net primary productivity model based on a biochemical model of photosynthesis.

Resource Analysis

Staff of the Resource Analysis Group characterize environmental resources and evaluate their development and sustainability, especially at large spatial scales. They also devise and improve methodologies for making such evaluations. Efforts of the group can be divided into those activities focused on the Oak Ridge Reservation and other DOE facilities and those activities not related to specific DOE facilities. The Resource Analysis Group characterizes and reports on environmental measurements taken at DOE facilities, develops environmental databases for DOE Environmental Restoration, manages the Oak Ridge National Environmental Research Park, and provides on-site and off-site environmental programs with geographic information system support. Members of the group are also involved in broader resource issues, including the sustainability of protected areas, the environmental implications of large-scale development of biomass energy, and the analysis and development of global environmental data sets. DOE is the primary sponsor of this group.

In FY 1994, members of the Resource Analysis Group presented their work at several foreign meetings; produced an annual environmental report for all DOE facilities managed by Martin Marietta Energy Systems, Inc.; and moved ahead in developing a land area plan for the Oak Ridge Reservation.

Theoretical Ecology

The Theoretical Ecology Group develops simulation and mathematical methods to

describe and predict the behavior of ecological systems. The tools developed within the group are applied to a spectrum of problems, including environmental assessments, theoretical questions in population and ecosystem dynamics, and analyses of phenomena that span spatial scales from a stream segment to the globe. Research focuses on landscape ecology, development of individual-based models of animal populations, development of landscape indicators and models for environmental monitoring and assessment, integration of socioeconomic and ecological models of land-use change, and development of analytical techniques that can be used to manage ecosystems. DOE, EPRI, NSF, NPS, EPA, and USFS are among the groups supporting this work.

An individual-based population model for sympatric populations of brown and rainbow trout was developed as part of the Program on Compensatory Mechanisms in Fish Populations. In collaboration with utility biologists, Theoretical Ecology Group staff are testing their model in a small stream in the Sierra Mountains of California. Researchers will apply the model to evaluate alternative flow and temperature regimes in an effort to assess instream flow requirements. This process-oriented model represents the growth, survival, and reproduction of individual trout and is designed to complement alternative modeling approaches that focus solely on amount of suitable habitat.

During FY 1994, other research in the Theoretical Ecology Group used neutral-landscape models to focus on the simulation of species responses to general changes in landscape structure. The models help researchers assess ecological processes in heterogenous environments

without being specific to a particular landscape.

TVA Cooperative Forest Studies Program

As a consequence of a common interest in the environmental impacts of energy development and utilization, TVA and the DOE Oak Ridge Operations Office have developed an agreement to pursue joint research activities specifically involving ESD staff and members of the TVA Resources Group. Under this arrangement, TVA personnel are assigned to ORNL to develop programs investigating the effects that emissions into air and water have on terrestrial and aquatic resources. This working relationship combines ESD's unique research-support facilities and the experience that TVA has gained from its power-producing and resource management activities. As a result, the group can produce timely and relevant research findings. A number of major collaborative projects have been undertaken. Whereas initial research projects centered on water quality and nutrient-cycling issues in the context of acid rain, more recent and proposed activities focus on (1) biological effects of chemical and physical changes in the environment that are associated with global change and (2) environmental impacts of the conversion of cropland to biomass plantations.

Belowground research on the Walker Branch Watershed Throughfall Displacement Experiment indicates that although total root elongation generally increased as treatment areas received more throughfall volume, no significant differences in treatment areas were detected during the 1994 growing season: because the rainfall was unusually high, the plants did not experience any stress from a

lack of moisture. The Environmental Impacts of Conversion of Cropland to Biomass Plantations project has virtually completed the installation of both equipment and crop and tree plots at three sites in the Tennessee Valley (including one at Alabama A. & M. University, supported through DOE's Biofuels

Feedstock Development Program).

This study will compare conventional crops with woody biomass from plantations with regard to erosion, water quality of surface runoff, belowground contamination, physical and chemical properties of soil, carbon sequestration, nutrient cycling, and wildlife biodiversity.

Technical Summaries

36 Exchange of Dissolved Nutrients Between Free-Flowing Water and Storage Zones of Streams Is Modeled

D. L. DeAngelis, D. R. Hart,¹ E. R. Marzolf, and P. J. Mulholland

The purpose of the National Science Foundation project "Nutrient Cycling, Ecosystem Structure, and Ecosystem Stability" is to characterize the recycling of nutrients along streams. As part of this characterization, it is necessary to determine (1) the rate of transfer of dissolved nutrients from the free-flowing part of the stream to nonflowing water near the stream's bottom and to within-stream sediments (called the transient storage zones) and (2) the rate of release of nutrients back into the free-flowing water. Researchers determined these rates for streams in the Walker Branch Watershed, using a combination of conservative tracer-injection experiments and mathematical modeling.

Conservative tracers (salt or tritiated water) were injected upstream at known concentrations, and the concentrations were measured at downstream locations. A partial differential equation model was used to describe the advection and dispersion of the solute along the stream as well as the exchange between the flowing water zone and the transient storage zone through turbulent diffusion. A new solution technique was developed that is both more efficient and easier to interpret

than previous methods of solution. A new technique was also developed for determining the parameters of nutrient transfer and dispersion.

These methods will make it possible to compare these important characteristics in a variety of streams.

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37 Seasonal Changes in Hydraulic Features Affect the Transport of Dissolved Compounds in Streams

E. R. Marzolf, P. J. Mulholland, and D. L. DeAngelis

An understanding of the hydraulic conditions [e.g., transient storage zone volume (S), water velocity (V), solute dispersion (D), wetted cross-sectional area (A)] of streams is necessary for understanding the behavior of dissolved solutes in streams. Conservative tracers were injected into a 70-m, first-order reach of Walker Branch and into 20-m laboratory streams throughout the year to examine relationships between hydraulic features and other seasonal characteristics of streams (e.g., flow, accumulation of leaves, periphyton mat development). A solution of $^3\text{H}_2\text{O}$ or NaCl was injected as a tracer, and concentrations of the tracer were then measured by liquid scintillation detection or by electrical conductivity determinations.

Hydraulic features such as the transient storage zone volume [i.e., the portion of water within reach residing in areas of low velocity (e.g., backwaters, sediments)] were estimated from a stream transient storage

zone model through use of an automated, nonlinear optimization method.

In Walker Branch, the strong linear relationship between V^2 and D and the analysis of Reynolds numbers suggest that during low-flow periods the flow is partially laminar. The change from laminar to turbulent flow occurs at about 10 L/s and appears to be reflected in greater rates of water movement between the free-flowing

and stationary storage zones, as indicated by increased piston velocities between the two zones. In autumn, leaf inputs reduced V and increased A ; this change increased solute exposure to microbe-colonized leaf surfaces and resulted in the highest rates of nutrient uptake within the reach during the year. In laboratory streams, S increased as algal biomass increased; this facilitated solute retention under conditions of high nutrient demand by the

Ramie Wilkerson takes a sample of attached algae from an 88-m-long laboratory stream housed in ESD. Pat Mulholland, Erich Marzolf, Susan Hendricks, and Wilkerson are using laboratory streams to determine if changes in biomass, metabolism, and nutrient cycling occur from upstream to downstream under constant environmental conditions.

periphyton mat. Further understanding of the hydraulic features in streams will be useful in analyzing the transport of other solutes, such as contaminants, within streams.

38 Laboratory Stream Studies Demonstrate Important Links Between Upstream and Downstream Nutrient-Cycling Processes

*P. J. Mulholland, E. R. Marzolf,
S. P. Hendricks, and R. V. Wilkerson*

Streams are long, narrow ecosystems with strong advective transport processes resulting from water flow. Stream organisms both alter and respond to the quantity and chemical form of materials transported in water. As a result, biological processes occurring in upstream areas can have strong effects on organisms downstream. However, the effects are sometimes difficult to observe in the field because of longitudinal variability in groundwater inflow and local environmental conditions.

Using a network of longitudinally linked laboratory streams housed in ESD, scientists sought to determine whether changes in biomass, metabolism, and nutrient cycling occurred from upstream to downstream over 88 m under constant environmental conditions. The studies indicated that stream algae became more nutrient deficient as a result of a net depletion of nutrients in the water from upstream to downstream. Scientists observed both increases in several measures of nutrient cycling and a shift in the dominant species from diatoms to blue-green algae from upstream to downstream.

In contrast, measurements of biomass, production, and respiration indicated few consistent upstream-downstream changes. Increases in nutrient cycling and changes in algal species composition apparently compensated for lower nutrient concentrations in stream water; this precluded large upstream-downstream changes in biomass and metabolism.

The study results indicate that stream algal communities can be longitudinally linked through nutrient cycling and transport processes, particularly in nutrient-poor streams. Nutrient cycling and algal species composition were more sensitive indicators of upstream-downstream changes than were the coarser measures of biomass and metabolism. Because stream ecosystems are longitudinal linked, evaluations of disturbance effects in streams must include local effects as well as the effects that the disruption of processes upstream have on downstream communities.

39 ESD Develops Information to Support Water Resource Strategic Planning

*A. W. Renshaw, R. S. Turner, and
D. S. Shriner*

Prudent management of water resources can facilitate worldwide sustainable energy and economic development. ORNL has the scientific, technical, and socioeconomic expertise to make major contributions in the water resources conservation/development area.

A dynamic strategic planning effort began in the fall of 1992, and a draft plan was developed outlining the means of using ORNL's unique capabilities to address water resource problems of national

significance. We produced several additional documents to support ORNL staff in achieving strategic goals in many areas. The brochure *Water Resources Activities and Goals* provides more detailed support information for the strategic planning effort as well as information for other organizations that ORNL may be working for and with. The brochure lists selected publications related to water resources that have been published by ORNL staff.

Two other documents are primarily for internal use: (1) a directory of organizations listing federal, state, academic, and private organizations that also have an interest in water resources and (2) a brochure that briefly describes ongoing projects that our research staff are currently undertaking and identifies the principal investigators and sources of funding. These documents consolidate information into single sources for dissemination to ESD staff and other organizations.

40 ORNL Provides Support for the National Acid Precipitation Assessment Program

A. W. Renshaw, R. S. Turner, and D. S. Shriner

ORNL is working with the National Acid Precipitation Assessment Program (NAPAP) Office in preparing an operating plan and an assessment plan. NAPAP is required to prepare periodic assessments to comply with the Clean Air Act Amendments (CAAA) of 1990.

To gather information germane to segments of the operating plan, two workshops were held in November 1993:

an Acidic Deposition Workshop in Easton, Maryland, and an Assessment Workshop in Oak Ridge, Tennessee. A Visibility Workshop has also been scheduled for 1994 in Washington, D.C.

NAPAP's Interagency Committee members are evaluating alternative means to assess acidic deposition control effectiveness. Alternatives include integrated assessment models and other less-integrated approaches in which specific aspects of monitoring, assessing, and reducing acidic deposition are left with separate federal departments and agencies.

The value of an integrated assessment model is that it addresses the problem of how one element in human and natural systems qualitatively and quantitatively affects the others. A major concern with this approach is that significant development will be needed to get a scientifically credible and policy-relevant model ready for use. NAPAP's first report to Congress on compliance with the CAAAs of 1990 is due in 1994; the first periodic assessment, in 1996.

41 Relationships Between Columbia River Flows and Juvenile Salmon Survival Are Examined

G. F. Cada, M. D. Deacon,¹ S. V. Mitz,¹ and M. S. Bevelhimer²

One of the most difficult issues facing the Northwest Power Planning Council (NPPC) in its attempts to restore salmon and steelhead to the Columbia River Basin is the question of the amount of stream flow needed to transport juvenile salmon safely downstream to the ocean through a series of dams and reservoirs. Compared

with preimpoundment conditions, lower river flows and decreased water velocities are believed to increase juvenile salmonid travel times to the ocean and to potentially reduce survival.

Because of continuing disagreement about the quantities of flow releases needed to increase smolt survival, the NPPC called for an independent review of literature relating to the influence of water velocity on the survival of juvenile salmon and steelhead from within and outside the Columbia River Basin. Most of the studies reviewed found a positive relationship between outmigration flows and survival, but substantial uncertainty remains about many of the estimates. Early survival estimates made in the basin did not quantify variance, and they contain biases, errors, or evidence of interactions with factors other than water velocity. Other influential factors that were examined in the review include predation, water quality, and the physiological state of the smolts at the time of migration. Our review concluded that despite the limitations of existing data, it remains a reasonable assumption that increasing survival corresponds positively to increasing flow in the Columbia River Basin.

The NPPC will use the report and other input to develop a working hypothesis regarding the flow/survival issue that (1) can provide a basis for inclusion of measures in the NPPC's Fish and Wildlife Program and (2) will be the subject of future research and adaptive management efforts.

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42 Benefits of Fish Passage and Protection Measures Are Examined at 16 Hydroelectric Projects

G. F. Cada, J. E. Francfort,¹ D. W. Jones, D. D. Dauble,² R. T. Hunt,³ and R. J. Costello⁴

As part of its mission to promote environmentally sound hydroelectric development, DOE's Hydropower Program supported a study of the benefits and costs of measures used to enhance upstream and downstream fish passage at dams; operational monitoring data from 16 case study projects across the United States were examined. Measures used to mitigate fish passage impacts included fish ladders and elevators and a variety of intake screens. In seven projects, the passage rates or survival of anadromous fish was successfully increased. Only one of the installations appears to have failed to enhance fish populations, but in the case of other study projects, the benefits are unclear. In six projects, only limited performance monitoring has been completed. Adverse environmental conditions or changing management goals have prevented an assessment of benefits at two other projects.

Costs of the mitigative measures ranged from 0.004 to 1.06 cents/kWh. Benefits of the mitigative measures for most case study projects could be expressed only in terms of the numbers of individual fish that were transported around the dam or protected from turbines; fish population-level effects or economic values were rarely known. The study identified the need for clearly defined mitigation goals, more extensive quantitative monitoring of the measures'

effects on both target and nontarget species, and the development of techniques to express benefits as well as costs in economic terms.

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43 Chinook Salmon Response to Flow Regulation Is Simulated for the Tuolumne River

*H. I. Jager, M. J. Sale, M. S. Bevelhimer,¹
C. C. Coutant, and H. E. Cardwell²*

ESD scientists used a population model to predict the response of fall-run chinook salmon to alternative minimum flow requirements for the New Don Pedro Project, a large multiple-use reservoir on the Tuolumne River in California. The flow schedules that produced the highest numbers of model outmigrants were characterized by relatively high spring flows during outmigration and relatively low winter flows. High spring flows mitigate against high water temperatures in spring.

The first round of model validation conducted included comparison of model results with seining data and sensitivity analysis. The comparison suggested that chinook development, growth, and survival rates are predicted well but that a substantial late-fall run must exist to explain why large numbers of fry emerge in spring. The sensitivity analysis showed the final date of upmigration to be a

sensitive parameter, but later dates were associated with lower numbers of outmigrants.

To address this issue and to improve model predictions, we have added a late-fall run of chinook.

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²*Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee.*

Fish ladders, like the one seen here, are just one of several options being studied to enhance upstream and downstream fish passage at dams. Other options include fish elevators and a variety of intake screens.

44 Mitigation Actions Are Recommended to Protect Chinook Salmon on the Lower Mokelumne River, California

*M. J. Sale, C. C. Coutant, R. D. Perlack,¹
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H. E. Cardwell³*

A Final Environmental Impact Statement was completed by ORNL staff in which modifications to the operation of the Lower Mokelumne River Project are recommended. This existing hydroelectric project is a multipurpose, multireservoir system licensed to the East Bay Municipal Utilities District (EBMUD) and supplies municipal water to Oakland and the East Bay area of California.

Chinook salmon and steelhead trout in the lower Mokelumne River have experienced recent population declines and mortality associated, in part, with discharges from Camanche Dam. Other stresses in the river, such as irrigation diversions and acid mine drainage, have also affected these important fishery resources. The California Department of Fish and Game and the California Sportfishing Protection Alliance have asked the Federal Energy Regulatory Commission to investigate and correct fishery impacts in the river. Subsequently, a wide range of potential mitigation actions were identified as part of this assessment.

All appropriate alternatives were evaluated in terms of (1) the benefits that would be accrued to anadromous fishery resources in the lower Mokelumne River and (2) the costs each action would impose on EBMUD's water supply system. Final recommendations include new minimum

flow and minimum pool elevation requirements at Camanche Reservoir, ramping rates on dam releases, interim attraction and out-migrant pulse flows, instream habitat improvements, and a series of studies, along with monitoring, to determine feasible means for solving off-site fish passage problems.

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45 New Soil-Remediation Technology Is Evaluated for Ecological Risk

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Technological advances in hazardous chemical removal from soils have begun to produce cost-effective methods, but the ecological effects of these treatments have seldom been addressed. For example, on-site composting is a cost-effective method to reduce concentrations of 2, 4, 6-trinitrotoluene and other explosives that contaminate many soils at U.S. Army and DOE munitions installations, but the effects of the residual contamination on terrestrial organisms were not known.

Researchers developed a replicated greenhouse-scale test system to evaluate a suite of responses across taxonomic groups and levels of organization. The responses of two soil invertebrates, three crops, and the existing soil microorganisms

were chosen to form a chain of evidence predictive of effects at higher levels.

During the 6-month study, researchers compared biological responses in two compost types: an uncontaminated reference and the final product from a U.S. Army composting study. The study examined long-term effects on plant growth and physiology, including photosynthesis, root nodulation, and symbiotic N₂-fixation in soybeans; invertebrate growth, reproduction, and population dynamics; and microbial processes, including soil lipid classes associated with microbial and microinvertebrate physiological status.

Compost prepared from the contaminated soil inhibited several aspects of plant performance, but few adverse effects on soil invertebrates were detected. In fact, reproduction was initially much higher in the contaminated soil compost than it was in the reference compost. This indicated that compost differences are not associated with contamination and highlighted a difficulty inherent in the assessment of hazardous waste sites: finding an appropriate reference soil to estimate ecological risk.

Nevertheless, these results, including those from complementary short-term tests, suggest some nonlethal adverse effects from the contaminated-soil compost, primarily on plants. Judicious application of this methodology can provide information on ecological effects by explicitly including measurements at several levels of ecological organization.

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46 Interactive Effects of Ambient Ozone and Climate Are Measured on the Basis of Stem Growth of Mature Forest Trees

S. B. McLaughlin and D. J. Downing¹

Historically, quantifying the effects of air pollution on forest productivity and function was hampered by difficulties in measuring the direct growth responses of mature forest trees to ambient levels of pollutants. Now, however, serial measurements of seasonal variations in the stem expansion rate have been made with a sensitive dendrometer system to estimate the effects of ozone and climate variables on the growth of large trees in an undisturbed forest environment.

Measurements of changes in the stem circumference of 28 mature loblolly pine (*Pinus taeda* L.) trees were made at 138 intervals during a 5-year study conducted on the Oak Ridge National Environmental Research Park. Significant differences in stand stocking and soil fertility were also included in the study design.

Large interannual and intraannual variations in physical climate and ozone were encountered over the study interval. Regression techniques detected the effects of ozone as high-frequency departures from seasonal growth trends. In addition, cumulative ozone exposure significantly influenced year-to-year variations in growth trends on an annual scale. Ambient ozone significantly reduced the stem expansion of mature trees, and effects varied widely among individual trees and years. The rapidity of stem responses to ozone indicated that ozone exposure reduced whole-tree control of water loss. High temperatures and low levels of soil

moisture amplified the effects; this amplification suggests that future climate changes that increase moisture stress will enhance the impacts of ozone on forests. Moreover, ozone-induced changes in whole-tree-water status suggest that tropospheric ozone may modify the gas exchange between the canopy and the atmosphere.

Mechanistic studies are needed to define the physiological processes and potential significance of such changes.

¹*Engineering Physics and Mathematics Division, ORNL.*

47 New Chamber Design Permits Control of Temperature in Global Change Studies

R. J. Norby, N. T. Edwards, J. Riggs, and C. H. Abner

The ability to predict how global climate changes will affect the distribution and productivity of forests is limited by the paucity of data on how the stresses associated with climate change might be alleviated or compensated for in a CO₂-enriched atmosphere.

ESD scientists developed and tested a system for temperature control in open-top CO₂-exposure chambers, as part of an effort to measure the interactive effects of CO₂ and climate variables on the competitive relationships and critical ecosystem processes of tree species under field conditions. The system design is based on evaporative coolers that replace the blower boxes of standard open-top chambers. A feedback control system regulates the heating and cooling of the airstream entering the chambers to

maintain the temperature within the chambers at ambient levels or at ambient levels plus 4°C regardless of weather conditions. Several performance criteria were set: reproducibility, reliability, and consistent attainment of ambient- and increased-temperature regimes without secondary confounding effects.

All of the performance criteria were met in a prototype system, and the experimental system has now been expanded to a fully replicated design in which sugar maple seedlings are being grown under ambient or increased temperatures combined with ambient or increased concentrations of CO₂. The project has been accepted as part of the Global Change in Terrestrial Ecosystems Core Project of the International Geosphere-Biosphere Programme.

48 Workshop Identifies High-Priority Research Areas Related to Belowground Responses to Increased Atmospheric CO₂

E. G. O'Neill, P. S. Curtis,¹ and J. A. Teeri²

Many studies of the effects of increasing atmospheric CO₂ levels point to soil systems as critical sources or sinks in global carbon cycling and as primary determinants of ecosystem response to climate change. A workshop was organized (1) to assess the current level of understanding of belowground responses to increased atmospheric CO₂ and to identify key areas where fundamental knowledge is lacking, (2) to evaluate existing and proposed methods for investigating belowground responses, and (3) to identify high-priority research topics to improve our understanding of belowground responses to increased CO₂ and the consequences for

These open-top CO₂-exposure chambers, designed to allow temperature control, are being used in studies attempting to predict how global climate changes will affect forest productivity and carbon storage.

entire ecosystems. The workshop—jointly organized by researchers from ESD, Ohio State University, and the University of Michigan Biological Station (UMBS)—was held May 30–June 2, 1993, at UMBS in Pellston, Michigan. Workshop participants identified carbon flux dynamics as the most important research priority, beginning with a reasonable estimate of carbon input through increased root turnover and exudation and including an assessment of carbon allocation to short- vs long-lived soil carbon pools. Other high-priority research areas are (1) CO₂ enrichment

effects on plant symbionts and pathogens, including feedbacks to community and ecosystem processes; (2) rates of microbially mediated soil nutrient transformations and the potential for long-term changes in nutrient availability; and (3) interactions of increased atmospheric CO₂ with other environmental variables, such as changes in amount or temporal patterns of water availability and potential temperature increases. The workshop will help provide structure and direction for the next decade's research into the effects that elevated CO₂

and climate change have on belowground systems. The critical nature of global change issues and the limited amount of research funds make the outcome of the synthesis and planning workshop important to researchers, funding agencies, and policy makers.

¹Ohio State University, Columbus.

²University of Michigan Biological Station, Pellston.

David Bransby of Auburn University stands in a field of switchgrass, a tall prairie grass that has been selected by the Biofuels Feedstock Development Program as a promising energy crop from which a renewable source of transportation fuel and biomass-generated electricity could be derived.

49 Physiological Studies Support the Development of Switchgrass as Herbaceous Energy Crop

S. D. Wullschleger

Widely recognized as an important perennial component of the tall-grass prairie and as a productive, warm-season forage, switchgrass (*Panicum virgatum* L.) has been selected by DOE's Biofuels Feedstock Development Program as a promising cellulosic energy crop from which a renewable source of transportation fuel and biomass-generated electricity could be derived. Little information is available, however, on this crop, and quantification is needed on the extent of genetic diversity that exists within readily available germ plasm for traits associated with superior plant productivity. Such information would be useful in future crop management and breeding activities.

A series of multisite field studies (in Texas, Tennessee, and Virginia) have been conducted to assess whether rates of photosynthesis differed among switchgrass varieties. Early in the season, photosynthetic rates were consistently 10 to 15% higher for the lowland varieties (e.g., Alamo, Kanlow) than they were for the upland varieties (e.g., Blackwell, Cave-in-Rock, Shelter). Later in the growing season, photosynthetic rates of upland varieties surpassed those of the lowland varieties. This transition coincided with a severe midseason drought, during which photosynthesis declined equally in all varieties.

Whether this reversal reflects a greater capacity of some varieties to recover from

drought (possibly because of osmotic adjustment or shifts in carbon allocation during stress), favoring increased rooting and water uptake poststress, is not known. Answers to these and other questions will come only as researchers learn more about the physiological and morphological traits that contribute to high yield and/or yield stability for this perennial forage and biofuels crop.

50 Threatened and Endangered Animal Species on ORR Are Surveyed

C. A. Gabrielsen

The Oak Ridge Reservation (ORR) provides habitats suitable for federally listed and state-listed threatened and endangered animal species. To maintain compliance with the Federal Endangered Species Act, current information on the animals' status within ORR is necessary.

A substantial amount of existing animal survey data reveals that nearly 50 listed species are permanent, potential, or transitory residents of ORR. However, many of the field surveys locating threatened and endangered animal species on ORR were conducted before 1980. Many changes have occurred at ORR, and habitats have been substantially altered; therefore, the lists need to be updated.

Data necessary for compliance with federal and state regulations regarding the threatened and endangered animals on ORR must be collected. In response to this need, the Environmental Restoration Remote Sensing and Special Surveys Program has initiated a Threatened and Endangered Animal Species Survey Project. A 2-year work plan outlining a

study, including field surveys, has been developed. Fish and Wildlife Services has reviewed the plan, and DOE has approved it. Land-use decisions made without current information could destroy necessary habitats and result in the inadvertent extirpation of a federally listed or state-listed animal species. Habitat information collected during this study will facilitate the making of informed decisions regarding land use.

51 ORR Resource Management Organization Is Restructured

P. D. Parr

The Oak Ridge Reservation (ORR) Resource Management Organization (RMO), established in 1982, was restructured and chartered to reflect changes in authority, management, and mission. The mission is to oversee and coordinate management of ORR resources, including land, buildings, structures, and infrastructure; wetlands; floodplains; rare or endangered plants and animals and their habitats; archaeological, cultural, and historical sites; forest; fish; wildlife; air; soils; geologic features; surface and subsurface water; and research areas. Defined roles are (1) to assist and advise Energy Systems and DOE Oak Ridge Operations (DOE-ORO) management in planning for the effective use and development of resources on ORR, as well as conservation, protection, and responsible stewardship; (2) to review documents and proposals pertaining to ORR resources and land to ensure their completeness, accuracy, and compliance compatibility with Energy Systems and DOE objectives; and (3) to assist DOE-ORO and Energy Systems management, as requested,

in assessing and coordinating proposed actions and land use by other DOE contractors, federal agencies, state and local governments, and the private sector when such actions and land use could potentially impact ORR resources.

The RMO consists of the RMO Council and the RMO Committee. The committee is divided into three working groups—administrative, natural, and functional—and consists of experts representing various ORR resources. Procedures describing the process that must be followed to obtain RMO approval for any changes in land or facility use or activities that impact ORR resources are now in the *Property Procedures Manual*.

52 Population Model Helps in Study of Habitat Selection by Smallmouth Bass

H. I. Jager, M. J. Sabo,¹ D. J. Orth,¹ and W. Van Winkle

Three factors believed to influence habitat selection by smallmouth bass in streams are (1) profitability, in terms of foraging success; (2) energetic costs, particularly when maintaining position in fast currents; and (3) predation risk. Scientists used a population model that assumes that fish optimize the ratio of growth to predation risk by leaving locations that have a lower-than-expected ratio.

Model simulations of juvenile smallmouth bass in a reach of the North Anna River, Virginia, predicted fish preferences for depths and velocities with and without spatial heterogeneity in each of the three factors listed. Model results were compared with observations of habitat preferences in the field and video

observations of profitability (i.e., number of bites) and energetic cost (i.e., number of tail beats). The field observations suggested that profitability was more important than energetic cost in determining habitat choice for this life stage, but they did not address the importance of predation risk.

None of the model scenarios produced habitat preferences identical with those observed in the field, but three of the scenarios came closest: (1) spatial heterogeneity in prey only, (2) spatial heterogeneity in energetic costs only, and (3) all three factors together. Another interesting model result highlighted the importance of prey refuges. Twice as many survivors were noted in simulations with spatial heterogeneity in predation risk, even though the average risk was the same in both cases. At the population level, the researchers hope to clarify the role that regulated stream flow and fish density play in strategy choice.

¹Virginia Polytechnic Institute and State University, Blacksburg.

53 Individual-Based Model Sheds Light on Behavioral Strategies of Trout

H. I. Jager, W. Van Winkle, and B. D. Holcomb¹

Two behavioral strategies have been observed in trout studies in streams: “movers” forage on benthic prey near the bottom of the stream and do not defend a foraging station; “stayers” tend to be larger in size, defend a foraging station, and spend more time foraging on drifting prey. Our individual-based and spatially explicit model of a sympatric trout population will

allow us to study these strategies. The foraging submodule identifies a velocity threshold above which drift foraging is more profitable than foraging on benthic prey. The simulated choice of foraging strategy can influence the energetic costs incurred by the model trout—its foraging success, growth, predation risk, movement history, and patterns in habitat use.

By keeping track of the simulated foraging behavior and habitat selection of individual model trout, researchers can predict whether individual fish continue to use one strategy for a significant length of time, and the consequences of strategy choice on survival and long-term reproductive success can be evaluated. At the population level, researchers hope to clarify the role of

regulated stream flow and fish density in strategy choice.

¹*Electric Power Research Institute, Oak Ridge, Tennessee.*

54 Increases in Global Temperature Affect the Release of Nitrate in Southern Appalachian Spruce-Fir Ecosystems

J. D. Joslin,¹ M. H. Wolfe,¹ C. T. Garten, and S. B. McLaughlin

The possibility of accelerated decomposition of organic matter and accompanying nitrate releases in nitrogen-

Researchers Dev Joslin and Mark Wolfe are examining the effects of temperature increases on nitrogen-saturated forests. This graph shows the mean concentrations of nitrate, Ca, Al, and Mg in soil solutions collected from lysimeters placed in both sunny and shady areas. The significant increase in solution nitrate concentration is consistent with the hypothesis that organic matter decomposition and nitrification are accelerated by elevated soil temperatures.

saturated ecosystems is a concern raised in response to predictions of global temperature increases from CO₂ emissions. Possible effects of excess nitrate production on ecosystems include elevated concentrations of soil solution aluminum, increased leaching of base cations from soil, elevated levels of aluminum and nitrate in streams, and species shifts in plant communities.

In a recent uncontrolled pilot study on a nitrogen-saturated spruce-fir forest in Southern Appalachia, researchers compared the soil solution on the sun side of a clearing with that on the shaded side. Significantly greater nitrate leaching accompanied the higher soil temperature (+2°C).

Researchers are examining the effects of temperature increases on nitrogen-saturated forests in a controlled field experiment using a previously tested passive solar "mini-greenhouse" to elevate soil temperature ~2°C (simulating postulated global warming). The potential impacts of changes in tree nutrition, stand biogeochemical cycling, and streamwater chemistry will be evaluated.

¹Tennessee Valley Authority, Knoxville.

55 Genetic Diversity Among Aspen Populations Increases as a Result of Seedling Regeneration After the 1988 Fires in Yellowstone National Park

G. A. Tuskan and M. G. Turner

Aspen (*Populus tremuloides* Michx.) in the Intermountain West region of North America typically regenerates stands through root sprouting and clonal

propagation. A single mature stand of aspen can occupy several hectares through this process. Before the fires of 1988 in Yellowstone National Park (YNP), aspen occurred in the park solely in mature, vegetatively propagated stands. After the 1988 fires, aspen seedlings were recorded for the first time in the park's 116-year history. This unique event provided an opportunity to study the effects of catastrophic environmental change on a species' genetic diversity.

The objectives of this project were to quantify the amount of genetic diversity within and among mature aspen populations in YNP and to determine whether aspen seedlings seen growing after the fires were direct progeny of the mature stands that existed before the fires. To accomplish these objectives, a polymerase chain reaction-based, randomly amplified polymorphic DNA (RAPD) procedure was used to derive estimates of genetic diversity. These genetic markers indicated that seedlings within geographic areas were more similar to each other than to neighboring seedling stands; that mature stands clustered as discrete clades, separate from the seedling clusters; and that there was no relationship between the geographic origin of mature stands and the genetic diversity among these stands. The RAPD markers also revealed that the mature stands were clonal in nature yet contained as many as ten and as few as three separate genotypes, suggesting that the mature stands had existed in YNP for a time long enough to accumulate numerous somatic mutations before the fires.

In addition, genetic diversity was substantially increased as a result of seedling regeneration after the fires. The processes that (1) eliminate genetic variability in newly regenerated seedling populations, leading to clonally

propagated mature stands, and (2) allow the accumulation of genetic variants within these mature stands have not yet been described.

Understanding these processes has implications for predicting a species' ability to respond to global climate changes.

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Environmental Analyses

Introduction

The Environmental Analyses Section of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) focuses on interdisciplinary analysis and assessment of environmental problems. In this context, the section develops problem-solving tools, such as methodologies, databases, and information and policy analyses. The section deals with environmental issues that range from those at individual sites and regional landscapes to those of national and global concern. The staff provide a variety of sponsors technical assistance for the development of environmental management and regulatory policies. Technical information and analyses produced by the section also serve in a broader capacity—as a resource for the scientific and technical communities. Section sponsors include the U.S. Department of Energy (DOE) Assistant Secretary for Environment, Safety, and Health; the DOE Assistant Secretary for Environmental Restoration and Waste Management; the DOE Office of Health and Environmental Research; the U.S. Environmental Protection Agency (EPA); the U.S. Air Force; the National Oceanic and Atmospheric Administration; the Martin Marietta Energy Systems, Inc., Environmental Restoration Program; and the Bonneville Power Administration.

Environmental Assessment

The goal of the Environmental Assessment Group is to apply state-of-the-art assessment tools to complex issues at individual facilities and at sites that are large geographically and to issues that are programmatic in scope. The group

prepares impact analyses for DOE, the Federal Energy Regulatory Commission, the Nuclear Regulatory Commission, and the U.S. Department of Defense as part of agency compliance with the National Environmental Policy Act (NEPA). Impacts on terrestrial and aquatic ecological resources, on land and water use, and on water quality are assessed for environmental impact statements (EISs) and related documents. Staff members provide technical reviews and analyses of NEPA documents for the DOE Office of NEPA Oversight, as well as technical support for the EPA Office of Federal Activities. As members of audit teams, staff in the group also help assess NEPA compliance at DOE facilities. In addition, the group provides NEPA training for DOE managers.

During FY 1994, the group participated in the preparation of nine EISs and ten environmental assessments, as well as contributed to the preparation of other materials, such as biological surveys, ecological risk assessments, and environmental reports for use in preparing NEPA documents. Staff provided comments on a monthly average of four to five documents covering a wide range of issue areas, including floodplains and wetlands, transportation, historic and archaeological sites, socioeconomics, accident potentials, water and air quality, human health, impacts on ecological resources, and radiological impacts. Major intensive review activities were conducted for the spent nuclear fuel-Idaho National Engineering Laboratory EIS, a series of NEPA documents for the Savannah River Site, a series of NEPA documents for the Formerly Utilized Sites Remedial Action Program, and the Foreign Research Reactor EIS.

Environmental Compliance

The Environmental Compliance Group provides information resources and regulatory expertise to assist various sponsors in their efforts to comply with federal and state environmental laws and regulations. The group tracks, monitors, and reports new environmental legal and regulatory initiatives; provides up-to-date reference materials on all major federal environmental laws; and uses scientific, engineering, legal, and regulatory expertise to analyze regulatory issues, develop environmental compliance methodologies, and assist the DOE Office of Environmental Guidance in creating and implementing environmental policy and guidance. Other important activities include developing and conducting courses on environmental laws and regulations for DOE, Energy Systems, and other sponsors. Staff also conduct environmental compliance audits at U.S. Air Force bases and other federal facilities. In addition, the Environmental Compliance Group serves as a resource for regulatory technical assistance to ORNL and the Energy Systems Environmental Restoration Program.

In FY 1994, the group developed numerous guidance documents on subjects that included the EPA's off-site rule under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); continuous releases of CERCLA hazardous substances; and DOE's responsibilities under the National Historic Preservation Act. Staff developed and presented new training workshops, including a 2-day overview of the Resource Conservation and Recovery Act and a 1-day introductory course on defining hazardous waste. The group also provided newsletters, reference books, and regulatory tracking services for DOE and contractor staff across the nation. Environmental Compliance Group staff

conducted numerous environmental compliance assessments for the Air Combat Command (ACC) of the U.S. Air Force, and they prepared for and presented to ACC personnel a 5-day course on hazardous waste management, the most in-depth training ever developed by the group. In addition, group staff prepared Environmental Compliance Assessment System manuals for the U.S. Army, Europe, to use in evaluating compliance at its European bases in Germany, The Netherlands, Italy, and other countries.

Environmental Risk

The Environmental Risk Group devises methods for the quantitative assessment of environmental risks; applies these methods to local-, regional-, and national-scale environmental problems; and provides regulatory agencies with guidance on the uses of environmental risk assessment. The group defines and measures the health of ecological resources, extrapolates test data from laboratory to field and from individuals to populations and ecosystems, quantifies ecological risks at the watershed and landscape levels, and predicts the movement of contaminants through food chains. Sponsors include EPA, DOE, the Energy Systems Environmental Restoration Program, the U.S. Department of Defense, and the Bonneville Power Administration.

In FY 1994, members of the Environmental Risk Group developed a monitoring and assessment program for the Oak Ridge Reservation (ORR) to evaluate impacts that DOE facility operations have on wide-ranging species. In addition, the group revised and updated an approach and strategy for assessing ecological risks on ORR. Staff also revised and updated toxicological benchmarks for wildlife, aquatic biota, sediment-associated biota, plants, and soil invertebrates and heterotrophic processes, as well as

developed a database to facilitate use of the benchmarks. The group completed baseline ecological risk assessments for two operable units on ORR; for the Portsmouth, Ohio, facility; and for the Paducah, Kentucky, facility.

Global Trace Gas and Climate Information Systems

The Global Trace Gas and Climate Information Systems Group provides the information, data, and analytical capabilities essential to performing comprehensive, resource-intensive regional and global evaluations of increases in radiatively active trace gases (also called greenhouse gases) in the atmosphere and the potential effects of such changes on environmental and societal resources. The group employs state-of-the-art information, data management, and analytical techniques to ensure proper exchange of information and data between researchers and a diverse user community of scientists, policymakers, educators, students, and corporate officials. To achieve the careful balance of information and data support needed to meet project requirements, the group relies on information theory, computer science, geographic information systems, library science, telecommunications, scientific visualization, statistical science, and data management.

The group produces journal articles, newsletters, brochures, ORNL and DOE

reports, and fully documented numeric data packages and computer model packages. The largest function of the group is to operate the Carbon Dioxide Information Analysis Center (CDIAC), in support of the DOE Global Change Research Program, and the World Data Center-A for Atmospheric Trace Gases, which is part of the World Data Center System coordinated by the International Council of Scientific Unions. The Global Trace Gas and Climate Information Systems Group also analyzes the potential effects that changes in climate and sea level would have on environmental and societal resources.

During FY 1994, the group staff, in their role as operators of CDIAC, published four numeric data packages covering (1) long-term climate data from the former U.S.S.R., (2) oceanic carbon chemistry, (3) carbon emissions from land-use change, and (4) data for assessing the vulnerability of the U.S. Gulf Coast to sea-level rise. Among the many reports and other documents published, the most important were *Trends '93: A Compendium of Data on Global Change* and *Direct Effects of Atmospheric CO₂ Enrichment on Plants and Ecosystems: An Updated Bibliographic Data Base*. CDIAC staff filled more than 7000 information requests from more than 2700 individuals in 67 countries and responded to approximately 1100 requests for numeric data packages and computer model packages.

Technical Summaries

56 Potential Ecological Impacts of Chlorofluorocarbon Replacement at DOE's Gaseous Diffusion Plants Are Cumulative and Global

J. A. Dickerman

While preparing a National Environmental Policy Act (NEPA) assessment for DOE's two gaseous diffusion plants, ESD scientists assessed the cumulative impacts of coolant usage in the uranium enrichment process. This included (1) the current coolant, chlorofluorocarbon (CFC-114), which leaked over 272,400 kg in 1992 and which potentially contributes to stratospheric ozone depletion, and (2) an interim replacement coolant, perfluorocarbon (PFC), an extremely powerful heat absorber that contributes to global warming (with four times the warming potential of the CFC-114 coolant) but one that is not an ozone-depleting chemical. Both ozone depletion and global warming are global issues with the potential of having a cumulative impact on ecological resources.

A review of the ecological literature on ozone depletion and global warming was presented in tables that identified ecosystem types, anticipated ecosystem impacts, and listed the causes of the impacts. Potentially, the largest impacts from stratospheric ozone depletion, to which CFCs contribute, are from UV-B-induced mutagenesis and immune function suppression in mammals. The largest potential impacts from global warming, to which PFCs contribute, involve the rate at which climatic patterns of

temperature and precipitation may change (10 to perhaps 100 times faster than in the historic past) and a possible result of substantial shifts in biome distribution.

The NEPA assessment showed that a proposed action alternative that minimized both CFC and PFC releases would minimize potential environmental impacts. That alternative was an aggressive loss minimization alternative, one in which funds proposed for the interim replacement of CFC-114 activities would be used instead to reduce leakages of CFC-114 (about 4% in 1992) to about 0.7% per year. This NEPA assessment considered a range of alternatives which, in this case, showed that the environmentally motivated proposed action (i.e., a mandated interim coolant replacement) was not actually the most environmentally supportive alternative.

57 Environmental Impacts of PCFB Technology Are Expected to Be Smaller than Those of Conventional Technologies

W. E. Schramm, G. K. Eddlemon, R. Miller, M. Socolof, C. C. Trettin, and B. M. Vogt¹

DOE's Clean Coal Technology Program promotes more efficient, reliable, and environmentally responsive coal use and environmental control technologies. The program consists of cost-shared demonstration projects. The potential environmental impacts of demonstrating one such technology, Pressurized Circulating Fluidized Bed (PCFB) combustion, were analyzed. Alternatives assessed included (1) no project and (2) a project of equal generating capacity using conventional generating and control

technology. The proposed project would install PCFB technology in an inactive coal-fired generating facility, the Des Moines Energy Center, Pleasant Hill, Iowa.

Compared with conventional combustion and control technologies, PCFB technology would likely increase combustion efficiency as well as reduce costs, emissions, and waste disposal problems. The greater efficiency of PCFB in comparison with conventional technology is expected to reduce coal consumption per unit of electricity generated. Compared with conventional combustion technology without controls, PCFB is expected to reduce emissions of sulfur dioxide (SO_2) by 90% and oxides of nitrogen (NO_x) by 70%. These rates exceed reduction rates currently achievable by conventional control technologies (e.g., SO_2 reductions of 70 to 90% for wet lime/limestone scrubbers, depending on type of coal, and NO_x reductions of 45 to 60% for low NO_x burners).

Additionally, PCFB technology would, unlike conventional control technologies, produce a dry solid waste that is easily disposable. Analyses indicate that operational impacts of the proposed project on air quality, surface water, groundwater, and waste management would generally be smaller than those of conventional technology. This is the case for two reasons: (1) the combustion process yields flue gas containing fewer pollutants, and (2) increased process efficiency reduces fuel and other resource demands as well as reducing emissions and wastes. Some impacts—including habitat loss from site redevelopment, socioeconomic effects, and project-related, airborne particulate concentrations—are similar whether PCFB or conventional technology is used. Particulate levels are similar because both

PCFB and conventional combustion technologies use a baghouse for particulate control.

Assessing the impacts of proposed clean coal technologies assists DOE in making environmentally sound decisions concerning program implementation.

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58 ESD Prepares an Environmental Assessment Sourcebook for EPA

L. L. Sigal

To meet an increased demand by localities, states, and foreign governments for information on the environmental assessment (EA) process, the U.S. Environmental Protection Agency's (EPA's) Office of Federal Activities asked ESD staff to prepare an EA sourcebook. The sourcebook is organized around the major activities required for a successful EA. These include initiation, scoping, assessment, decision making, and postdecision analysis. In each major section, activities are discussed, and the needs, tools, issues, linkages, and key references for those activities are described. In addition, attachments provide information that is not often readily available, particularly to those in foreign countries or those just starting EA programs.

A computer software supplement to the sourcebook is also included. Because the generic elements of the EA process are emphasized, the sourcebook could be used by any group charged with the responsibility of providing adequate

environmental information to decision makers for projects and programs that may directly or indirectly impact the environment.

59 ORNL Technical Review Enhances the Quality and Credibility of the DOE Spent Nuclear Fuel and Idaho National Engineering Laboratory Environmental Impact Statement

E. D. Smith, L. L. Sigal, and G. K. Eddlemon

The DOE environmental impact statement (EIS) on programmatic spent nuclear fuel (SNF) management and Idaho National Engineering Laboratory (INEL) environmental restoration and waste management is a complex, high-profile document, prepared under exceptional time constraints in response to a court order that mandated its schedule and certain of its contents. The EIS has two components: (1) a programmatic EIS concerned with the entire program of DOE management of DOE and U.S. Navy SNF and (2) a site-specific EIS concerned with a 10-year program of waste management, SNF management, and environmental restoration projects at INEL.

A major purpose of the EIS is to respond to stakeholder concerns about the impacts of transporting SNF to INEL and managing it there. DOE also had to reexamine its entire SNF management program following the 1992 phase-out of DOE SNF reprocessing and a 1993 DOE study that identified vulnerabilities in DOE's management of SNF.

A passerine (songbird) nest in a hybrid poplar tree located on a plantation in Minnesota. Scientists are studying the use of large-scale, commercial energy crop plantings by both resident and migratory bird species.

ORNL, in support of the DOE Office of NEPA Oversight, conducted a comprehensive technical and National Environmental Policy Act-compliance review of the prepublication draft EIS. To provide expertise in all relevant technical areas, ESD organized a review team of more than 20 staff members drawn from 5 ORNL divisions. Despite exceptional time constraints (in the first review cycle,

reviewers had only about 3.5 working days to evaluate thousands of pages of material), ORNL reviewers contributed hundreds of comments and recommendations on technical validity of the data and analyses, major omissions and inconsistencies, significant environmental issues, organization of the EIS, and presentation of information. Three ESD staff members participated in comment resolution meetings in which EIS preparers, DOE managers, and reviewers worked together to solve problems identified during the review.

As the only comprehensive, independent technical review before publication, the ORNL review significantly enhanced the quality and credibility of the draft EIS, which was issued for public comment June 30, 1994. The review effort demonstrated ORNL's technical depth, breadth, and familiarity with DOE sites, facilities, and programs, as well as the staff's ability to deliver high-quality work under difficult time constraints.

60 Large-Scale Hybrid Poplar Plantings Provide the Opportunity to Continue Addressing Environmental Research Questions

V. R. Tolbert

The Biofuels Feedstock Development Program's (BFDP's) scale-up of energy crop production systems reached a major milestone in mid-June with the completed planting of the first large-scale hybrid poplar plantations on 1000 acres in Minnesota. The plantings, which ranged in size from 25 to 160 acres, should

provide answers to questions regarding the environmental effects of the large-scale commercialization of energy crops compared with results obtained from the earlier BFDP small-scale demonstration plots (5 to 20 acres).

University of Minnesota scientists will conduct the environmental research conceived and sponsored by ORNL's BFDP, comparing utilization of these larger plantings by both resident and migratory bird species with utilization of forest, grassland, and row crop areas of similar size. The results of this large-scale study will be compared with results obtained during the past 2 years from small-scale plantings. Those studies showed that energy crop plantations can contribute to bird biodiversity by providing more diverse habitats for forest and edge species in areas that are typically dominated by row crops and by Conservation Reserve Program grasslands. Studies of small mammals will also be expanded to include these large-scale plantings to address further habitat utilization and movement patterns between energy-crop plantations and forest or grassland areas.

BFDP is also sponsoring research using these large-scale plantings to address soil carbon, groundwater depletion, and the chemical fate of pesticides, herbicides, and nutrients beneath the individual plantation sites compared with that of row crops, grasslands, and forest lands of equal size. This research is designed to determine the potential for carbon sequestering by energy crops and the effects of energy crop production on the environment. Large-scale plantings offer a unique opportunity for BFDP to evaluate the role of scale and environmental effects in efforts to successfully commercialize energy crops.

61 Programmatic Environmental Impact Statement Helps USAP Minimize Impacts, Improve Planning, and Comply with National and International Mandates

J. W. Webb

Environmental analysts in ESD and the Energy Division of ORNL are helping the U.S. Antarctic Program (USAP) prepare a programmatic environmental impact statement (PEIS). The analysts have first-hand knowledge of research and support activities through visits to Antarctica in 1992-93 and through the preparation of a variety of environmental documents about the activities (e.g., using explosives, drilling, using research balloons, preparing a new ice runway, relocating existing runway facilities, building new facilities).

Key questions to be addressed in the impact statement include whether (and how much) to augment financial support and scientific staff in Antarctica, how to minimize fuel use and waste and to optimize energy efficiency, whether (and how) to construct a new South Pole Station and other new facilities on the continent, whether (and how) to treat human waste at McMurdo Station, and how to protect the continent's fragile and unique environment from the impacts of program activities.

Antarctic research for the United States must comply with U.S. and international environmental review requirements, such as the National Environmental Policy Act and the Antarctic Treaty. The PEIS with its supporting analyses will provide USAP decision makers with information

that will help determine the direction of future research.

62 Legal and Regulatory Interpretations of "Adverse Ecological Effects" Are Identified

*W. S. H. Ramsey, P. M. O'Connell,¹
J. S. Fackenthal, C. G. Heckman, and
C. F. Baes III*

In its second generation, the National Acid Precipitation Assessment Program (NAPAP) must pose questions about the effectiveness of current acid precipitation controls in the context of the Clean Air Act, as amended, and its implementing regulations. One legislative mandate of NAPAP is to determine the reductions in acid deposition needed to prevent adverse ecological effects. However, the phrase "adverse ecological effects" is not defined.

A team of environmental regulatory and legal analysts reviewed federal environmental laws and regulations and case law to determine congressional, agency, and judicial views of this and similar phrases. The phrase "adverse ecological effects" has been variously interpreted in environmental statutes, regulations, and case law. Although no single definition was found, legal and regulatory interpretations identify elements that are central to assessing ecological effects. These elements include (1) the toxicological hazard potential to select organisms, (2) loss of the use value of an ecosystem-dependent resource, and (3) endangerment of a species or natural landmark of national significance.

Such interpretations (e.g., natural resource damage assessment and injury

determinations) also identify methods accepted in regulatory contexts for determining that an "adverse ecological effect" has occurred. Knowledge of these components and methods may be used in determining whether "adverse ecological effects" caused by acid precipitation have been prevented by regulatory controls on air emissions. This legal and regulatory review supplements technical approaches to defining ecological terms by identifying interpretations accepted by Congress and agencies implementing the environmental laws.

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63 Careful Attention to Environmental Issues Will Likely Result in a Higher Level of Production and Use of Biomass as Fuels in the Future

M. S. Salk and G. Marland

The viability of future technologies will depend not only on economic, technical, and political considerations but also on the need to maintain a sustainable environment. Thus, as part of a situation analysis, current environmental issues were reviewed to determine those most likely to have either positive or negative affects on

Natural resources, such as this wetland, and their associated endangered species can be preserved through the enforcement of environmental regulations. The Environmental Compliance and Assessment Group is helping the U.S. Army, Europe, to document such regulations to better protect the resources that they use.

the future use of biomass as fuel. Those likely to have such impacts include air pollution, global climate change, quality and quantity of surface water and groundwater, soil degradation, deforestation, preservation of unique habitats, maintenance and enhancement of biodiversity, prevention of major extinctions, solid and hazardous wastes, refuse removal from land, fuel spills, and the misuse of fertilizer and pesticide.

As with any energy technology, interactions between and among these factors, or interactions between them and other environmental stresses, may result in cumulative environmental effects. The issues that prove most significant will be closely related to site-specific characteristics (e.g., soil type, water quality). Opportunities for greater use of biomass as fuel will result from its positive effects on air quality and other environmental issues, whereas some issues, such as the potential misuse of fertilizers and pesticides (a concern for all farming operations, not just those growing biomass for fuel), may reduce the potential use of biomass. A higher level of environmentally compatible production and use of biofuels in the future will result from careful attention to measures that either minimize potential negative impacts or maximize positive ones.

64 Environmental Compliance Group Assists in Overseas Compliance

C. F. Sigmon, A. A. Aramowicz Smith, R. L. Jolley,¹ M. L. Bell, J. S. Fackenthal, W. S. H. Ramsey, and M. J. Rooks²

Federal agencies that have activities overseas must comply with applicable host

nation requirements in addition to U.S. government requirements that might apply overseas. Determining the applicability of requirements and evaluating compliance with them are difficult tasks. Determining the applicability of overseas requirements depends on sponsor interpretations of applicability, sponsor priorities, and limitations on resources of U.S. entities overseas.

ESD's Environmental Compliance Group (ECG) assists the U.S. Army, Europe (USAREUR) in tackling the difficult challenge of overseas compliance by developing compliance evaluation tools for the Army's Environmental Compliance Assessment System (ECAS). ECAS documents are assessment tools to guide personnel conducting environmental audits of USAREUR installations. Thus, ECG assists USAREUR in ensuring that its overseas activities protect human health and the environment and that they do not violate the laws of host nations.

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65 Model of Nitrogen Outputs from Forested Watersheds in the Chesapeake Bay Drainage Basin Can Be Improved

C. T. Hunsaker, C. T. Garten, and P. J. Mulholland

The Chesapeake Bay Agreement between several states and federal agencies requires that by the year 2000, controllable phosphorus and nitrogen that enter the tidal bay be reduced by 40%. To attain this goal, the Chesapeake Bay Program

needs accurate estimates of nutrient loadings, including atmospheric deposition, from various land uses. The current form of the Chesapeake Bay Watershed Model, which uses the Hydrologic Simulation Program, overestimates nitrate concentrations and outputs but performs adequately for ammonium concentrations.

We reviewed the literature on forest nitrogen pools and fluxes and identified nitrogen data from research catchments in

the Chesapeake Basin for model development. Based on this information and on expert opinions elicited during a workshop, our recommendation was that a nitrogen module for forests be added to the existing Watershed Model in an effort to improve estimates of nitrogen output to the bay. We specified the structure of the nitrogen module, possible functional forms for fluxes, and watersheds with adequate data for model parameterization.

A collection of numeric data on CD-ROMs produced by CDIAC. The two-disc set contains approximately 1 gigabyte of global change data frequently requested by researchers as well as by the policymaking, education, and corporate communities. The data are also available on the Internet.

66 Ecoregions Effectively Characterize Landscape Pattern for Regional Assessments

*C. T. Hunsaker, R. V. O'Neill,
B. L. Jackson,¹ and S. P. Timmins²*

The characterization of landscape patterns is important for long-term ecological monitoring and assessment because it may be an integrative indicator of ecosystem condition at the regional scale. The premise for regionalization, regardless of the purpose, is that the characteristics of the region are more homogenous within the region than they are outside the region.

The way in which we measure landscape pattern is a function of many attributes, but three are especially important—data resolution, geographic extent, and number of land cover types. Thus, an important decision is the selection of the assessment region; options are ecologically based or politically based (i.e., aggregations of states, or counties).

This study evaluates the behavior of several landscape metrics for large geographic areas in the conterminous United States. Behavior includes distribution of values across the potential range of metrics, independence among metrics, and the ability to discriminate between landscapes on the basis of land cover data (urban, agricultural, rangeland, forest, wetland, barren land, tundra, snow or ice, and water).

The aggregated ecoregions as defined by J. Omernik of the U.S. Environmental Protection Agency in Corvallis, Oregon, and the Standard Federal Regions (aggregations of states) were evaluated using Advanced Very High Resolution

Radiometer imagery at 1-km² resolution. Metrics include proportion of landscape in a land cover type and the number of edges between types, as well as integrative measures such as patch size distribution, shape complexity of patches, and dominance and fragmentation of the landscape.

Integrative landscape metrics, which characterize patterns for all land covers in a single value, can discriminate among different landscape types; however, their discriminating power is not maximized for large regions. Ecoregions maximize the homogeneity of land cover types within a region and have a wider range of metric values than do Standard Federal Regions; thus ecoregions are the most useful for regional monitoring and assessment.

Basic investigations such as this are critical for designing programs to assess ecosystem condition and developing good management plans.

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67 A 1/16 Sample of the United States Cannot Serve as the Sole Basis for Monitoring Landscape Pattern

*C. T. Hunsaker, R. V. O'Neill,
B. L. Jackson,¹ S. P. Timmins,² and
D. A. Levine³*

Current research suggests that metrics of landscape patterns may reflect ecological processes operating at different scales and may provide an appropriate indicator for monitoring regional ecological changes. Landscape

condition is a resource of interest to the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP).

Investigators have examined the extent to which a 1/16 areal subset of the landscape, using equally spaced 40-km² hexagons, can characterize the spatial extent of land cover types and landscape pattern (number of types of edges, patch shape complexity, dominance, and contagion). This type of equal area support base is being used for EMAP's field monitoring of forests and surface waters.

For 200-m resolution data, the hexagon subset gives a reasonable estimate of overall landscape cover but may not be adequate for monitoring uncommon land cover types such as wetlands. For agriculture and forest, the proportion of the full landscape analysis units is only outside the 95% confidence interval of the hexagon estimate 4–8% of the time, whereas the proportions for wetlands and barren areas are outside the confidence interval 11–34% of the time.

Also, the hexagon subset does not appear adequate as the sole basis for monitoring landscape pattern. The values for contagion, dominance, and shape complexity calculated on the full landscape units are outside the 95% confidence interval of the hexagon estimate 27–76% of the time.

Other statistical analyses include regressions between full landscape and hexagon subsets, mean differences and standard errors, along with tests on the number of positive and negative values, and percentage of relative error of hexagon estimates. Two or more types of

land cover data at different spatial resolutions will likely be required for adequate monitoring of landscape pattern change for the nation.

Research continues on methods of determining the appropriate sample units (including size, shape, and distribution) for estimating landscape pattern and the selection of adequate indicators of landscape pattern for long-term monitoring of ecological condition (i.e., sensitivity to change).

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68 Landscape Status and Trends Are Quantified at the Regional Scale

*R. V. O'Neill, C. T. Hunsaker,
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J. D. Wickham*

Remotely sensed data for the Southeastern United States (Standard Federal Region 4) were used to develop an approach for reporting landscape patterns in a large, heterogeneous region. The study indicated that landscape indices are more meaningful and interpretable if Region 4 is disaggregated into three component ecoregions, each representing an area with relatively homogeneous ecological processes. The analyses also revealed that some of the available indices are not independent (i.e., they may provide redundant information about some aspects of pattern).

The indices are also sensitive to the calculation scale (i.e., the unit area or

extent over which the index is computed). To avoid bias, this "sample area" must be two to five times larger than landscape patches.

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69 Data Center Continues Information-Sharing Activities in Support of U.S.-China Bilateral Agreement

T. A. Boden

The DOE Global Change Research Program and the People's Republic of China's Academy of Sciences (PRC-AS) signed a collaborative agreement in August 1987 to study the greenhouse effect. The objectives of the agreement are to improve the performance of general circulation models, to quantify methane emissions from Chinese rice paddies, and to prepare climate databases suitable for long-term regional and local climate analyses.

The Carbon Dioxide Information Analysis Center's (CDIAC) role in the Joint Research Project on the Greenhouse Effect is to provide data processing, archival, documentation, and distribution support to the climate data and methane emission components of the project. In the early years of the agreement, CDIAC provided computer hardware and software support to the Institutes of Atmospheric Physics and Geography (Beijing, PRC) and developed protocols for data exchange. During the ensuing years, as data collection and compilation efforts intensified and progressed, CDIAC's principal role became one of archiving, documenting, and distributing data sets generated under the DOE-PRC-AS bilateral agreement.

To date, CDIAC has archived ~20 databases, fully documented 8 U.S. and PRC instrumental climate databases, and distributed ~1000 copies of the documented databases and DOE technical reports to individuals in more than 100 countries.

At a recent meeting in Beijing, it was agreed that during the coming years CDIAC will continue all of these data-related support activities but will focus primarily on documenting and analyzing (1) a 2000-year proxy precipitation record being compiled by the Chinese and (2) the methane flux measurements made in Chinese rice paddies.

70 CDIAC Produces an Updated Bibliographic Database on the Effects that Elevated Levels of CO₂ Have on Vegetation

R. M. Cushman, B. R. Strain,¹ and J. D. Cure¹

The effects of increased concentrations of CO₂ on plants and ecosystems is an important issue in assessing global change. The Carbon Dioxide Information Analysis Center (CDIAC), in collaboration with Boyd R. Strain and Jennifer D. Cure of Duke University, has updated a 1986 bibliography on the effects of atmospheric CO₂ on plants and ecosystems.

The new bibliography, *Direct Effects of Atmospheric CO₂ Enrichment on Plants and Ecosystems: An Updated Bibliographic Database* (ORNL/CDIAC-70), provides complete bibliographic citations, abstracts, keywords, and common and scientific plant names for 798 references that were published between 1980 and 1994; half of

the cited references were published in 1990 or later.

A version of the bibliography in machine-readable form is also available. Used with appropriate bibliographic database software, the bibliography offers new possibilities of database management for the user, such as searching by author, keyword, and year.

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71 Coastal Hazards Database for the U.S. Gulf Coast Is Published as a CDIAC Numeric Data Package

T. W. White

The Carbon Dioxide Information Analysis Center (CDIAC) published a coastal hazards database that provides an overview of the relative vulnerabilities of the U.S. Gulf coastline to inundation and erosion hazards associated with increasing sea levels. This database quantitatively describes the U.S. Gulf Coast by integrating point, line, and polygon data into 0.25° latitude by 0.25° longitude grid cells and 1:2,000,000 digitized line segments containing 22 data and 7 relative-risk variables on elevation, geology, geomorphology, vertical land movement, erosion and accretion, tidal range, and wave height.

Several algorithms for calculating a coastal vulnerability index (CVI) are included in the documentation. The CVI algorithm least affected by data error is that calculated by taking the square root of the mean product of the seven risk variables divided by the number of variables present. An analysis using this CVI indicates that

the Gulf coastline is particularly vulnerable to inundation because of low-lying topography composed primarily of limestones and sandstones overlaid by unconsolidated sediments and unstable landforms (i.e., high-risk values for elevation, lithology, and geomorphology are predominant on the Gulf).

Nearly half of the Gulf shoreline is eroding, and measurements of local vertical movement indicate a relative sea level change of more than 1 m/year for the entire Gulf Coast. The Gulf Coast is a low-energy coastline with microtidal mean tide ranges (<2 m) and with wave heights under 5 m. For this reason, the Gulf of Florida has lower CVI values than those calculated for the Atlantic Coast portion of the state. Gulf Coast CVI values range from 2.12 to 40.09; the mean approaches 16 (i.e., moderate risk). Areas at high risk include the Louisiana barrier islands, New Orleans; Freeport, Texas; and portions of the Florida Everglades.

72 ESD Assists in Reevaluating the Strategy for Managing Transuranic Wastes at ORNL

J. R. Trabalka

An ESD staff member chaired an interdisciplinary team charged with reevaluating the strategy for managing transuranic-contaminated (TRU) wastes at ORNL. A proposal had suggested that the Waste Handling and Packaging Plant (WHPP) process ORNL's TRU wastes for disposal in the Waste Isolation Pilot Plant (WIPP) in New Mexico. Because much of ORNL's TRU waste is mixed hazardous and radioactive waste, processing in the WHPP

was required for compliance with the Land Disposal Restrictions imposed by the Resource Conservation and Recovery Act (RCRA).

The project had not been accepted, however, because of delays in the opening of WIPP and uncertainties in its Waste Acceptance Criteria (WAC), uncertainties in DOE waste management strategies, and the negative reaction to the high costs of WHPP. The team was asked to identify alternatives to the WHPP and to evaluate them through the use of a common set of criteria (e.g., safety, compliance, technical soundness).

Uncertainties dominated the evaluation process; most were not reducible by engineering studies or through technical assessments. Some uncertainties were associated with issues that were national in scope and that required both social and scientific solutions. Others were more local in origin but carried equal weight (e.g., the uncertain future for low-level waste disposal on the Oak Ridge Reservation).

Major uncertainties regarding the quantities of solid TRU wastes from ORNL that could be disposed of in WIPP related to (1) the unique nature and limited characterization of ORNL's solid TRU wastes, (2) limitations of current assay technologies, and (3) questions about

the feasibility of retrieving wastes in earthen trenches. The evaluation of alternatives was also hampered by uncertainties in WAC for disposing of secondary wastes from processing.

Under such conditions informed judgment, supported by formal decision-aiding tools (such as multiobjective utility analysis), must be relied upon to develop and to evaluate alternatives. Although the team found nothing conceptually wrong with WHPP, it concluded that a phased, step-wise approach that copes with current uncertainties and resource constraints in planning and making decisions about TRU-waste processing should be presented to DOE and other stakeholders for consideration as an alternative. This approach would (1) allow resolution of critical technical, regulatory, and political issues before a commitment to a processing alternative or facility is made; (2) iteratively incorporate the results of external decisions on disposal options into process design activities; (3) utilize feedback from waste characterization, risk assessment, technology development, and pilot-scale processing activities in the design of full-scale processing capabilities; (4) defer investments in capital facilities until critical issues have been resolved and DOE strategies are developed; and (5) spread capital costs over a longer period to cope with the current budget shortfall.

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Environmental Biotechnology

Introduction

The Environmental Biotechnology Section of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) carries out basic and applied research on (1) mechanisms that influence the response of biological systems to contaminants, (2) effects of receiving systems on the availability and distribution of materials to which they are exposed, and (3) modifications of biological systems to enhance degradation or immobilization of contaminants. Experimental, observational, and simulation studies are conducted at different levels of biological organization, from the subcellular and biochemical levels to the ecosystem level. Section activities are supported by the U.S. Department of Energy (DOE) Headquarters; the U.S. Department of Defense; and the environmental compliance and remedial action programs at DOE facilities in Oak Ridge (ORNL, the Oak Ridge Y-12 Plant, and the Oak Ridge K-25 Site) as well as at the Kansas City, Missouri, plant and the gaseous diffusion plants in Paducah, Kentucky, and Portsmouth, Ohio.

Biological Markers

The Biological Markers Group assists in the assessment of the health of the environment by identifying and evaluating biological responses induced in biota exposed to contamination. Biological responses are studied at the molecular, biochemical, and physiological levels both to understand the basic toxicological mechanisms that underlie responses elicited by exposure to environmental contaminants and to relate the responses to effects

observed at higher levels of biological organization.

In FY 1994, using the biological indicator approach, staff assessed the health of several aquatic systems, including streams receiving mixed contaminants, rivers affected by pulp and paper effluents, reservoirs containing polychlorinated biphenyls (PCBs) and heavy metals, and natural lakes containing hydrocarbon compounds. Researchers also conducted field assessments, laboratory analyses, and bioassays to determine the effects that environmental stressors had on the health of these systems, to evaluate the effectiveness of remedial actions, and to assess compliance with environmental regulations. Currently, new indicators of aquatic ecosystem health that involve DNA diversity and antioxidant enzymes are being developed and tested in a variety of aquatic systems.

Biological Monitoring and Assessment

The Biological Monitoring and Assessment Group conducts projects that evaluate the ecological health of aquatic and terrestrial ecosystems near the three DOE facilities on the Oak Ridge Reservation (ORR) and the ecosystems associated with the DOE facilities in Paducah, Kentucky, and Portsmouth, Ohio. The biological monitoring programs provide a basis for assessing compliance with environmental regulations. The programs also help identify causes of adverse ecological impacts and assess the effectiveness of remedial action programs by documenting ecological recovery. Biological monitoring techniques range from manipulative field experiments and new in situ bioassays to

more conventional approaches, including quantitative biotic surveys and laboratory toxicity tests. The Biological Monitoring and Assessment Group consists of three projects that reflect different aspects of the biological monitoring programs: Ecotoxicology, Biomonitoring, and Ecological Monitoring.

Ecotoxicology

The biological monitoring programs not only use established biomonitoring protocols but also include the development of new procedures, as appropriate, for assessing toxicity. The goals of the Ecotoxicology Project are (1) to develop alternative methods for assessing water quality through the use of lower trophic level indicators, such as the autotrophs (algae) and heterotrophs (fungi, bacteria, and protozoans) that constitute stream periphyton communities, and (2) to apply these methods in both DOE regulatory monitoring programs and work-for-others projects. The project also conducts experimental studies of community structure and food webs in contaminated and noncontaminated streams, ponds, and wetlands to determine how contaminants modify aquatic communities or indirectly alter populations, communities, or ecological processes.

In FY 1994, a major accomplishment of the Ecotoxicology Project was the development and validation of an earthworm toxicity test that can be used to estimate the acute and chronic toxicity of soils. Results of the test were used in a site-wide baseline ecological risk assessment for the Portsmouth Gaseous Diffusion Plant. In cooperation with Biomonitoring Project staff, Ecotoxicology Project staff identified lithium as a toxicant of concern in some waste treatment operations at the Y-12 Plant. Results of

this investigation were used to establish a waste acceptance criterion for lithium that was protective of the environment. A combination of both field and laboratory studies demonstrated that fish can acclimate to chlorine, a toxicant that has been associated with fish kills in some ORR streams. Other research showed that fatty acid profiles of stream periphyton communities can be used as high-resolution biomarkers of exposure to chlorine.

Biomonitoring

Biomonitoring is a major component of the environmental compliance programs at the three DOE facilities in Oak Ridge and the DOE gaseous diffusion plants in Kentucky and Ohio. The Biomonitoring Project uses various aquatic species in laboratory tests to detect acute and chronic toxicity of water (both effluents and receiving streams) and sediments. These tests are necessary to comply with the requirements of the National Pollutant Discharge Elimination System (NPDES) permits issued under the Clean Water Act and to comply with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act that are related to ecological risk assessment. The Biomonitoring and Ecotoxicology projects support the ESD concept of biomonitoring as a combination of established toxicity-testing protocols and innovative ecotoxicological approaches that together can be used to assess regulatory compliance and ensure environmental protection and restoration.

In FY 1994, staff completed more than 200 compliance-related aquatic toxicity tests required under the NPDES permits for the DOE Oak Ridge facilities and under the Kentucky Pollutant Discharge Elimination System permit for the Paducah Gaseous Diffusion Plant. Staff provided significant

support for various environmental restoration programs that required both water and sediment toxicity tests in order to assess ecological risks. Special studies also were implemented (1) to identify sources of toxicity in the groundwater treatment facility and Outfall 201 at the Y-12 Plant and in the sewage treatment plant at ORNL and (2) to develop site-specific criteria for metals at the Paducah facility.

Ecological Monitoring

The Ecological Monitoring Project evaluates the ecological effects and human health risks of regulated discharges from ongoing operations and fugitive emissions from waste disposal sites at DOE facilities in Tennessee, Kentucky, Ohio, and Missouri. Such monitoring documents compliance with NPDES permits and provides a direct measure of the effectiveness of remedial actions at contaminated sites. Staff also conduct research on the transport and transformations of chemicals in surface water and groundwater and in terrestrial environments, and they develop innovative methods for monitoring the transport and effects of chemicals in the environment.

In FY 1994, staff of the Ecological Monitoring Project continued to provide information that guides remedial actions. Such guidance has led to the striking, well-documented ecological recovery of fish and invertebrate communities in several streams affected by operations of DOE facilities. Elimination and reduction of discharges of chlorinated water to streams at the Paducah Gaseous Diffusion Plant, the Oak Ridge K-25 Site, the Oak Ridge Y-12 Plant, and ORNL resulted in the repopulation of reaches of streams that previously contained very limited aquatic life. Results of research on the life

history of the Tennessee dace, a fish uncommon in East Tennessee but abundant in some ORR streams and listed for special protection by the Tennessee Wildlife Resources Agency, will be used to guide environmental restoration activities that may affect critical habitat of this species. An evaluation of the site-specific relationship between waterborne inorganic mercury concentrations and methylmercury accumulation in fish was conducted for the Y-12 Plant to assist the Tennessee Department of Environment and Conservation in setting mercury discharge limits in the NPDES permit for the facility. PCB monitoring using fish, caged clams, and semipermeable membrane devices at the DOE Oak Ridge facilities helped researchers identify contaminated aquatic environments and sources of PCB contamination in those systems. Furthermore, measurements of contaminant transfer from landfilled fly ash to terrestrial organisms provided key data for assessing ecological risks at a site under evaluation for possible remediation.

Contaminant Transport

The mission of the Contaminant Transport Group is to assist the ORNL Environmental Restoration Program in reducing both on-site and off-site risks to human health and the environment that result from past waste disposal practices. The group (1) provides data to identify contaminant sources in the ORNL waste disposal areas and to prioritize areas for remediation, (2) characterizes contaminant transport mechanisms through surface water and shallow subsurface pathways in order to select and design effective remediation strategies, and (3) assesses the performance of remedial actions in reducing contaminant risks.

The group's mission is accomplished principally by implementing the Waste Area Grouping (WAG) 2 Remedial Investigation and Site Investigations Project. Staff monitor surface water tributaries and seeps to collect data to evaluate temporal discharge patterns and fluxes during both baseline and transient storm events. Data are also collected to characterize the spatial distribution of contaminants in sediments and the distribution of contaminants between dissolved and particle-associated phases in suspended sediments. Other group activities include database manipulation and data visualization using geographic information system techniques, safety and quality assurance/quality control oversight, and project coordination and management.

Principal accomplishments in FY 1994 include (1) providing technical and assessment support of surface water sampling in ORNL waste disposal areas in order to prioritize potential actions by the ORNL Environmental Restoration Program and (2) conducting soil and sediment sampling in WAG 2 to identify major contaminant source areas for potential corrective action. Results of these efforts were summarized in the *Third Annual Environmental Restoration Monitoring and Assessment Report*, a key Federal Facilities Agreement milestone for the ORNL Environmental Restoration Program.

Environmental Chemistry

The Environmental Chemistry Group investigates the transport, transformation, and accumulation of materials in surface water environments, including sediments and biota. Investigations conducted by the group form an important link between information on basic principles and processes and their applications to current

applied research, such as environmental restoration and remedial actions.

Significant accomplishments by the Environmental Chemistry Group in FY 1994 were associated with the Clinch River Environmental Restoration Program, which addresses the transport, fate, and distribution of waterborne contaminants released from ORR and which assesses potential risks to human health and the environment that are associated with those contaminants. The *Phase 2 Sampling and Analysis Plan* for the Clinch River remedial investigation and baseline risk assessment was submitted to regulatory agencies for review, and sampling and analysis for contaminants in sediment and water were completed in FY 1994. Information collected during this phase of the study will be used to characterize the nature and extent of contamination in the Clinch River and to assess the risks to human health and the environment from those contaminants. The *Remedial Investigation/Feasibility Study and Proposed Plan* for the lower Watts Bar Reservoir study area was also submitted for regulatory review in FY 1994. The report concluded that the greatest risks to human health would result from the consumption of certain species of fish containing PCBs and the transfer of sediment from deeper areas of the reservoir to upland disposal sites where farming might occur. Existing laws and regulations would be effective in protecting human health from these contaminants.

Microbial Interactions

The Microbial Interactions Group uses powerful new techniques in molecular biology to complement traditional microbiological methods to better understand the processes by which microorganisms transform hazardous

chemical contaminants in soils, surface water, and groundwater. The goals of these investigations are to optimize the microbial degradation of hazardous chemical contaminants and to demonstrate the application of innovative microbial techniques and bioremediation approaches as a means of solving contamination problems at DOE sites.

Investigations of deep subsurface formations at DOE sites were expanded in FY 1994 to include shale reserves in Colorado and volcanic outcrops in New Mexico. Microorganisms from the new sites appear to have application for remediation of DOE sites. A new project was initiated to examine the relationship between bacterial heterogeneity and the physical/chemical heterogeneity in shallow subsurface environments, whereas microbial monitoring of trichloroethylene degradation at a Savannah River demonstration site was completed, and the technology was transferred to other DOE sites (e.g., Hanford, Washington). An unexpected finding—that the addition of surfactants to the lux bioreporter system enhances the bioavailability of contaminants to natural organic matter—may have significance for site bioremediation activities.

One cooperative research and development agreement (CRADA) was completed in FY 1994, and work on another was initiated. The ORNL-Envirogen CRADA to assess the effectiveness of a bench-scale vapor-phase bioreactor in removing trichloroethylene from a complex aqueous waste stream was completed, and an ORNL-National Center for Manufacturing Science (NCMS) CRADA was prepared for review and approvals. In collaboration with NCMS partners at Ford Motor Company, General Motors,

and Texaco, researchers will develop and demonstrate approaches to improving in situ bioremediation of contaminated aquifers. In other work, researchers developed a consortium of microorganisms that is capable of degrading glycol-based wastes, such as antifreeze and deicing fluids, thus providing an opportunity for establishing partnerships between ORNL and various industries.

Reservation Data Systems

The Reservation Data Systems Group primarily provides data management support for environmental restoration projects conducted at the three DOE facilities in Oak Ridge. The group also supports environmental restoration activities through the development and operation of the Oak Ridge Environmental Information System (OREIS) and through leadership of the Environmental Restoration Data Quality Program, which is aimed at developing common data management practices among environmental restoration projects. OREIS is sponsored by the DOE Oak Ridge Operations Office to fulfill the requirements of state and federal oversight agreements instituted in response to environmental restoration activities across ORR. The successful implementation of OREIS and the Environmental Restoration Data Quality Program will promote consistency in the data, increase their legal defensibility, and enhance the cost-effectiveness of environmental restoration activities. Through the initiation of a new activity this past year, the group also supports to the National Aeronautics and Space Administration (NASA) Earth Observing System Data and Information System (EOSDIS) through the ORNL Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics.

EOSDIS is part of the NASA contribution to the effort by the U.S. Global Change Research Program to develop a predictive understanding of the global environment.

A key accomplishment in FY 1994 was the successful transition of OREIS from a developmental program to an operational system. ORNL staff, as well as state and federal regulators, can now access and

display environmental restoration data for ORR through OREIS.

The ORNL DAAC became operational this year and is now electronically linked to other NASA data centers. The ORNL DAAC has developed a local user interface to allow users to search and order data that are available locally.

Technical Summaries

73 Integrative Assessment Approaches Help Evaluate the Effects of Contaminant-Related Stress on Aquatic Ecosystem Health

S. M. Adams and M. S. Greeley, Jr.

Many species of fish, because of their position in the food chain, are integrators of environmental conditions and, therefore, may reflect the overall health of an aquatic ecosystem. A variety of methods or approaches are available for evaluating the effects of environmental conditions or stressors on fish populations.

Each approach, however, typically has its own unique limitations and advantages, each of which will influence the evaluation and interpretation of the effects of stress on fish populations. For fish inhabiting streams that receive a variety of industrial effluents, including polychlorinated biphenyls, polycyclic aromatic hydrocarbons, heavy metals, and chlorine, ESD scientists compared and evaluated three approaches for investigating how contaminants affected fish health. These approaches include (1) individual variable responses, primarily at lower levels of biological organization; (2) statistically based integrative indices, based on multivariate responses; and (3) ecologically relevant measurements, such as population and community-level responses.

Individual variables best reflect stress responses at the biochemical, physiological, and histopathological levels and are used to evaluate the effects of short-term

environmental stressors. Multivariate analyses provide a more integrative assessment of stress, because this approach takes into account the interrelationships and associations among stress responses. Ecologically relevant measurements, however, reflect the combined and cumulative effects of both indirect and direct stress pathways.

The studies showed that applying all methods together provides the best strategy for evaluating fish health to make environmentally sound decisions regarding the ecological implications of stressors on aquatic ecosystem health.

74 Preliminary Studies Suggest that Contaminant Plumes from a Military Reservation Are Not Adversely Affecting Fish Health in Cape Cod Ponds

M. S. Greeley, Jr., and S. M. Adams

The accelerated pace of military base closings in the United States underscores the need for more innovative and sensitive approaches to the assessment of the environmental impacts of both active and deactivated U.S. Department of Defense (DOD) facilities. One such approach used in biological monitoring and assessment activities at various DOE sites involves the comparative evaluation of a diverse suite of molecular, biochemical, physiological, and population/community bioindicators of toxicant exposure and effects in organisms inhabiting potentially contaminated sites.

ESD researchers are currently in the process of applying the bioindicator approach to the assessment of the

biological effects of groundwater contamination associated with a DOD site on Cape Cod, Massachusetts. Two small recreational lakes, Ashumet and Johns Ponds, near Falmouth, Massachusetts, are in the paths of several distinct groundwater contaminant plumes migrating from the Massachusetts Military Reservation. Preliminary results of this study suggest that the exposure of pond fish to chemical toxicants in the plumes has been minimal to date.

More intensive studies are now under way to better characterize the exposure history of fish in the ponds and to explain the relatively high incidence of surface tumors and other abnormalities observed in a species of catfish during the preliminary studies. The ongoing investigation is expected to serve as a test of the applicability of the bioindicator approach to environmental assessments associated with DOD facilities. The results of this investigation will also aid in the interpretation of the results of similar studies being conducted on or near the Oak Ridge Reservation.

75 The Genetic Relationship Between Two Species of Freshwater Snails Is Analyzed

K. L. Lee, A. J. Stewart, and L. R. Shugart

DNA fingerprinting is a powerful tool in the analysis of genetic relationships and genetic diversity. Among current DNA fingerprinting methods, the polymerase chain reaction (PCR)-based, randomly amplified, polymorphic DNA (RAPD) technique is particularly suitable for the genetic analysis of populations. The main advantages of the RAPD technique include (1) the requirement of only small

quantities of DNA, (2) the ability to work even when base sequence in the target genome is not known, and (3) the ability to scan the entire genome.

ESD researchers have recently adapted the RAPD fingerprinting technique to assess the taxonomic relationships of two closely related species of freshwater pleurocerid snails, *Elimia clavaeformis* Lea and *Pleurocera uncialis*. Several DNA purification protocols were attempted; one was found to be economical, fast, and able to produce DNA with sufficient purity for PCR. This protocol included extracting the DNA with phenol (to remove proteins) and purifying it by precipitating mucopolysaccharide contaminants in a concentrated salt solution. DNA yield from individual snails using this protocol was 2 to 60 μ g per snail. Analysis of purified DNA samples from the snails on 0.8% agarose gels revealed undegraded high-molecular-weight DNA.

Thirty-seven arbitrary primers were tested to analyze purified snail DNA from the two species. Nine of these primers generated RAPD fragments that could be detected on agarose gels. Five of the nine primers amplified RAPD fragments that were polymorphic in individual snails of the same species. Thus, these five primers can be used for the genetic diversity analysis of snails.

Additionally, four of the five primers are highly informative in the analysis of taxonomic relationships of the two snail species. Primer OPD-5 amplified a 900-bp fragment limited to *Pleurocera*, whereas primer OPD-3 generated a 730-bp fragment only in *Elimia*. These two DNA fragments could be diagnostic for individuals of *Pleurocera* or *Elimia* respectively. On the other hand, primer

OPD-5 and primer UBC-4 amplified 400-bp and 740-bp RAPD fragments, respectively, which were common to both *Pleurocera* and *Elimia*. These fragments may represent DNA markers specific for a family or a higher level taxonomic group.

Further analyses of other snail species and genera will be used to determine the specificity of these DNA markers to pleurocerid snail species.

76 Laboratory-Formulated Sediments Should Provide Meaningful Controls for Toxicity Tests

A. M. Gonzalez and L. A. Kszos

Contaminants introduced into natural waters are often concentrated in sediments through adsorption and may adversely affect benthic organisms that feed on or inhabit the surface sediments. In the laboratory, sediment toxicity can be evaluated by monitoring the survival, growth, or reproduction of surrogate benthic invertebrates exposed to sediment samples. The ESD Toxicology Laboratory currently maintains healthy cultures of *Hyalella azteca* and *Chironomus tentans*, both of which are being considered by the U.S. Environmental Protection Agency as standard test organisms for sediment toxicity testing. Organisms such as these have successfully been used in toxicity evaluations of sediments for the Clinch River/Poplar Creek Phase II Sampling and Analysis Plan, a component of the Watts Bar Reservoir Remedial Investigation.

One clear weakness of current sediment toxicity testing protocols is the lack of an appropriate control with which sediment

toxicity test data may be compared. The current practice is to use sediments sampled from a reference site, typically upstream of the presumably impacted sites, but which may not itself be "clean." The ESD Toxicology Laboratory is developing artificial sediments that can be made to match test sediments with respect to key geochemical and geophysical properties, such as particle size distribution, organic matter and organic carbon content, and pH. Such substrates could be used as site-specific controls, thus minimizing the influence of major differences in sediment geochemistry on organism response. This methodology would increase the sensitivity of the sediment bioassay to the presence of toxicants. The initial goal is to develop an artificial sediment that will support biological activity for prolonged periods and then to evaluate the interactions of the artificial sediment with such contaminants as copper or polychlorinated biphenyls.

77 Environmental Effects of Storm Water Pollutants Are Evaluated at ORNL

*R. L. Hinzman, A. J. Stewart,
G. R. Southworth, and M. J. Filson*

Despite the best management practices, total suspended solids (TSS) and oil and grease (O&G) concentrations in storm water runoff frequently exceed the National Pollutant Discharge Elimination System (NPDES) permit limits at ORNL. At the request of the ORNL Office of Environmental Compliance and Documentation, ESD staff initiated a study to clarify whether these noncompliances are only a regulatory problem or are a source of ecological impact that requires remediation.

A review of the 1988-92 NPDES noncompliance data showed that ORNL operations were conducted with care. Only 7% of the TSS and O&G noncompliances were one-time occurrences indicative of a spill.

Laboratory tests were conducted to examine the effects of storm water runoff on the survival and reproduction of *Ceriodaphnia dubia* and on the feeding rate of *Elimia clavaeformis*. Storm water runoff from one outfall was acutely toxic to *Ceriodaphnia*, and water from two outfalls significantly lowered snail feeding rates. However, the tests could not determine whether the observed effects were because of TSS, O&G, or some other constituent. Five databases were searched for literature published since 1988 on the ecological effects of storm water runoff and alternatives for best management practices. Current storm water treatment options were identified, and proactive approaches for addressing storm water noncompliances were recommended.

An analysis of sediment samples collected from seven sites in area streams showed that total petroleum hydrocarbons (TPHs) accumulated in the sediment of at least some sites in White Oak Creek (WOC) at concentrations that could adversely affect biota. Hydrocarbon signatures in sediments collected from WOC downstream of ORNL outfalls and from East Fork Poplar Creek downstream of the Oak Ridge Y-12 Plant were similar to each other but different from off-site reference streams. This disparity suggests that TPH accumulation in sediment may be related to facility operations. Sediment toxicity testing could be conducted to assess the potential ecological effects of this accumulation.

78 Toxicity of Lithium Drives the Need for New Waste Acceptance Criteria

A. J. Stewart and L. A. Kszos

Routine compliance testing shows that effluent from the Oak Ridge Y-12 Plant's Groundwater Treatment Facility is acutely toxic to *Ceriodaphnia dubia* (a microcrustacean) and to fathead minnow larvae. Subsequent testing suggests that the toxicity is due to the presence of lithium.

Lithium is a light, strong metal (only one-third as massive as sodium) used in various DOE operations, including fusion weapons, fission reactors, and gamma detectors. Virtually no information exists about the toxicity of lithium to aquatic biota despite widespread and increasing industrial usage, and surprisingly little information exists about the concentrations of lithium that occur naturally in surface waters. When additional toxicity tests were conducted with lithium-spiked control water, wastewaters, and stream-water samples, the results confirmed that lithium is acutely toxic at concentrations as low as 1 mg/L. Water type appeared to influence the toxicity of lithium: the metal was about six times more toxic in low-sodium diluted mineral water than it was in sodium-rich wastewaters.

These findings are significant to Waste Treatment Operations at the Y-12 Plant because (1) some batches of wastewaters treated at the Y-12 Plant's West End Treatment Facility (WETF) contain lithium at high concentrations (>5000 mg/L), (2) lithium is exceptionally difficult to remove from solution by conventional waste-treatment procedures, and

(3) WETF effluent typically contains a high concentration of sodium. The results of the toxicity tests are being used to establish waste acceptance criteria for lithium at WETF.

79 Mercury Found in Periphyton and Grazing Fish in East Fork Poplar Creek Is an Indicator of Contaminant Movement

W. R. Hill and A. J. Stewart

The impressive sorptive capacity and large surface area of periphyton (substrate-attached algae and microheterotrophs) gives it the potential to be an important mediator of contaminant movement in aquatic ecosystems.

Periphyton's role as an entry point of mercury into stream food webs was investigated in East Fork Poplar Creek (EFPC), a second-order stream contaminated by spills of elemental mercury from the Oak Ridge Y-12 Plant. Both methylmercury and inorganic mercury were analyzed in periphyton and whole-body samples of fish (periphyton-grazing stoneroller minnows and omnivorous striped shiners) that were collected at three sites in EFPC.

Total mercury concentrations were very high at the site closest to the Y-12 Plant (exceeding 50 $\mu\text{g/g}$ dry mass in stonerollers), and they decreased with distance downstream from the plant. Interestingly, inorganic mercury was the predominant form in both periphyton and fish. The proportion of methylmercury increased with distance downstream: methylmercury in periphyton was 0.15%, 0.23%, and 0.37% of total mercury at the

three sites (from upstream to downstream); organic mercury was 1.6%, 9.5%, and 21.4% of total mercury for stonerollers at the sites. Methylmercury concentrations were much lower in stonerollers than in striped shiners; these results suggest that a periphyton diet may be an important influence on mercury speciation.

The predominance of inorganic mercury found in stonerollers and striped shiners contrasts with previous research, which has shown methylmercury to be the major species present in fish tissue. Because inorganic mercury is much less toxic than methylmercury, the results of this study may have important implications for ecological risk analysis.

80 Kingfishers on the Oak Ridge Reservation Accumulate Trace Metals and Radionuclides from Aquatic Prey

T. L. Ashwood and L. A. Baron¹

Belted kingfishers are highly territorial predators that consume half of their body weight per day in fish and crayfish from streams and lakes. This high rate of consumption leads to a high potential for exposure to contaminants that have accumulated in their prey; however, no information is available in the wildlife or toxicological literature on the impacts of contaminants on kingfishers.

Researchers in ORNL's ESD are investigating contaminant levels in kingfishers that feed from streams on the Oak Ridge Reservation (ORR). Initial results of analyses on three dead kingfishers found at different locations on ORR suggest that each had accumulated high concentrations of some trace metals

or radionuclides. Although reference site values are not available for kingfishers, the wide variations in results for each contaminant among the three birds suggest that values at the high end of the ranges should be considered elevated. Cadmium ranged from <0.20 to 7.21 mg/kg in feathers and from <0.20 to 4.04 mg/kg in kidneys. Mercury ranged from 2.72 to 13.9 mg/kg in feathers and from 1.46 to 26.8 mg/kg in kidneys. Cesium-137 ranged from 3 to 151 pCi/g in muscle.

Lead and selenium were also measured in samples from each bird, but the ranges among birds were not as wide. Kingfisher nest burrows are being probed with a remote video camera and grabber to obtain samples of discarded feathers and unsuccessful eggs without harming the birds.

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81 Long-Term Monitoring of Stream Biota near DOE Oak Ridge Facilities Detects Changes in Organic Contamination Concentrations

M. J. Peterson and G. R. Southworth

From 1985 to 1993, organic contaminant concentrations in stream biota were monitored near DOE facilities in Oak Ridge. One of the primary objectives of the monitoring effort was to detect spatial and temporal changes in biotic contamination to evaluate the effectiveness of pollution abatement activities.

Asiatic clams (*Corbicula fluminea*) were the bioindicator of choice for monitoring most organic contaminants, because clams can accumulate organic pollutants that are

rapidly metabolized by fish. On an annual basis, Asiatic clams taken from an uncontaminated reference stream were placed in cages for 4-week exposures in the receiving streams. Clam monitoring successfully detected a localized source of chlordane contamination, and annual follow-up monitoring tracked a steady decrease in contamination. The use of clams to resolve spatial differences in polychlorinated biphenyl (PCB) contamination was found to be limited in the presence of sublethal concentrations of residual chlorine; therefore, the use of resident fish was preferred for monitoring PCBs under those exposure conditions.

Annual monitoring of resident sunfish from White Oak Creek, a stream receiving discharges from the ORNL complex, showed a significant decrease in PCB concentration over a 5-year period at all five sites monitored.

Overall, the long-term, concurrent monitoring of resident fish and transplanted Asiatic clams was effective in identifying and evaluating changes in organic contaminant bioaccumulation downstream of the DOE facilities.

82 Dechlorination of Outfalls in Upper EFPC Does Not Decrease Rate of Fish Mortality

M. G. Ryon

Upper East Fork Poplar Creek (EFPC), adjacent to the Oak Ridge Y-12 Plant, was surveyed daily in June 1994 to establish baseline fish mortality. The last regularly scheduled surveys of dead fish in EFPC had been suspended in May 1993, following the dechlorination of major outfalls in November 1992. A decrease in

the mortality rate and an increase in fish community density had been expected as a result of the reduced levels of total residual chlorine (TRC).

The June 1994 surveys revealed, however, that the overall mortality rate did not decrease in relation to the size of the population. Contrary to expectation, the June 1994 surveys found a total of 115 dead fish, a higher total than those from the daily surveys in June 1991 and June 1992, which counted 77 and 36, respectively. Thus, the mean daily mortality rate increased from 1.80 per day in June 1992 to 5.48 per day in June 1994.

Adrian Gonzalez prepares a sediment sample for a sediment toxicity test using laboratory-cultured benthic macro-invertebrates. These tests are used to evaluate the toxicity in stream or lake-bed sediments. The results are then used as one line of evidence in ecological risk assessments.

However, the increase in the daily mortality rate was matched by an increase in fish community density at the sample site closest to the survey area: the density rose from 2.22 to 5.64 fish per square meter. Therefore, despite the greater total number of dead fish, the relative proportion of dead fish to the total fish community was similar in 1992 and 1994 (i.e., 0.17% and 0.19%).

Apparently, the reduction of TRC levels in upper EFPC did not lower the overall mortality rate in relation to the population. The continued level of overall mortality may result from the increased number of fish exposed to chlorine (even in smaller quantities), another toxicant effect, or the migration of fish into contaminated reaches upstream of the dechlorinators.

83 Total Residual Chlorine Profile of WOC and Its Associated Outfalls Is Evaluated for Possible Effects on Fish Populations

E. M. Schilling, M. G. Ryon, B. A. Carrico,¹ R. P. Hoffmeister,¹ J. W. Lotts,² and W. K. Roy

A fish kill that resulted in an occurrence report was investigated in White Oak Creek (WOC) in November 1993. Sporadic fish kills in WOC have occurred since 1987, and some were thought to be associated with toxic concentrations of total residual chlorine (TRC). Future remediation efforts include a plan to dechlorinate many of the ORNL outfalls to WOC.

A chlorine profile of WOC was conducted in January 1994 to determine TRC concentrations in WOC and identify the

outfalls discharging to WOC from the main ORNL complex upstream from Melton Valley Drive. Water samples were taken at 25-m intervals and at all flowing outfalls. Measurements of elevated TRC in outfalls discharging to WOC ranged from 0.18 to 0.84 mg/L. Exposure to similar TRC concentrations have been shown to have detrimental effects on the fish populations. Instream TRC concentrations ranged from 0.03 mg/L (at Melton Valley Drive) to a high of 0.17 mg/L (just above Fifth Creek confluence). No measurable instream TRC concentrations were found upstream from White Oak Avenue.

The U.S. Environmental Protection Agency water quality criteria limit for a chronic concentration of TRC is 0.011 mg/L. Continued monitoring of WOC and its associated outfalls will allow researchers to determine trends in TRC concentrations and expected changes in the fish populations resulting from future dechlorination actions.

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84 Temporal Trends Reflect Recovery in the Benthic Macroinvertebrate Community of a Chronically Affected Watershed

J. G. Smith

Temporal trends in benthic macroinvertebrate community structure in five streams within a single watershed have been followed for 6 years to help assess (1) the impact of operations and (2) the effectiveness of pollution abatement activities and remedial actions taken at ORNL.

An initial characterization of the macroinvertebrate community structure determined that the sampling sites closest to one or more major effluent discharges generally exhibited the greatest evidence of impact. Invertebrate community structure at these sites also exhibited the greatest evidence of change indicative of improving conditions (e.g., significant increases in total richness) as pollution abatement projects (e.g., effluent dechlorination) were implemented or other ORNL operational changes occurred (e.g., reactor shutdown).

By contrast, community structure changed little at sites located much farther downstream (far-field sites) or at sites where no abatement activities were implemented. This pattern of temporal change helps demonstrate the effect of ORNL effluents on the community structure near the point of discharge. The absence of responses at far-field sites suggests that more substantial abatement activities and remedial actions may be needed and that more time may be necessary for the communities to respond to subtle changes in water quality.

85 A Site-Specific Water Quality Criterion for Mercury Is Determined for EFPC at the Oak Ridge Y-12 Plant

G. R. Southworth, R. R. Turner, and B. D. Nourse¹

In the renewed National Pollutant Discharge Elimination System permit, the Tennessee Department of Environmental Conservation (TDEC) plans to regulate mercury discharges from the Oak Ridge Y-12 Plant to East Fork Poplar Creek (EFPC) to ensure that the discharges do not result in the accumulation of hazardous

concentrations of mercury in aquatic biota. The U.S. Environmental Protection Agency (EPA) water quality criterion for mercury, 0.012 $\mu\text{g/L}$, which has been adopted as the Tennessee water quality standard, is determined based on assumptions that are inappropriate for many aquatic systems. In promulgating that criterion, EPA recommended using site-specific data on actual mercury concentrations in fish to evaluate whether regulated discharges are acceptable.

To help TDEC set mercury discharge limits that will protect the classified uses of EFPC but that will also be technically achievable with current treatment and remediation technologies, researchers used data on mercury concentrations in fish and water in EFPC to calculate a site-specific mercury criterion for the upper reaches of EFPC. Human health risk assessment procedures were used to determine mercury concentrations in fish that would be safe for human consumption, and a predictive relationship between total aqueous mercury and mercury bioaccumulation in the predominant sport and food fish in EFPC was developed. Site-specific toxicity data and toxicity data used by EPA to calculate the national water quality criterion were reviewed to ensure that the site-specific criterion would not have adverse ecological consequences.

Because the relationship between total aqueous mercury and the accumulation of methylmercury in fish is very complex and poorly understood, researchers used two approaches to define the upper and lower bounds of the predictions. One approach used a simple linear extrapolation of the existing data for upper EFPC, where aqueous mercury concentrations are high (1 to 2 $\mu\text{g/L}$), whereas the other approach used bioaccumulation factors and

methylmercury-to-total mercury ratios for lower EFPC (where aqueous mercury is much lower) to provide a more conservative prediction.

The range of aqueous mercury concentrations predicted to yield a mean mercury concentration in fish equal to 0.4 $\mu\text{g/g}$, the "safe" value determined by the risk analysis, was 0.1 to 0.6 $\mu\text{g/L}$. Conservative interpolation between these upper and lower bounds of reasonable estimates has led to the recommendation of 0.2 μg of total aqueous mercury per liter as an appropriate criterion for upper EFPC. Achievement of such a concentration in the stream would represent a great reduction ($\sim 80\%$) in mercury concentration and would be a challenging goal for the Y-12 Plant environmental restoration and compliance programs.

¹*Health Sciences Research Division, ORNL.*

86 Quantitative Sample Collection Objectives Lead to Improved Data Usability

C. J. Ford, J. J. Beauchamp, and R. D. Schmoyer

The Clinch River Environmental Restoration Program is conducting the second phase of a remedial investigation (RI) on Clinch River and Poplar Creek. One RI goal is to provide risk assessment using data representative of the river-creek system by studying several reaches along the river and the creek.

One hypothesis of risk assessment is that current contaminant concentrations in Clinch River or Poplar Creek exceed risk criteria for human health or the

environment. System variability and the number of samples needed to accept or reject the risk assessment hypothesis were estimated from existing water flow and from a suite of contaminant concentration data that represent a variety of chemical behaviors.

Each sample number was calculated by using a contaminant coefficient of variation (CV), a contaminant action level (AL), and a specified confidence or power level. Statistical power is the probability of finding that the upper 95% confidence

Researchers Walter Hill and Art Stewart sampled algae and grazing fish at three sites downstream from the Oak Ridge Y-12 Plant. They found that (1) the percent of methylmercury to total mercury increases as it moves up the food chain (i.e., algae → stonerollers → shiners) and (2) the percent of methylmercury increases with distance from the Y-12 Plant.

limit (c.l.) of the mean is less than the AL for a particular contaminant. The CV estimate is used to calculate the 95% c.l. to be compared with the AL. The number of samples needed was calculated by combining power, CV, and a 1:2 ratio of contaminant concentration to AL. For the Clinch River, the number of samples that were needed to address the hypothesis ranged between 7 and 190 per study reach per quarter, depending on the contaminant. For Poplar Creek, between 3 and 15 samples per study reach per quarter were necessary to address the hypothesis.

These techniques will be used in future studies to optimize sample design and improve data usability. The combination of quantitative analysis of existing data and randomized sample collection yields a sampling and analysis plan appropriate to the system being characterized and the questions being addressed.

87 Data Review Activities Are Under Way for Phase 2 of the Clinch River Remedial Investigation

S. K. Holladay, C. C. Brandt, C. J. Ford, D. A. Levine,¹ R. B. Cook, R. L. Moody,² K. A. Newman,² D. D. Schmoyer, C. M. Chavannes,² G. W. Suter, and B. G. Blaylock

Innovative approaches to data collection and review are being used to assess and document the quality of the data produced in Phase 2 of the Clinch River Remedial Investigation. Field documentation and data review are being performed to verify all of the information produced in

support of the sampling event, including information in the field logbooks, on the chain-of-custody forms, in the sample preparation record, and available field data. All field quality-control samples—such as trip blanks, rinse blanks, field blanks, and field replicates—are being assessed.

All data deliverables are inventoried upon arrival to ensure that the required sample results and quality control documentation are present. As soon as they become available, analytical results are distributed to responsible personnel for evaluation and modification of the conceptual model as needed. Five percent of the analytical data is assessed by full data validation, which includes reviews of holding times, calibration criteria, surrogates, matrix spikes, duplicates, blanks, laboratory control samples, and other instrument parameters. Holding times, spike recoveries, and laboratory control samples will be reviewed for all analytical data that are available electronically.

Software developed by the U.S. Environmental Protection Agency (EPA) is used to screen and load the electronic data. CAVEAT, software developed by Science Applications International Corporation, is used to assist in the analytical review and validation of all EPA Superfund Contract Laboratory Program electronic deliverables.

During each step of the review process, the data are qualified through the use of predefined flags. The final data assessment involves the integration and evaluation of all the review information to assess the usability of the data in relation to the project data quality objectives. Any problems that may affect data quality are

reported as programmatic exceptions and are tracked until they are resolved.

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88 Groundwater Transport of Multiple Bacterial Strains Is Detected Through PCR Analysis

R. S. Burlage, A. V. Palumbo, and J. F. McCarthy

A goal of DOE's Subsurface Microbiology Program is to describe factors that control bacterial transport through soil subsurface. Tracing individual species of bacteria under field conditions is often difficult because (1) genetically modified microorganisms cannot be used and (2) a large population of indigenous microorganisms is present.

Because molecular methods can overcome these problems, they were employed to distinguish injected bacteria from indigenous bacteria. A field experiment was performed with five different bacterial strains used by investigators in the program. Strains were grown in 20-L carboys and transported to the injection site, a well-characterized field site near Georgetown, South Carolina.

Samples were then withdrawn from five wells and collected by filtration on filters with a 0.2- μ m pore size. A reference strain was added to the samples to determine DNA extraction and polymerase chain reaction (PCR) efficiency. Using a modified extraction technique, researchers obtained total DNA from these filtered samples. DNA samples were then

subjected to PCR analysis for each of the five strains.

PCR primers (20-mer) were described for each strain, as well as a set of nested primers that were used for reamplification of weak signals. Thus, tools were developed that could be used to examine the transport or survival of bacteria. Other field injections are planned to identify factors that enhance or inhibit bacteria transport.

89 Selective Agents Are Necessary to Isolate Rare Native Strains for Bacterial Transport Studies

A. V. Palumbo, R. S. Burlage, S. P. Scarborough, and J. F. McCarthy

Unlike in controlled laboratory studies, in field experiments researchers can have difficulty tracing the transport of injected bacteria because of high background concentrations of bacteria in a receiving aquifer (e.g., 2×10^5 colony-forming units per milliliter at a proposed field site in Oyster, Virginia). In a collaborative transport experiment funded by the DOE Subsurface Science Program, researchers are examining the application of molecular techniques (DNA hybridization and polymerase chain reaction) to field transport studies. These techniques will be used to obtain quantitative results on breakthrough of multiple strains of bacteria with different surface properties, size, and shape.

In this study, scientists are constrained to using bacteria from the site in Oyster or from its vicinity; the strategy is to use highly selective media both to isolate rare

strains for use in the transport studies and to combine colony hybridization with specific DNA probes for use in transport monitoring. Rare strains for injection can be isolated by using either unusual carbon sources (e.g., naphthalene) or selective agents (e.g., antibiotics) that inhibit growth of most of the bacteria. No useful strains

have been isolated by using unusual carbon sources because nonspecific growth on carbon in site water or on impurities in the agar interferes with strain isolation. Several pigmented strains were isolated on media containing streptomycin, nalidixic acid, kanamycin, and rifampicin. However, all of them are resistant to multiple

Kym Campbell places a water sample in a double-seal plastic bag held by Jennifer Field. Contaminant levels in water samples from the Clinch River and Poplar Creek were evaluated during Phase 2 of the Clinch River Remedial Investigation, conducted in part by Clell Ford, John Beauchamp, and Denise Schmoyer.

antibiotics and thus cannot be used together.

Other selective agents (e.g., 8% NaCl, cadmium, copper, phenol) have also been used successfully to isolate very rare strains from the site. DNA probes are being prepared from these strains before injection at the Oyster field site.

90 Novel Thermophilic Metal-Reducing Microorganisms Are Isolated from Deep Subsurface Sediments

T. J. Phelps, S. M. Pfiffner,¹ C. Zhang,² and D. C. White³

Investigating metabolism, metal reduction, and the survival of thermophilic microorganisms isolated from deep subsurface environments provides an important knowledge base from which to evaluate the potential of deep subsurface bacteria to alter or mitigate wastes. ESD researchers and collaborators have examined subsurface environments that are >2500 m beneath the land surface and have in situ temperatures of 20 to >70°C. Fermentative and metal-reducing microorganisms that appear distinct from known taxa have been isolated from these deep subsurface formations.

Thermophilic metal-reducing anaerobes isolated from >2-km depths in the Taylorsville Triassic Basin were compatible with the geologic setting from which they were derived. They metabolize, grow, and survive at 70°C with an alkaline pH of 7.5 to 8.5 under brackish conditions. Furthermore, these unusual microorganisms tolerate brines containing 0.5 to 5% salt, and they reduce iron, manganese, and uranium when using carbohydrates or

volatile fatty acids as an energy source. Investigations also focus on the ability of these micro-organisms, which were hydrologically and geologically isolated for millions of years, to survive under in situ temperatures and pressures and at low nutrient levels.

The metabolic and physiologic characteristics of subsurface microorganisms and the geochemical features that constrain microbial abundance and activities in subsurface environments have been documented. Procedures developed through these studies have been implemented by DOE bioremediation demonstration projects and by environmental consulting firms.

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91 Population Parameters of Small Mammals Are of Little Value as Endpoints of Toxicant Exposure in Biomonitoring Programs

B. T. Walton, S. S. Talmage, D. L. DeAngelis, and J. J. Beauchamp

Biological monitoring is undertaken at many DOE sites to determine whether hazardous chemicals have been released to the environment or whether known releases have an adverse impact on the biota inhabiting chemically contaminated areas.

Guidance from the U.S. Environmental Protection Agency (EPA) calls for surveying terrestrial vertebrate populations

to determine whether they are adversely affected at hazardous waste sites. To assess the value of the studies undertaken at chemically contaminated field sites, researchers at ORNL conducted a critical review of the published scientific literature on small mammal population studies. On the basis of a critical analysis of the published literature spanning more than 40 years, ORNL researchers concluded that population studies failed to show

and earlier, mitigate against detecting single-factor causes of population declines in the field.

A major concern for demographic studies of small mammals under field conditions is the inability to show statistically significant differences caused by chemical treatment against a background of high variability in animal numbers. Considering the populations, and in the face of the experimental limitations of population complexity and unpredictability of factors that influence the size of small mammal studies, ORNL researchers concluded that conducting field studies to detect effects of hazardous chemicals on small mammal populations in the field is of questionable value.

This plate contains bacteria that are resistant to nalidixic acid, a nonclinical antibiotic. Isolating this bacteria will allow researchers Tony Palumbo and Bob Burlage to trace the movement of native strains of bacteria in the subsurface.

demographic changes in small mammal populations exposed to toxicants in the field. Moreover, fundamental properties of the dynamics of small mammal populations, documented by ecologists since the 1940s

92 Signature Lipid Biomarker Analysis Is Applied to Assess Biomass, Community Structure, Nutritional Status, and Specific Metabolic Attributes of the Deep Subsurface Microbiota

D. C. White¹ and D. B. Ringelberg¹

Analysis of deep subsurface sediments, drilling muds, and makeup fluids by signature lipid biomarker (SLB) analysis quantitatively assesses viable biomass, community structure, and nutritional or physiological status of the microbiota in situ and thus provides quality assurance that the microbes recovered from sample cores are not contaminants acquired in the recovery process. With the legitimacy of the isolates established by the SLB analysis, the properties of subsurface microbial communities and isolates can be examined.

Organisms recovered from the Taylorsville Triassic Basin >9000 ft below ground surface exhibited the attributes necessary for survival: thermophily, salinity resistance, and anaerobic metabolism (with metal reduction as the terminal electron acceptor). In situ SLB analysis of the extant microbiota from a semiarid site showed high levels of sulfate-reducing bacteria associated with lacustrine, but similar levels were not present in paleosol or fluvial subsurface sediments within a 30-m facies recovered from a depth of 170 m. Subsurface sediments generally show a decreasing viable biomass with increasing depth; however, sediments recovered from high-discharge sites showed high proportions of actinomycetes signature lipids in comparison with low-discharge areas in the same horizon. When added to subsurface soils, specific microbes, such as the anaerobic dechlorinator *Desulfomonile tiedjei*, can be detected or identified by their lipopolysaccharide lipid A hydroxy fatty acids.

SLB analysis of microbial communities at the Savannah River Site indicated that Type II methane-oxidizers increased as the subsurface in situ remediation of TCE became more effective. SLB analysis detected that the shifts in the microbial communities correlated with effective biodegradation of petroleum hydrocarbons from the Kwajalein Atoll. Furthermore, SLB analysis of the rhizosphere microbiota from white oak trees showed increased fine-root rhizodeposition of viable microbial biomass when the trees were exposed to elevated levels of atmospheric CO₂.

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93 Data Coordination Activities for the ORNL Site Environmental Restoration Program Are Initiated

L. J. Allison, L. A. Hook, and J. W. Autrey

Documenting the availability and location of historical and current environmental measurement data relevant to the ORNL Environmental Restoration Program is a major concern of ORNL Environmental Restoration management. For the scope of the Environmental Restoration Program, several types of environmental measurement data are required: sampling, field measurement, analytical laboratory, geographic information system, and facility management.

Many groups collect data, and group activities may overlap with one another or with earlier sampling programs. To avoid a duplication of effort within Environmental Restoration and ORNL, a formalized Environmental Data Coordination Activity was initiated. Issues include the need for data coordination within the ORNL Environmental Restoration Program, the types of data in the scope of the program, and the need for standardized data formats and naming conventions that are consistent with DOE Oak Ridge Operations Office Environmental Information System standards.

In addition, data collected by the ORNL environmental compliance monitoring programs for use by the Environmental Restoration Program, along with the methods by which the data are obtained and managed, are concerns. An inventory of environmental measurement data within

ORNL was initiated to determine the extent of existing data. The survey requested information about the types of data (e.g., groundwater chemistry, surface water flow, geographic information system), the data custodian, the data management system, and the person with final-decision authority about the data. Interviews with data managers have been scheduled to complete the compilation of information.

The ORNL Site Environmental Restoration Data Coordination Committee will review the results of the data inventory before suggesting additional action.

94 Specific Data Transfer Format Is Defined for OREIS

R. A. McCord

The Oak Ridge Environmental Information System (OREIS) was developed and is being managed by ORNL ESD staff, the Computing Applications Division, the Health Sciences Research Division, and Computing and Telecommunications Services to fulfill a regulatory requirement for a consolidated database of environmental measurements. The first major activity of OREIS was to define and to test a relational database model that could store the wide diversity

of environmental measurements. Those measurements, which are transferred to OREIS, are generated from activities that support the monitoring of current operations and the remediation of contamination from previous operations.

When OREIS first began to collect environmental data sets from restoration projects, data were transferred in the format (structure and database) used for the project activities. The inconsistencies and incompleteness of data and documentation received from the projects resulted in significant delays associated with loading data into the OREIS database.

To correct this problem, OREIS staff defined a specific format for data transfer. This format includes the specification of required and optional fields; the definition of one data record per measurement; the use of OREIS units, codes, and definitions; and the use of a database transport file structure. The specification of the format more clearly defines the database requirements for projects and will promote consistency and completeness of the data before they are transferred to OREIS. This new strategy for data transfer should enable OREIS and related environmental programs to better meet the regulatory expectations for data access.

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Division Operations

Introduction

The Division Operations Section of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) supports ESD in the following areas: administration; environment, safety, and health; finance; information; and operations. At the close of FY 1994, ESD employed 238 staff; during the year, more than 350 guests and staff from other divisions also worked on ESD projects. The division is housed mainly in nine buildings that contain offices, research laboratories, and special-purpose rooms. ESD is responsible for two large field installations and several other field locations on the Oak Ridge Reservation.

The Administrative Support Group handles personnel and staffing-related functions, education efforts, and the day-to-day oversight of activities in the ESD facilities. The group also is responsible for interactions with U.S. Department of Energy representatives; organizational units within Martin Marietta Energy Systems, Inc.; and other ORNL divisions and offices.

The Environment, Safety, and Health Group focuses on helping the division meet the multitude of environmental, safety, and health requirements set forth to ensure that work is conducted in a manner

that is safe for staff and the environment. This group helps the division decipher requirements related to such concerns as safety reviews and documentation, waste-related activities, training, and radiation protection.

The Finance Group provides support coordinated by a staff member from the Finance and Business Management Division. The group assists ESD in tracking budgets and meeting reporting requirements, in establishing subcontracts, and in estimating costs for work proposals.

The Information Support Group provides editing, graphics, library, information management, and information processing services. The information processing services include assistance with publication clearance forms, the compilation of division statistics, and the production of division-level reports and other information.

The Operations Support Group offers computer networking assistance, as well as support from the Plant and Equipment Division and the Instrumentation and Controls Division. The group's activities include scheduling work priorities for its staff from other divisions and ensuring that ESD receives the best possible research and maintenance support. Computing support provides a network backbone for the division and fulfills administrative requirements, such as those regarding inventories and security.

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Program Activities 2

Biofuels Feedstock Development Program

Introduction

The Biofuels Feedstock Development Program (BFDP) is the U.S. Department of Energy's (DOE's) national program to develop new crop-based sources of biomass for energy. BFDP supports the missions of DOE and DOE's Office of Energy Efficiency and Renewable Energy, Biofuels Systems Division, and Biomass Power Program. The Environmental Sciences Division (ESD) of Oak Ridge National Laboratory (ORNL) leads and manages BFDP. Universities, U.S. Department of Agriculture (USDA) facilities, and industrial cooperators participate in BFDP research and development activities each year.

The mission of BFDP is to lead the nation in research, development, and demonstration of environmentally acceptable and commercially viable biomass supply systems. The program is designed to integrate and promote multiple objectives in agriculture, energy, and the environment by fostering the best research, development, and demonstration in the private, academic, and government sectors. The program is committed to ensuring that information on biomass supply systems is accurate, understandable, and accessible.

ESD has provided field management, research, and analysis for BFDP since 1980. The program currently supports projects in six major areas, referred to as tasks: Model Wood Energy Species; Model Herbaceous Energy Species; Environmental Research; Systems

Integration and Analysis; Scale-up, Feasibility, and Demonstration; and Energy Crops Data and Information Management. Researchers at universities and USDA facilities perform much of the research in the program, particularly in the first two tasks. Throughout its history, the program has included 25 to 35 such outside cooperators at any given time. ESD's research efforts have emphasized basic genetics, physiology, and biotechnology projects that support the development of woody and herbaceous crops, resource assessments and economic analyses, and environmental research and analysis.

BFDP's primary DOE sponsor is the Biofuels Systems Division in the Office of Transportation Technologies. BFDP also works with other governmental and private organizations. Recent activities include assessments, cooperative projects, and work-for-others efforts with the National Renewable Energy Laboratory, the U.S. Environmental Protection Agency, the Electric Power Research Institute (EPRI), the Tennessee Valley Authority (TVA), and the National Audubon Society.

The technical summaries in this section provide details about research accomplishments in the Biofuels Feedstock Development Program. For further information about research associated with the program, see technical summaries 49, 60, and 63, located elsewhere in the report.

Model Wood Energy Species

BFDP has supported research on the production of short-rotation woody

crops since 1978. Having conducted an extensive species-screening program and developed management systems for short-rotation woody crops, BFDP is currently focusing its efforts on developing the genus *Populus* as a model wood energy species. Using hybrids developed through BFDP research, commercial production of *Populus* as a short-rotation crop has begun in the Pacific Northwest. Improvements in productivity, site adaptability, and tolerance for biotic and abiotic stresses are required before such systems are feasible in other regions. *Populus* crop development projects in the upper Midwest and the South are addressing these topics, whereas work in the Pacific Northwest now emphasizes performing genetic mapping and understanding the genetic control of *Populus* productivity. Other woody crops projects are developing production systems for hybrid willow in the Northeast and for silver maple in the Midwest.

Model Herbaceous Energy Species

The objective of the Model Herbaceous Energy Species task is to select and improve herbaceous crops and cropping systems in a way that is environmentally and technically sound and that attracts industry support and cost-shared research. Part of the objective is to ensure that environmental risks and costs are minimized and that a portfolio of high-quality feedstocks is available for end users. The task emphasizes switchgrass (*Panicum virgatum*), a native perennial, warm-season grass. Switchgrass was chosen for development as a model species for herbaceous crops research because of its performance in screening trials. In the trials, switchgrass was very productive on a wide range of sites with relatively low levels of fertilizers and pesticides.

Seven actively funded projects are currently under way in the herbaceous crops task, including management, breeding, physiology, and tissue culture of switchgrass. The near-term focus of these projects is to develop the management techniques, physiological understanding, and breeding technology necessary to establish, produce, and harvest switchgrass in an economically and environmentally sound manner. The longer term objectives are to characterize and improve switchgrass as a biofuels crop.

Environmental Research

The Environmental Research task is focused on developing environmental data specific to energy crop production systems. The objectives of this task are (1) to provide reliable information to support the environmental soundness of recommended biofuel supply systems and (2) to provide innovative approaches to energy crop production that will promote environmental benefits. In this task, environmental data and information are developed in a way that addresses the sustainability of energy crop production and provides relevant and accurate information to support the development of effective environmental assessments.

The Environmental Research task is closely coordinated with other BFDP tasks, and it promotes interaction with other external research and environmental groups. Research projects have been developed through extensive discussions and interactions with industrial, utility, and environmental organizations. For example, the initial studies of biodiversity in short-rotation woody crops included support for and cooperation with the USDA Forest Service and the National Audubon Society. Research supported by this task includes studies associated with

the scale-up planting of hybrid poplar in Minnesota and a cooperative research project with TVA and Alabama A. & M. University that addresses erosion and chemical movement from biomass plantings.

Studies indicate that energy crop development promises to improve soil and water quality, increase the diversity of selected avian and mammal species, and reduce greenhouse gases. The potential for converting millions of acres from other uses must be considered in planning the expansion of biomass energy technologies to the demonstration, scale-up, and commercialization stages. These landscape changes will raise questions that must be addressed for biomass development to be feasible.

Systems Integration and Analysis

The Systems Integration and Analysis task was created in FY 1994 from portions of two former tasks—the Economic Analysis and Integration task and the Environmental Research and Analysis task. Systems Integration and Analysis thus unites all the analytical elements associated with feedstock supply systems. The overall objective is to provide timely and relevant information to BFDP, DOE's Biofuels Systems Division, industries, and other government organizations engaged in biomass energy research and development.

The task supports a range of analyses evaluating and defining the interactions between factors affecting the price, supply, and environmental effects of biomass energy crops. Participants include ESD staff, other ORNL staff, TVA, other federal agencies, and universities. In FY 1994, researchers began a major 3-year integrated analysis project covering six Midwestern and five Southeastern states.

Scale-up, Feasibility, and Demonstration

The Scale-up, Feasibility, and Demonstration task was created in FY 1994 to develop information about the economics of commercial-scale energy crop plantings and to provide an identifiable and consistent contact within BFDP for industries that need information on feedstock development. In cooperation with EPRI, the Minnesota Department of Natural Resources, and USDA, this task supported operational-scale short-rotation woody crop plantings on 1000 acres in Minnesota during FY 1994. The task also provided technical support for a series of feasibility studies supported by DOE, EPRI, and private groups. In these studies, potential users of energy crops evaluated various energy crop data (such as cost and supply data) and assessed the feasibility of various end uses.

Energy Crops Data and Information Management

The Energy Crops Data and Information Management task addresses the increasing demand for information about energy crops. Information is requested by researchers, policymakers, entrepreneurs, utility companies, and landowners. Staff now place increased emphasis on defining the audience for each information product. BFDP develops and distributes a variety of products and services—newsletters, fact sheets, technical reports, white papers, document distribution, and public accessibility on the Internet. Staff produce and distribute the newsletter *Energy Crops Forum* three times a year. In addition, staff respond to general and specific information requests, assembling packages of reports and reprints, queries of databases, and copies of slides.

Technical Summaries

95 Biomass Cost Varies Across Tennessee

R. L. Graham

An innovative analysis of the potential spatial variation in the supply and delivered price of biomass in Tennessee was recently completed. This analysis examined the projected delivered price of wood from energy crops to 21 evenly spaced locations across Tennessee. Such a study is the first to systematically examine the spatial variation in the marginal cost (expressed in dollars per delivered dry ton) of supplying biomass, taking into account both spatial variations in transportation costs and in farm-gate biomass prices. (Farm-gate prices are the prices paid to the farmer.)

The supply and farm-gate price information for the study was derived from a county-level biomass database created by the Biofuels Feedstock Development Program. BRAVO, a computer model based on a geographic information system and developed at The University of Tennessee, was used to calculate the transportation costs associated with supplying biomass to the 21 locations. Even at low demands (e.g., 100,000 dry tons per year, an amount sufficient to support a 20-MW power plant), some spatial variation existed in the marginal cost of delivered biomass.

The central and the far southwest portion of the state had the lowest marginal costs (~\$35 to \$40 per delivered dry ton), and a \$10 spread occurred between the highest and the lowest cost locations. At high demand (e.g., 1 million dry tons per year,

an amount sufficient to support a large ethanol plant), the spatial differences were amplified and delivered prices were higher. At this demand level, all of the lowest delivered prices were in the north-central portion of the state (~\$43/dry ton), and the spread was \$25.

The study demonstrated that fewer locations will be suited for energy technologies with large demands for biomass feedstock at a single location. Energy technologies that demand small or moderate amounts of biomass will be feasible at more locations.

96 Tissue Cultures Are Not Valid Surrogates for Whole-Plant Assessments of Water Stress Tolerance in Poplar Clones

T. J. Tschaplinski and G. A. Tuskan

The use of water stress-tolerant poplar clones would greatly expand the acreage potentially suitable for energy plantings and would increase the productivity of available sites. In vitro assays of water stress tolerance would greatly reduce the time and effort needed to characterize the genetic potential of selected poplar (*Populus* spp.) clones.

To determine whether in vitro assays can be used to assess water stress tolerance, six clones in a pedigree consisting of black cottonwood (*P. trichocarpa* ♀ Torr. & Gray) and eastern cottonwood (*P. deltoides* ♂ Bartr.) and four hybrid progeny were regenerated in tissue culture and subjected to 0–20% polyethylene glycol MW 8000 in the nutrient medium, providing osmotic potentials that ranged from –0.40 to –1.29 MPa. Water stress tolerance was

assessed by measuring callus growth and solute accumulation that occurred under various stress levels.

Among the light-grown cultures (16-h photoperiod), clones with the highest relative growth rate after 18 d in the nutrient medium without polyethylene glycol included hybrids 246 ♀, 242 ♂, and the *P. deltoides* ♂ parent—the same clones that tended to be the most stress tolerant in previous whole-plant studies. However, stress treatments yielded few differences in

relative growth rate between clones, and differences were not related to solute accumulation. Polyethylene glycol provided severe osmotic stress that suppressed growth and dehydrated the callus cultures. Inorganic cations and free amino acids constituted the bulk of the solutes in calli, whereas concentrations of soluble sugars were low. Therefore, results obtained from callus cultures growing under artificially induced water stress regimes did not parallel those obtained from water stress studies on whole plants.

This regenerated hybrid poplar plantlet was used in an in vitro screening study for drought tolerance. The study demonstrated that excised plant tissues behave much differently than their donor plants in terms of response to drought and thus cannot be used as surrogates in drought screening studies.

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Environmental Information Analysis Program

Introduction

The Environmental Information Analysis Program was created within the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) in FY 1992 to consolidate ongoing research data management projects under common leadership. The program highlights the division's abilities to support large, integrated environmental database projects with extensive data analysis components. The management of research data has become a vital component of modern observational and theoretical science. The significant global change projects of the 1990s—such as the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) project; the DOE Computer Hardware, Advanced Mathematics, and Model Physics project; and the National Aeronautics and Space Administration's (NASA's) comprehensive Earth Observing System Program—have large data management components that are vital to their success. The ability to intelligently manage and analyze large environmental data sets is one of ESD's historically unique capabilities.

The Environmental Information Analysis Program consists of four components: the ARM Archive, which supports the DOE ARM project; the Carbon Dioxide Information Analysis Center (CDIAC), which supports DOE's global change-related research; the ORNL Distributed Active Archive Center (DAAC), which supports NASA's Earth

Observing System Program; and the Oak Ridge Environmental Information System (OREIS), which supports the data needs of local restoration efforts at DOE facilities in Oak Ridge.

The technical summaries in this section provide details about research accomplishments in the Environmental Information Analysis Program. For further information about research associated with the program, see technical summaries 7, 8, 69, 70, 71, and 94, located elsewhere in the report.

Atmospheric Radiation Measurement Archive

ESD manages the long-term archive for the ARM project, a DOE field project that will obtain precise measurements of atmospheric radiation-related phenomena to improve general circulation models used in predicting climate. The ARM Archive is a worldwide resource of meteorological and atmospheric physics information. The information will be useful not only for refining general circulation models but also for understanding other atmospheric phenomena such as tornado and precipitation formation. The ARM Archive stores, manages, and processes data collected during the ARM project and makes that data available for use by the ARM Science Team members and the general scientific community.

The archive has received data since June 1992 and currently houses approximately 60 gigabytes of data in more than 340,000 files. The data are stored in an ORNL mass storage system

that was modified by the ARM Archive to increase its storage capacity of data from 1.1 terabytes to 5 terabytes. A graphical user interface is provided so that users can directly request data based on the set of instruments that collected the data and on a date range of interest. The requested data files are made available for pickup via File Transfer Protocol, and the requester is notified that the data are ready to be claimed. Design and implementation of improvements to the user interface and data documentation are proceeding.

The ARM Archive is closely integrated with the ORNL Center for Global Environmental Studies, and close coordination with ORNL's High Performance Computing initiative has been established. The new Intel Paragon supercomputer and the massive ARM Mass Storage System are linked to allow complete and close interaction of the two systems.

Carbon Dioxide Information Analysis Center

The purpose of CDIAC is to acquire or compile, quality-assure, document, archive, and distribute data and other information concerning CO₂, other greenhouse gases, and climate change in support of DOE's Global Change Research Program (GCRP). By serving as GCRP's information-gathering and distribution center, CDIAC provides technical support for GCRP; the general research, policy-making, education, and corporate communities; and the public. CDIAC also operates the World Data Center-A for Atmospheric Trace Gases, which is a component of the World Data Center System of the International Council of Scientific Unions.

CDIAC activities include obtaining and evaluating data and technical literature,

producing numeric data packages (NDPs) and computer model packages (CMPs), and distributing CO₂-related reports. During FY 1994, CDIAC published four new NDPs; topics included long-term climate data from the former U.S.S.R., oceanic carbon chemistry data, carbon emissions from land-use change, and data for assessing the vulnerability of the U.S. Gulf Coast to sea-level rise. The center also published three issues in the *DOE Research Summary* series and an issue of the newsletter *CDIAC Communications*. In addition, CDIAC published *Trends '93: A Compendium of Data on Global Change* (the third report in the *Trends* series) and *Direct Effects of Atmospheric CO₂ Enrichment on Plants and Ecosystems: An Updated Bibliographic Data Base*.

During FY 1994, CDIAC filled 7485 information requests from 2796 individuals in 67 countries and responded to 1099 requests from 59 countries for NDPs and CMPs. This brings CDIAC's total to 52,405 requests from users in 113 countries since 1985.

Oak Ridge Environmental Information System

The Environmental Restoration programs of the DOE Oak Ridge Operations Office and Martin Marietta Energy Systems, Inc., completed in FY 1994 the initial development of OREIS to meet requirements described in the Federal Facilities Agreement and the Tennessee Oversight Agreement. According to these agreements, DOE will centralize and consolidate environmental data from all restoration and compliance programs on the Oak Ridge Reservation.

The first goals of the OREIS development team are to make the data useful to more environmental programs, to improve the consistency of the data quality, to

improve the defensibility of the data and its analytical products, and to reduce the redundancy of data collection and handling by different environmental programs. Subsequent goals include specifying minimal data management standards and developing a robust database and information system to manage, display, and analyze the data. The OREIS framework—the database, standards, and information system—will be used to implement the data management program for environmental restoration activities at the DOE facilities in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio.

A two-part evaluation process for the beta version of OREIS was successfully implemented during the third quarter of 1994. Twenty-four volunteers representing primary user groups participated in an intensive 2-day hands-on training session, which was followed by a 6-week period during which they extensively tested and used OREIS functions. A second survey involved a broader representation of potential OREIS user groups that did not participate in the beta testing. The results of both surveys were reported and used as a basis for modifications to the system before its authorized release.

In June, DOE Headquarters approved the implementation of OREIS. The approval fulfilled a milestone for the DOE Oak Ridge Operations Office and authorized the release of OREIS as a production system.

ORNL Distributed Active Archive Center

In July 1993, ESD received funding from NASA to develop and operate one of nine Distributed Active Archive Centers (DAACs) for NASA's Earth Observing

System Data and Information System (EOSDIS). EOSDIS is part of NASA's contribution to the U.S. Global Change Research Program's effort to develop a predictive understanding of the global environment. The mission of the ORNL DAAC is to provide data and information about the Earth's biogeochemical dynamics and ecology for the global-change research community, policymakers, educators, and the general public. This information includes (1) ground-based products relating to biogeochemical dynamics and (2) links to data available through other DAACs.

The ORNL DAAC became operational in July 1994 and is now linked to the NASA system-wide Information Management System (IMS). This link allows users to search for and order data from any of the EOSDIS DAACs through a single user interface. A local user interface that offers capabilities not available through the system-wide IMS has been developed and is now operational.

Current data holdings include those from NASA's First International Satellite Land Surface Climatology Project Field Experiment (FIFE) project and the Oregon Transect Ecosystem Research project. Obtaining these data holdings is part of a larger effort to move appropriate data from NASA's Pilot Land Data System to the ORNL DAAC. Staff in the ORNL DAAC are also working with NASA's Boreal Ecosystem-Atmosphere Study (widely known as BOREAS) and the FIFE Follow-on Investigation in order to receive and distribute data from these projects. During this past year, staff formed a close working relationship with CDIAC; as a result, the user community can now access many of CDIAC's data holdings through the NASA system-wide IMS and through the local ORNL DAAC user interface.

Technical Summaries

97 CDIAC Compendium Documents Recent Trends in Global-Change Data

T. A. Boden, D. P. Kaiser, R. J. Sepanski,¹ and F. W. Stoss¹

Recently published by the Carbon Dioxide Information Analysis Center (CDIAC), *Trends '93: A Compendium of Data on Global Change* provides synopses of frequently used global-change data. This third edition of *Trends* presents historical and modern records of atmospheric concentrations of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), two chlorofluorocarbons (CFC-11 and CFC-12), a hydrochlorofluorocarbon (HCFC-22), and two halons (H-1301 and H-1211) from an expanded number of globally distributed sites. Additional trace-gas data include historical atmospheric CO₂, CH₄, and N₂O records derived from ice cores.

Trends '93 provides revised and updated estimates through 1991 for global, regional, and national CO₂ emissions produced from the burning of fossil fuels, gas flaring, and the production of cement. Updated global emissions estimates through 1992 are presented for CFC-11 and CFC-12. *Trends '93* also updates and expands the presentation of long-term temperature records, whose spatial coverage ranges from an individual Antarctic (ice core) site to the entire globe and from the earth's surface to the lower stratosphere.

New subject matter in *Trends '93* includes a chapter for long-term regional precipitation records, several time-series

records for atmospheric aerosols, and isotopic ¹⁴C measurements for atmospheric CO₂ from several globally distributed sites.

The compendium documents the recently observed reductions in the growth rates of atmospheric CO₂ concentrations and emissions, cooling trends in global and hemispheric temperatures following the Mt. Pinatubo eruption of 1991, and reductions in global emissions of atmospheric CFC-11 and CFC-12. The report and electronic versions of the data are available from CDIAC at no cost.

¹*The University of Tennessee, Knoxville.*

98 CDIAC Assembles a Unique Numeric Data Package of Climate Data and Begins a Historical Analysis of Cloud Cover over the Former U.S.S.R.

D. P. Kaiser

In recent years many meteorological data have been exchanged between the National Climatic Data Center (NCDC), in Asheville, North Carolina, and the Research Institute of Hydrometeorological Information (RIHMI) in Obninsk, Russia. Under a Work for Others (WFO) agreement with NCDC, the Carbon Dioxide Information Analysis Center (CDIAC) has quality-assured, documented, and made available to the public an important RIHMI database of meteorological observations made at 3- and 6-hour intervals at 223 U.S.S.R. stations during 1936-90.

The RIHMI database offers a wealth of meteorological data for a large and climatologically important part of the

earth's land area. To determine the suitability of the RIHMI database for regional climate change research, we used the database to examine the spatial distribution of a critical atmospheric variable (i.e., total cloud amount) over the U.S.S.R. The resulting distribution was compared with data from the unique atlas *Global Distribution of Total Cloud Cover and Cloud Type Amounts Over Land*.¹ Seasonal and annual means of total cloud amount for 84 latitude/longitude grid cells over the U.S.S.R. were compared for the common data period 1971–81.

For all seasons, the RIHMI means were higher for most grid cells (typically by 3–6%); differences over the central reaches

of Siberia were even greater. However, for mean annual cloud amount, ~30% of the cells showed differences of <1%; these cells are located mainly in the western part of the country, where the RIHMI database has its greatest station density. For the central and eastern regions of the U.S.S.R., an area of varied topography where the RIHMI station density is much lower than that of the atlas's database, the RIHMI database may yield questionable values of total cloud amount. However, for the western reaches of the country, this database may be suitable for studies involving analysis of total cloud amount.

The possible causes of the seemingly systematic seasonal differences between the

A flux measurement tower and an aircraft take concurrent measurements of CO₂ fluxes. The measurement of CO₂ fluxes is one of the ways that the ORNL DAAC supports NASA's field investigations.

two databases are being investigated further.

¹S. G. Warren et al., *Global Distribution of Total Cloud Cover and Cloud Type Amounts Over Land*, National Center for Atmospheric Research, Boulder, Colo., 1986.

99 Procedures Are Developed for Processing and Validating Environmental Data for the OREIS Database

R. J. Olson

The primary function of the Oak Ridge Environmental Information System (OREIS) is to consolidate and maintain consistent and qualified data associated with environmental restoration and monitoring. The assumption is that the data in OREIS meet universal criteria; however, the data meet only the data quality objectives defined by each project, and the project data generators are responsible for validating the data. OREIS checks the integrity of data and metadata in the database.

One of the most difficult aspects of compiling data into the OREIS database from projects or from other sources has been the process of deciding when the data are of sufficient quality to meet the OREIS database objectives. The majority of data coming to OREIS are very clean; however, portions of data often have problems (e.g., invalid codes). Often, a 90% rule applies to processing the data: 90% of that data are good, but 10% have problems. Of that 10%, 90% have problems that can be resolved fairly quickly (possibly requiring twice as much time as did the first pass, when the initial data was

read in), but 10% of this set (1% of the initial set) have more severe problems.

Making several telephone calls and examining the data, researchers can resolve 90% of the more severe problems (the resolution of these problems may take four times as much time as the resolution of the second-iteration problems, however). The remaining problems (involving 0.1% of the initial set) may never be completely resolved and could thus delay the transfer of the majority of data into the OREIS database.

Guidelines were developed for determining when to stop working on resolving the problems and to begin placing the unresolved data, with appropriate metadata and flags, in a specially designated area of the database. The decision to set aside data is based on how crucial the data are to the complete data transmittal, the availability of knowledgeable staff to resolve and authorize the changes, and the difficulty of the problem at hand (i.e., whether the original lab sheets, log books, and data files are available). The problem data are described, the attempts to resolve them are documented, and the questionable data are removed from the data set to be placed in the active OREIS database and are stored separately as "set aside" data sets.

100 ORNL Distributed Active Archive Center Provides Data on Biogeochemical Dynamics

R. S. Turner, L. D. Voorhees, and P. F. Daugherty

The National Aeronautics and Space Administration (NASA) has designated

ORNL as the site for the Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics, one of eight DAACs established by NASA as a part of the Earth Observing System (EOS) Data and Information System (EOSDIS) project.

EOS and EOSDIS are part of NASA's contribution to the U.S. Global Change Research Program, an interagency effort of the U.S. government to develop a predictive understanding of the global environment.

The ORNL DAAC provides (1) an information management system that is integrally linked to the other DAACs; (2) a data archive and distribution system, including a user services function;

(3) value-added products that summarize and synthesize biogeochemical dynamics data from around the globe; and (4) guidance and support in the areas of data management, data quality assurance, and data integration to enable field experimenters to prepare those data for archive and distribution to other global change researchers. The ORNL DAAC is developing an on-line user interface and a user services office.

A User Working Group of global change researchers from ten outside organizations provides science oversight and guidance to DAAC developmental activities and operational functions. The DAAC's on-line user interface was demonstrated at the center's first User Working Group meeting on March 21-22, 1994.

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Environmental Restoration Program

The Environmental Restoration (ER) Program of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) coordinates and manages activities performed by various ESD staff members in support of U.S. Department of Energy (DOE) Environmental Restoration and the Environmental Restoration Program of Martin Marietta Energy Systems, Inc. DOE Environmental Restoration has embarked on a 40-year mission to reduce or eliminate risks to human health and the environment that result from past DOE operations. ESD staff are involved in all aspects of the environmental restoration process, including the preliminary assessment and identification of problems, site characterization, identification and selection of remedial actions, cleanup and site closure, and development of performance criteria and monitoring to assess the effectiveness of remediation activities.

Restoration of the environment continues to challenge scientists to develop innovative, cost-effective, technically sound approaches to environmental problem solving. ESD is involved in approximately 30 projects supported by DOE or Energy Systems' Environmental Restoration Program and approximately 50 projects closely related to efforts supported by the DOE Waste Management Program, the DOE Office of Technology Development, and other DOE programs, as well as the U.S. Environmental Protection Agency, the U.S. Department of Defense, the Electric Power Research Institute, and others. Efforts for DOE and Energy Systems' Environmental Restoration Program link ESD resources with those of other ORNL organizations, other DOE facilities, federal

agencies, academia, and industry and thus provide a broad base of technical expertise. These activities are grouped into five general areas on ESD's organization chart: On-Site and Off-Site Investigations, Groundwater Operable Units, Technical Support and Integration, Information Systems, and Remediation Demonstrations. Some projects supported by Environmental Sciences Division's ER Program are described below; other examples are presented in the section activities described elsewhere in this report.

Current ESD activities focus on the DOE sites in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio, although significant efforts are under way at other sites. Among other things, researchers at these DOE sites are working to identify natural hydrologic integrators of contaminant fluxes, such as surface water and groundwater drainages. The Clinch River is an example of a hydrologic integrator for the contaminant releases from the three DOE facilities in Oak Ridge. Environmental characterization and monitoring within these hydrologic integrator areas support risk-based prioritization of efforts, development of conceptual models of environmental processes to guide and focus investigations, feasibility studies, and assessment of the effectiveness of remedial actions.

Groundwater investigations also take a holistic approach to guiding characterization and remediation. Groundwater efforts include nonintrusive geophysical methods that allow rapid characterization of subsurface features and contaminant flow pathways without the use of expensive drilling or the generation of

contaminated spoils. Conceptual and numerical models are being developed, evaluated, and improved to guide the investigation and remediation of contaminated groundwater at the DOE sites in Oak Ridge, Paducah, and Portsmouth. Researchers use a supercomputer-supported three-dimensional model of groundwater flow to predict the effects that remedial actions (e.g., capping of buried waste) have on groundwater flow and contaminant movement.

The ER Program also supports the Energy Systems Groundwater Program Office, which provides technical support and guidance on groundwater issues to the three Oak Ridge facilities and the Paducah and Portsmouth gaseous diffusion plants.

Surface water hydrologic monitoring activities support models of contaminant flux and are linked with investigations of subsurface processes and pathways of contaminant movement. These efforts provide tools to assist in environmental restoration decision making and provide opportunities to test fundamental hypotheses about issues ranging from microscale soil processes to large-scale watershed phenomena.

Researchers' assessments of human health and ecological risk integrate information about contaminated media, contaminant movement, and the ecosystem, and they help focus environmental restoration efforts on the contaminants, pathways, areas, biotic populations, and communities of greatest concern. Risk assessment is essential for the selection of appropriate remedial actions. New tools for risk assessment are being developed, evaluated, and improved in conjunction with environmental restoration tasks and activities.

Biological monitoring provides information needed to assess ecological health, identify problem areas, guide remediation efforts, and document recovery at various levels: at the individual contaminated site, within the watershed, and at the facility as a whole (e.g., on the DOE Oak Ridge Reservation). Biomarkers, which are measures at the genetic or biochemical level, provide sensitive indicators of the exposure and response of organisms to toxic chemicals and other environmental stresses. Population studies provide a means of quantifying impacts and tracking the responses of populations to remedial actions. Investigations of terrestrial and aquatic ecosystems integrate the effects of multiple impacts, track the transfer of contaminants through the food chain, and provide information at scales appropriate for predicting and evaluating the effectiveness of remedial actions.

ESD staff are in the vanguard in developing data management systems, such as the Oak Ridge Environmental Information System, which provides a consolidated, consistent, user-friendly point of access for all environmental restoration and environmental compliance data for Energy Systems. Remote sensing, global positioning, and geographical information systems continue to be powerful tools for supporting environmental restoration activities.

The Clinch River Remedial Investigation includes examination of the nature and extent of contamination in sediment, surface water, and biota; identification and evaluation of remediation alternatives; and implementation of remedial actions and interim measures needed to protect human health and the environment. The primary approach is to conduct a phased remedial investigation on the Clinch River-Watts Bar Reservoir system, use information to identify high-priority sources of

contaminants to the off-site surface water system, carry out interim and final remediation in the river-reservoir system if necessary, and perform long-term monitoring of the river-reservoir system to assess the effectiveness of both off-site and on-site remediation activities.

Technology demonstrations are an increasingly important aspect of ESD's restoration activities. In situ vitrification demonstrations, in which soil and simulated wastes are melted to form leach-resistant glass and crystalline material, are leading to applications suitable for disposal trenches at ORNL. Soil remediation

demonstrations at the Portsmouth facility, where volatile organic compounds have been successfully removed at low cost, have led to full-scale application of the technologies at significant cost savings.

ESD plays a key role in merging basic research and efforts for environmental restoration, waste management, and technology development. Through the merger, we are in a better position not only to find new technologies and approaches but also to implement these technologies at DOE sites and create links with the private sector so that the technologies will be available in the global marketplace.

ESD Award Highlights 3

ESD Scientific, Technical, and Administrative Awards

Scientific Achievement

ESD awarded its 1993 Scientific Achievement Award to Philip M. Jardine for his meticulous research in soil chemistry and his innovative investigations into processes affecting the transport of chemicals through heterogeneous soils. By integrating information from the laboratory scale to the watershed scale, he has elucidated the processes that determine water flow, mobility of solutes, soil weathering, and the migration of contaminants under saturated and unsaturated flow conditions through soils with pores of various sizes. He has also developed experimental methods to determine chemical transformations during leaching using undisturbed soil columns and flow conditions representative of field environments.

Jardine's research is helping scientists better understand the processes that control the transport of mixed hazardous waste containing radionuclides, heavy metals, and organic chemicals. In addition, his insights into lateral flow paths are helping researchers develop more effective technologies for environmental remediation.

Philip M. Jardine

Technical Achievement

Tammy W. White received ESD's 1993 Distinguished Achievement Award for Technical Support in recognition of her expertise in geographic information systems (GIS) and her role as cochair of ESD's GIS Self-Directed Work Team and Operations Committee. She developed new techniques for data management using SAS and ARC/INFO and authored several scientific reports and posters. White was instrumental in planning a new system, including budgeting and acquiring equipment. She became proficient in GIS at a time when ESD and ORNL had few experts.

Tammy W. White

Patricia M. Presley

Administrative Achievement

ESD presented Patricia M. Presley the 1993 Distinguished Achievement Award for Administrative Support in recognition of her outstanding performance and professionalism in the position of secretary to the Hydrosystems Group. She successfully used her capabilities in desktop publishing, computer graphics, and database management to increase productivity and improve the quality of organization work products. As part of her work, Presley designed and implemented a prototype information management system for the division.

Lists 4

Awards and Honors

The following ESD personnel received professional, corporate, and/or organizational awards and honors during FY 1994.

S. M. ADAMS

Award of Achievement in Scholarly/Professional Articles, International Technical Publications Competition, Society for Technical Communication; Award of Distinction in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication; Outstanding Book of the Year in the Biological Sciences, Association of American Publishers; appointment as Scientific Book Editor, Ecological Society of America; appointment to Adjunct Faculty, Duke University; appointment as Associate Editor, *Journal of Aquatic Ecosystem Health*

M. O. BARNETT

Laboratory Cooperative Postgraduate Research Training Appointee, DOE, administered by Oak Ridge Institute for Science and Education

L. W. BARNTHOUSE

Technical Achievement Award, Martin Marietta Energy Systems, Inc.; appointment to Committee to Review the U.S. Department of Interior's Biomonitoring of Environmental Status and Trends Program, National Research Council

M. S. BEVELHIMER

Certificate of Appreciation for Service as President, Tennessee Chapter, American Fisheries Society

T. A. BODEN

Appointment as Director, World Data Center-A for Atmospheric Trace Gases; Award of Merit in Promotional Brochures and Award of Merit in Informational Brochures, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

R. S. BURLAGE

Appointment to Committee on Environmental Microbiology, American Society for Microbiology; appointment as editor, special issue of *Journal of Microbiological Methods*

M. D. BURTIS

Award of Achievement in Newsletters, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

P. J. CRABTREE

Certification as a Professional Secretary, Professional Secretaries International

W. D. CRUMBY

Award of Achievement in Scholarly/Professional Articles, International Technical Publications Competition, Society for Technical Communication; Award of Distinction in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

R. M. CUSHMAN

Award of Achievement in Newsletters, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

V. H. DALE

Distinguished and Sustained Scientific Achievement Award, East Tennessee Chapter, Association for Women in Science

P. F. DAUGHERTY

Corporate Honoree, Tribute to Women, Knoxville YWCA

W. E. DOLL

Appointment as Chair, Hazardous Waste Committee, Near Surface Geophysics Section, Society of Exploration Geophysicists

N. T. EDWARDS

Appointment to Editorial Review Board, *Tree Physiology*

M. P. ELLESS

Certification as a Professional Soil Scientist, American Registry of Certified Professionals in Agronomy, Crops, and Soils

R. H. GARDNER

Distinguished Landscape Ecologist Award, U.S. Chapter, International Association for Landscape Ecology; appointment to Scientific Advisory Committee for the Risk Analysis Program, Electric Power Research Institute; appointment as chairman of the Scientific Review Committee for the Sustainable Biosphere Initiative, Ecological Society of America

D. D. GATES

Best Paper Award, Waste Management '93 Symposium, American Nuclear Society; appointment as ORNL project team leader, DOE and U.S. Army Corps of Engineers

K. N. GIBSON

Award of Merit in Annual Reports, Technical Publications Competition,

East Tennessee Chapter, Society for Technical Communication

R. L. GRAHAM

Corporate Honoree, Tribute to Women, Knoxville YWCA; Significant Event Award, ORNL

M. S. GREELEY

Award of Achievement in Scholarly/Professional Articles, International Technical Publications Competition, Society for Technical Communication; Award of Distinction in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

P. J. HANSON

Appointment to Editorial Review Board, *Tree Physiology*; appointment to Editorial Board, *Journal of Environmental Quality*; Award of Merit in Scholarly/Professional Articles, East Tennessee Chapter, Society for Technical Communication

R. D. HATCHER, JR.

President-Elect, American Geological Institute; appointment to Nuclear Safety Research Review Committee, Nuclear Regulatory Commission; appointment to the U.S. National Committee on Geology Board of Radioactive Waste Management's New York Review Committee, and the National Research Council Commission, National Academy of Sciences Commission on Geosciences, Environment, and Resources

S. E. HERBES

Best Paper Award, Waste Management '93 Symposium, American Nuclear Society

P. L. HENRY

World-Class Teamwork Award, for the Biological Monitoring and Abatement

Program publishing team, ORNL Values Committee

S. G. HILDEBRAND

(Accepting for ESD)

Outstanding Division Award, Equal Employment Opportunity/Affirmative Action Program, ORNL; Special Events Sponsorship Award, Equal Employment Opportunity/Affirmative Action Program, ORNL

R. L. HINZMAN

Appointment to the Program Planning Committee for the Watershed '96 Specialty Conference, Water Environment Federation

D. D. HUFF

Certificate of Appreciation, 1994 Annual Meeting Organizer, American Water Resources Association

C. T. HUNSAKER

Technical Achievement Award, Martin Marietta Energy Systems, Inc.; appointment to Board of Trustees, Institute of Professional Environmental Practice; appointment to Advisory Council, Committee for the National Institutes for the Environment

M. A. HUSTON

Award of Excellence in Trade/News Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication; appointment as a Review Panel Member, *Tree Physiology*

G. K. JACOBS

Appointment to Technical Advisory Panel for the Hanford Low-Level Waste Disposal Program, DOE; Award of Excellence in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee

Chapter, Society for Technical Communication

B. R. JAMES

Certification as a Registered Professional Geologist, Tennessee

P. M. JARDINE

1993 Scientific Achievement Award, ESD

L. J. JENNINGS

World-Class Teamwork Award, for the Biological Monitoring and Abatement Program publishing team, ORNL Values Committee; Award of Merit in Annual Reports, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

N. E. KORTE

Appointment to Editorial Review Board, *Ground Water Monitoring and Remediation*

S. Y. LEE

Council, The Clay Minerals Society; Honorary Research Scientist, Institute of Rural Development, Korea

P. J. LEMISZKI

Certification as a Professional Geologist, Tennessee

S. E. LINDBERG

Invitation for extended sabbatical, Meteorological Institute of Stockholm University, Lund University, and the Swedish Environmental Research Institute

R. J. LUXMOORE

Award of Excellence and Award of Achievement in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

L. K. MANN

Award of Achievement in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

G. MARLAND

Appointment to Editorial Board, *Mitigation and Adaptation Strategies for Global Change*

T. P. McKENZIE

Teamwork Award, ESD

M. T. NANEY

Award of Excellence in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

T. R. NELSON

Award of Merit in Informational Brochures, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

J. E. NYQUIST

Appointment as chair of the Groundwater Geophysics Committee, Society for Exploration Geophysicists

D. H. OGLE

Award of Merit in Annual Reports, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

E. G. O'NEILL

Appointment as Guest Editor, *Plant and Soil*

R. V. O'NEILL

Distinguished Statistical Ecologist Award, International Association for Ecology

A. V. PALUMBO

Appointment to Advisory Committee, The University of Tennessee, Center for Environmental Biotechnology; patent disclosure, Innovative Use of an Indigenous Microorganism as an Environmental Tracer; patent disclosure, Natural Soil Inducers for Contaminant Degradation Released by Physical and/or Chemical Manipulations

P. D. PARR

Elected Vice President, Association of Southeastern Biologists; Teamwork Award, for southern pine beetle control on the Oak Ridge Reservation, ESD

T. L. PHIPPS

Quality Assurance Certificate of Recognition, ORNL

C. M. POOLE

Operations and Support Award, Martin Marietta Energy Systems, Inc.

W. M. POST III

Appointment as Associate Editor, *American Naturalist*

P. M. PRESLEY

1993 Distinguished Administrative Support Award, ESD

J. W. RANNEY

Appointment as Assistant Director, Joint Institute for Energy and Environment; appointment as international editor, *Biomass and Bioenergy*

A. W. RENSHAW

Award of Distinction in Annual Reports, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

D. ROGERS

Teamwork Award, ESD

B. A. ROSENSTEEL

Teamwork Award, for southern pine beetle control on the Oak Ridge Reservation, ESD

D. D. RHEW

Award of Merit in Annual Reports, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

K. A. ROSE

Award of Merit in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication; appointment as Associate Editor, *Transactions of the American Fisheries Society*

M. G. RYON

Teamwork Award, for southern pine beetle control on the Oak Ridge Reservation, ESD

M. J. SALE

Sustained Achievement Award, ESD; Significant Event Award (Team), Lower Mokolunne River Project Final Environmental Impact Statement, ESD and Energy divisions, ORNL

T. K. SAWYER

World-Class Teamwork Award, for the Biological Monitoring and Abatement Program publishing team, ORNL Values Committee

E. M. SCHILLING

Teamwork Award, for southern pine beetle control on the Oak Ridge Reservation, ESD

D. S. SHRINER

Appointment as scientific advisor, White House Office of Science and Technology Policy

L. R. SHUGART

Invited lecturer, University of LaLaguna, Tenerife, Spain; appointment to Organizing Committee, National Institute of Environmental Health Sciences; Award of Merit in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

R. L. SIEGRIST

Best Paper Award, Waste Management '93 Symposium, American Nuclear Society; appointment to Groundwater Committee, Water Environment Federation

L. L. SIGAL

Certificate of Appreciation, International Association for Impact Assessment

E. D. SMITH

Award of Excellence in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

J. G. SMITH

Teamwork Award, for southern pine beetle control on the Oak Ridge Reservation, ESD

D. K. SOLOMON

Award of Achievement in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

F. W. STOSS

Award of Excellence and Award of Achievement in Newsletters, Award of Merit in Promotional Brochures, and Award of Merit in Informational Brochures, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication; Award of Achievement in Photographs and Award of Achievement in Catalog Design, Arts Competition, East Tennessee Chapter, Society for Technical Communication; appointment as Editor, *ES&H News*; appointment to Editorial Board, *Electronic Green Journal*; appointment to the Scientific and Technical Information Advisory Board, School of Information Science, The University of Tennessee

S. H. STOW

Appointment to Geology and Public Policy Committee, Geological Society of America

J. M. STRONG-GUNDERSON

Patent disclosure, Innovative Use of an Indigenous Microorganism as an Environmental Tracer; patent disclosure, Natural Soil Inducers for Contaminant Degradation Released by Physical and/or Chemical Manipulations

G. W. SUTER II

Technical Achievement Award, Martin Marietta Energy Systems, Inc.; Significant Event Award, Martin Marietta Energy Systems, Inc.; election as Fellow, American Association for the Advancement of Science; appointment to Editorial Board, *Human and Ecological Risk Assessment*; Award of Excellence in Scholarly/Professional Articles, and Award of Merit in Books, Technical Publications Competition,

East Tennessee Chapter, Society for Technical Communication; appointment to Editorial Board, *Environmental Toxicology and Chemistry*

J. S. TINDELL

Teamwork Award, ESD

D. E. TODD

Award of Merit in Scholarly/Professional Articles, Technical Publications Competition, East Tennessee Chapter, Society for Technical Communication

C. C. TRETTIN

Appreciation Award, Southern Appalachian Man and the Biosphere

T. J. TSCHAPLINSKI

Appointment to Editorial Review Board, *Tree Physiology*

M. G. TURNER

Finalist, Tribute to Women, Knoxville YWCA

J. A. WATTS

T. O. Gilliland Award, WATtec; Outstanding Equal Employment Opportunity/Affirmative Action Program Division Representative of the Year, ORNL

J. W. WEBB

Teamwork Award, for southern pine beetle control on the Oak Ridge Reservation, ESD

O. R. WEST

Best Paper Award, Waste Management '93 Symposium, American Nuclear Society

D. C. WHITE

Nelson Distinguished Lecturer in Molecular Biology, Biotechnology and Medicine, Montana State University

T. W. WHITE

1993 Distinguished Technical Achievement
Award, ESD

Competition, East Tennessee
Chapter, Society for Technical
Communication

S. D. WULLSCHLEGER

Award of Merit in Scholarly/Professional
Articles, Technical Publications

T. F. ZONDLO

Certification as a Professional Geologist,
Kentucky

International Activities

ESD staff have developed a sound base of international activities and work with a variety of foreign governments and research organizations. Following is a list of the FY 1994 activities.

- Held an invited seminar at three institutions in Brazil during August 1994: the Brazilian Environmental Protection Agency; the Federal University of Brazil; and the University of Sao Paulo, Center for Water Research and Applied Ecology. The seminar topics were related to contaminant effects on aquatic ecosystems and to establishment of linkages between ecosystem and human health (S. M. Adams)
 - Presented a paper at the Joint Eighth Commission on Atmospheric Chemistry and Global Pollution, the Second International Global Atmospheric Chemistry Project Scientific Conference, and the Fifth Global Emissions Inventory Activity Workshop in Fuji-Yoshida, Japan, September 1994 (R. J. Andres)
 - Developed environmental compliance assessment manuals with the Headquarters of U.S. Army, Europe and assisted in their use in pilot assessments. Because of their vast experience in environmental compliance assessment, ESD personnel are also helping to restructure the U.S. Army, Europe's entire environmental compliance assessment program (A. A. Aramowicz Smith and C. F. Sigmon)
 - Participated in a meeting in Vienna, Austria, in April 1994 to finalize results of an international study on the validation of environmental transport models for radionuclides.
- Representatives from approximately 30 countries, including the former Soviet Union, attended the meeting, which was sponsored by the International Atomic Energy Commission (B. G. Blaylock)
- Operated the World Data Center-A for Atmospheric Trace Gases, a component of the World Data Center System of the International Council of Scientific Unions (T. A. Boden)
 - Served as invited guest on the Intergovernmental Panel on Climate Change (IPCC) to archive and distribute the input data sets and results of the IPCC Working Group I model calculations of the relationship between emissions and future atmospheric concentrations of CO₂. The IPCC findings form the scientific basis of international agreements to control global climatic change (T. A. Boden and R. J. Sepanski)
 - Published *Trends '93: A Compendium of Data on Global Change* (the third report in the *Trends* series) in collaboration with researchers and institutions around the world (T. A. Boden, D. P. Kaiser, R. J. Sepanski, and F. W. Stoss)
 - Collaborated with the All-Russian Research Institute of Hydrometeorological Information-World Data Center (RIHMI-WDC) in Obninsk, Russia in publishing *Selected Translated Abstracts of Russian-Language Climate-Change Publications: II. Clouds* (ORNL/CDIAC-64; *Proceedings of RIHMI-WDC*, Issue 159), the second of four dual-language volumes. The

series opens up to western researchers a wealth of climate-change literature that has previously been available only in Russian (M. D. Burtis and K. B. Ravina)

- Responded to 7485 requests from 2796 individuals in 67 countries and replied to 1099 requests from 59 countries for numeric data packages and computer model packages (CDIAC)
- Presented a paper at the International Symposium on Ecological Effects of Arctic Airborne Contaminants, Reykjavik, Iceland, October 1993 (L. W. Cooper)
- Presented a paper at the 45th Arctic Science Conference on Bridges of Science Between North America and the Russian Far East, Vladivostok, Russia, August 1994 (L. W. Cooper)
- Collaborated with Korean and Russian scientists in research funded by the Office of Naval Research to assess radioisotope contamination resulting from activities of the former Soviet Union, March 1994 (L. W. Cooper and J. M. Grebmeier)
- Participated in a meeting of national liaison groups for GREENTIE (Greenhouse Gas Technology Information Exchange), a program of the International Energy Agency and the Organization for Economic Cooperation and Development, in Maastricht, The Netherlands, September 1994 (R. M. Cushman)
- Conducted a site review of aquatic ecology projects supported by the Swedish Natural Sciences Research

Council, Sweden, October 1993
(D. L. DeAngelis)

- Participated in a meeting of the Fossil Fuel Era Working Group of the International Geosphere-Biosphere Programme's Global Analysis, Interpretation, and Modeling Task Force in Sheffield, England, in December 1993 to modify photosynthesis and plant productivity models for incorporation into a global terrestrial carbon cycling model. The group completed the required modifications and used the model to simulate the global distribution of leaf area index and net primary productivity under natural conditions (W. R. Emanuel)
- Participated in an International Geosphere-Biosphere Programme workshop on The Application of Forest Stand Models to Evaluate Global Change Issues in Apeldoorn, The Netherlands, March 1994 (W. R. Emanuel)
- Traveled to Bonn, Germany, in March 1994 to participate in an overview of Global Analysis, Interpretation, and Modeling Task Force activities for the Fourth Annual Meeting of the International Geosphere-Biosphere Programme National Committees; lead work on the experiment that addresses fossil fuel era changes in the global carbon cycle; and described that work as part of the overview (W. R. Emanuel)
- Participated in an International Geosphere-Biosphere Programme workshop on Comparison of Global Net Primary Productivity Models in Potsdam, Germany, July 1994 (W. R. Emanuel)

- Traveled to Germany to participate in meetings related to the ORNL Distributed Active Archive Center, July 1994 (C. T. Garten, Jr.)
- Took part in a discussion meeting on the exchange of trace gases between land and atmosphere, held at The Royal Society, London, July 1994 (C. T. Garten, Jr.)
- Traveled to France to participate in the IUFRO symposium entitled Environmental Constraints and Oaks: Ecological and Physiological Aspects, September 1994 (P. J. Hanson)
- Participated in the First International Symposium on Ecosystem Health and Medicine in Ottawa, Canada, in June 1994 as a member of a panel session addressing integrated frameworks and indicators for evaluating ecosystem health (C. T. Hunsaker)
- Participated in a workshop on diversity and function of tropical forest ecosystems, Mexico, December 1993 (M. A. Huston)
- Served as technical consultant to a United Nations panel on technology for integrated land management, The Netherlands, June 1994 (M. A. Huston)
- Collaborated with the National Climatic Data Center (U.S. Department of Commerce's National Oceanic and Atmospheric Administration) in hosting the International Workshop on Quality Control of Monthly Climate Data in Asheville, North Carolina, October 1993. The workshop, held to support development of the Global Historical Climatology Network, brought together climate experts from 12 countries to discuss techniques for improving the quality of the long-term climate databases that are used for studies of climate change (D. P. Kaiser and R. S. Vose)
- Served as invited participant in an on-site review of 20 Russian scientific data centers in Obninsk, Moscow, and St. Petersburg by the National Research Council's Committee on Geophysical and Environmental Data, July 1994 (P. Kanciruk)
- Participated in the Intergovernmental Panel on Climatic Change Scientific Assessment Working Group I Session on the Link Between Emissions and Atmospheric Concentrations of CO₂ held in September 1993, at Carqueiranne, France (A. W. King)
- Presented a paper at the International Conference on Atmospheric CO₂ held in September 1993, at Carqueiranne, France (A. W. King)
- Represented ORNL ESD as visiting scientist at the Swedish Environmental Research Institute in Goteborg, Sweden, April-July 1994 (S. E. Lindberg)
- Served as invited participant at the University of Lund Integrated Environmental Systems Research Program Exploratory Workshop on Biogeochemistry in Transition in Lund, Sweden, May 1994 (S. E. Lindberg)
- Served as invited program reviewer, Geestacht National Physics Research Center, Hamburg, Germany, in May

1994 for the International Review of Mercury Research (S. E. Lindberg)

- Served as invited speaker, Geestacht National Physics Research Center, Hamburg, Germany, May 1994; Department of Inorganic Chemistry Seminar Series, Chalmers' Technical University, Goteborg, Sweden, May 1994; Meteorological Institute of Stockholm University Seminar Series, Stockholm, May 1994 (S. E. Lindberg)
- Participated in the Exploratory Workshop on Biogeochemistry in Transition, University of Lund Integrated Environmental Systems Research Program in Lund, Sweden, May 1994 (S. E. Lindberg)
- Participated as Organizing Program Committee member of the International Conference on Mercury as a Global Pollutant, Electric Power Research Institute, Environment Canada, and U.S. Environmental Protection Agency, in Whistler, British Columbia, Canada, July 1994 (S. E. Lindberg)
- Served as co-organizer, Special Workshop on mercury, the purpose of which was to develop a proposal to the International Geosphere-Biosphere Programme on the Global Mercury Cycle in Goteborg, Sweden, June 1994, and in Whistler, British Columbia, Canada, July 1994 (S. E. Lindberg)
- Served as scientific coordinator of Gardsjon Mercury Air/Surface Exchange Project, a joint study of mercury fluxes over background soils and waters at Lake Gardsjon, Sweden, including ORNL, National Oceanic and Atmospheric Administration, and the Swedish Environmental Research Institute (S. E. Lindberg)
- Participated in an International Workshop on Integrated Assessment of Global Climate Change hosted by the International Institute for Applied Systems Analysis in Vienna, Austria, October 1993 (G. Marland)
- Presented invited lecture at the People's Republic of China and the United States' Third Joint Workshop on Atmospheric Chemistry in Beijing, People's Republic of China, August 1994 (G. Marland)
- Participated in several workshops of the Global Emissions Inventory Activity to develop methodologies and international datasets in Fuji-Yoshida, Japan, September 1994 and Denver, Colorado (G. Marland)
- Served as a contributing author on the Intergovernmental Panel on Climate Change Working Group I report *The Global Carbon Cycle* (G. Marland)
- Collaborated with E. Tipping of the Freshwater Biological Institute in Ambleside, United Kingdom, on geochemical modeling of actinide complexation with natural organic matter (J. F. McCarthy)
- Organized a symposium on colloid and bacterial transport for the Western Pacific Geophysics Meeting in Hong Kong in July 1994 (J. F. McCarthy)
- Served as keynote speaker at the Commission of European Communities Natural Analogue Working Group

- Meeting in Sante Fe, New Mexico, in September 1994 (J. F. McCarthy)
- Presented a paper at the IUFRO symposium entitled Environmental Constraints and Oaks: Ecological and Physiological Aspects, France, August–September 1994 (R. J. Norby)
 - Presented papers at the IGBP symposium entitled Terrestrial Ecosystem Response to Elevated CO₂, Italy, October 1993 (R. J. Norby and E. G. O'Neill)
 - Presented a paper at the Fourth International CO₂ Conference, in Carqueiranne, France, October 1993 (T.-H. Peng)
 - Presented a paper at the Fifth Conference of Kuroshio Edge Exchange Processes, a Republic of China Global Ocean Flux Study Program, and World Ocean Circulation Experiment, February 1994 in Taipei, Taiwan (T.-H. Peng)
 - Presented an invited paper at the Royal Society of London discussion meeting on The Role of the North Atlantic in the Global Carbon Cycle in London, England, September 1994 (T.-H. Peng)
 - Participated in a Dahlem conference on The Role of Nonliving Organic Matter in the Earth's Carbon Cycle in Berlin, Germany, October 1993 (W. M. Post III)
 - Participated in a workshop in Fort Collins, Colorado, as contributing lead author on the Intergovernmental Panel on Climate Change Working Group II report *Mitigation Option in Agriculture* (W. M. Post III)
 - Traveled to Taiwan to participate in a workshop on biomass energy, June 1994 (J. W. Ranney and R. L. Graham)
 - Served as invited expert and participant at the Workshop on Biomarkers and Wildlife Health Assessment sponsored by the Canadian Wildlife Service in Mont Tremblant, Quebec, Canada, November–December 1993 (L. R. Shugart)
 - Participated in the Scientific Aspects of Marine Pollution meeting, Working Group 33, on Indicators of Marine Ecosystem Health sponsored by the United Nations Environmental Program in London, England, March 1994 (L. R. Shugart)
 - Served as invited lecturer for a master's degree course on "Chemical Pollution of the Environment" sponsored by the Department of Ecology and Geology, University of LaLaguna, Tenerife, Spain, May 1994 (L. R. Shugart)
 - Served as invited speaker and member of the Scientific Committee at the European Society for Comparative Physiology and Biochemistry 15th Annual Conference on Biochemical and Physiological Effect of Pollutants and Toxicological Assessment of Environmental Quality sponsored by Societa Itallana di Biochimica in Genova, Italy, September 1994 (L. R. Shugart)
 - Collaborated with the Research Institute of Hydrometeorological Information in Obninsk, Russia and the National Climatic Data Center in Asheville, North Carolina, in publishing the numeric data package *Daily*

*Temperature and Precipitation Data
for 223 USSR Stations*

(ORNL/CDIAC-56, NDP-040). The database, covering the years 1881-1989, includes data on minimum, mean, and daily temperatures; daily precipitation amount; and extensive station-inventory, station-history,

and quality-assurance information
(R. S. Vose)

- Attended meetings and visited sites with representatives of industries and research institutes involved in bioenergy projects, Brazil, May 1994 (L. L. Wright)

Research and Development Subcontracts and Interagency Agreements

O. J. Grooms

Presented here are the businesses and organizations with whom ESD had a subcontract or interagency agreement during FY 1994. The ESD researcher who served as technical contact is given in parentheses after the title of the project.

Advanced Sciences Group, Inc.

Provide ESD with technical assistance in assessing environmental impacts of the DOE Integrated Environmental Restoration and Waste Management Program (L. W. Barnthouse)

Provide technical help and expertise in the area of ion chromatography and chelate chemistry (P. M. Jardine)

Provide experienced biologist to assist with the collection and processing of environmental samples (L. A. Kszos and A. J. Stewart)

Alabama A. & M. University

Provide quantitative data on the environmental effects of the conversion of agricultural lands to energy crops (J. H. Cushman)

Alaska, University of

CO₂ emission will be analyzed, compared, based on two energy data sets, and a methods paper written on CO₂ emissions calculations (G. Marland)

Algae Associates

Provide analytical services in phytoplankton taxonomy including specific activities of identification, enumeration and biomass measurements of samples

taken from Johns and Ashumet ponds in Falmouth, MA (W. R. Hill)

Amana Society, Inc.

Establishment and maintenance of silver maple monoculture viability trials (L. L. Wright and G. A. Tuskan)

American Corn Growers Association

Identify biomass crop information needs and develop and promote mechanisms to disseminate information (M. E. Downing)

American Water Resources Association

Support for the American Water Resources Association (AWRA) 1994 International Conference and Symposia on "Managing Water Resources During Global Change" (M. J. Sale)

Analysas Corporation

Geographic Information Analysis and Computer Programming (C. T. Hunsaker)

Arizona, University of

Analysis and modeling of hydrology and particle transport in support of a DOE project on field mobility of colloidal particles (J. F. McCarthy)

Auburn University

Development of optimal establishment and cultural practices for switchgrass as an energy crop (S. B. McLaughlin)

Automated Sciences Group, Inc.

Technical support of a physiological ecologist for analysis on effects of stress on aquatic organisms (S. M. Adams)

Technical support of a laboratory biochemist in assays and measurement of biological and sediment samples (S. M. Adams)

Provide biological data analyst support for the Clinch River ER Program (R. B. Cook)

Provide fishery ecologist support to the Clinch River ER Program and the hydro-system group at ORNL (R. B. Cook and M. J. Sale)

Develop and adopt geophysical methods for the solution of problems in radioactive and hazardous waste management (R. B. Dreier)

Provide technical services support of regulatory and policy analysis activities of the Environmental Assessment Group in planning, organizing, and developing meetings, documents, and training materials (L. L. Sigal)

Battelle Pacific Northwest Laboratory
Support in the application of in situ vitrification at ORNL (G. K. Jacobs)

Beak Consultants, Ltd
Complete Portsmouth Gaseous Diffusion Plant Baseline Risk Assessment and provide assistance in planning, reviewing, and performing other ecological risk assessments for Environmental Sciences (L. W. Barnhouse)

Brooks Rand, Ltd.
Chemical analysis of methylmercury water samples (G. R. Southworth and R. R. Turner)

California, University of
Quantitative histopathological analysis of selected organs of fish collected as a component of the BMAP, Clinch River

environmental restoration projects, and the Hartwell project (S. M. Adams)

C-14 Dating of Groundwater Samples
(L. E. Toran)

Explores the feasibility of using growth enhancers developed at Los Alamos National Laboratory to increase biomass yields in woody and herbaceous energy crops (G. A. Tuskan)

CER Corporation

To provide the services of Senior Earth Scientists, Associate Earth Scientists, Assistant Earth Scientists, Earth Sciences Graphics/Expert Systems Programmers and Earth Scientists Programmers for the Environmental Sciences Division (W. A. McNabb)

Provide support for compliance assessments of Holloman, Barksdale, and Beale Air Force bases (C. F. Sigmon)

Assist in environmental compliance assessment of Ellsworth, Fairchild, and K. I. Sawyer Air Force bases (C. F. Sigmon)

Support compliance assessments at Seymour Johnson, Offutt, Shaw, and Whiteman Air Force bases (C. F. Sigmon)

Clarion University of Pennsylvania

Quantitative analysis of estrogen receptor binding capacity and kinetics of liver cells from fish collected in conjunction with the Hartwell Reservoir study, the BMAP investigation of East Fork Poplar Creek, and the Clinch River Environmental Restoration Program (M. S. Greeley)

Clemson University

Complete DOE-sponsored field injection experiment and initiate hydrologic

characterization of a new field site
(J. F. McCarthy)

Colorado State University
Involvement with the National
Atmospheric Deposition Program
that requires sample analysis by a central
analytical laboratory for comparability of
data on atmospheric deposition on a
national scale (S. E. Lindberg)

Learn more about the environmental issues
associated with large acreages of short-
rotation woody crop (SRWC) plantations
(L. L. Wright)

Columbia University
Assist the Carbon Dioxide Information
Analysis Center by developing analytical
techniques for quality-assuring ocean
carbon date (T. A. Boden)

Cornell University
Support services for coordinator for EPRI
COMPMECH Key Species Project on
Percids (W. Van Winkle)

Council on Environmental Quality
(Executive Office of the President)
NEPA Effectiveness study: Develop
conclusions and recommendations related
to improving the effectiveness of
implementation of the National
Environmental Policy Act (NEPA) within
the Federal government (L. L. Sigal)

Duke University
Authorize funding to cover student support
for ESD (D. S. Shriner)

Perform hydrologic research on the
permeability structure in Bear Creek
Valley (R. B. Dreier)

Ebasco Environmental
Develop tracking and analysis framework
and DEMOS software selected by NAPAP

as the strawman for the NAPAP
assessment (V. H. Dale)

EG&G, Idaho, Inc.
Perform microbial Biology analyses on
sediments from the Oyster, Virginia site
(A. V. Palumbo)

Energy Performance Systems
Analysis and reviews on how to match the
objectives of the Short Rotation Woody
Crops Program with the needs of potential
utility users of wood (L. L. Wright)

Envirogen, Inc.
Examine degradation of sorbed TCE
and isolate and characterize adhesion
deficient TCE degrading bacteria
(A. V. Palumbo)

Environmental Careers Organization
Provide summer internship for four
students from Xavier and Tulane
universities at ORNL (C. W. Gehrs)

Assist with the coordination of the
Environmental Monitoring and Assessment
Program's (EMAP) ecological indicators
effort and contribute to landscape
characterization tasks (C. T. Hunsaker)

Hawaii Geothermal EIS—act as GIS
analyst (C. T. Hunsaker)

Provide technical help and expertise in the
area of ion chromatography and chelate
chemistry (P. M. Jardine)

Assist with Environmental Compliance
Assessment Tasks at Grand Forks Air
Force Base (C. F. Sigmon)

Provide assistance with USAF
Environmental Compliance Assessment
Tasks at Holloman, Moody, Offutt, Shaw,
and Whiteman Air Force bases
(C. F. Sigmon)

Provide summer internships for three students from Fort Valley State College for Environmental Toxicology, Environmental Analysis, and Ecosystem Studies sections (S. H. Stow and S. G. Hildebrand)

Environmental Consulting Engineers, Inc.
Provide field technical support to hydrogeologic studies on the Oak Ridge Reservation (D. D. Huff)

Field support and data base management and development for active site monitoring (C. M. Morrissey)

Test and evaluate new groundwater modeling code on ORNL supercomputer (L. E. Toran)

Environmental Systems & Technologies
Provide modeling services to evaluate the effectiveness of the UVB system in the in situ remediation of groundwater contamination (P. M. Kearl)

Geo/Resource Consultants, Inc.
Provide technical assistance in developing and implementing training in environmental laws and regulations, perform regulatory analyses and develop compliance guidance, and perform environmental compliance assessments at federal facilities (C. F. Baes and C. F. Sigmon)

Georgia, University of
Cosponsorship of the 1993 U.S. National Rapeseed Variety Trials (J. H. Cushman)

Analytical services for water and soil samples from Walker Branch Watershed (P. J. Mulholland)

Analytical services for water and soil samples from Walker Branch Watershed (C. C. Trettin)

Optimizing energy yields in black locust through genetic selection (G. A. Tuskan)

Georgia Institute of Technology
Assist ORNL in concentrating natural organic matter (NOM) from groundwater for a DOE project on characterization and microbial utilization of NOM (J. F. McCarthy)

H&R Technical Associates
Provide data base development and maintenance services to the Oak Ridge Reservation Hydrology Support Program (D. D. Huff)

Huntsman Marine Science
Provide services of coordinator for the Flatfish Key Species Project, which is part of the EPRI-funded Program on Compensatory Mechanisms in Fish Populations (COMPMECH) (W. Van Winkle)

ICF Kaiser Engineers, Inc.
Technical support in reviewing environmental documents (E. D. Smith)

Idaho, University of
Assemble data on production rates and costs of harvesting and processing forestry residues as part of an energy feedstock production process model for DOE's Biofuels Feedstock Development Program (M. E. Dowling)

Perform landscape pattern analysis on the Gap data base for Idaho; collaborate on one or more manuscripts comparing landscape analyses for different parts of the U.S.; select vertebrate species to relate to landscape metrics for Idaho (C. T. Hunsaker)

Indiana University at Bloomington
Student support for Environmental Analysis Section (L. W. Barnthouse)

Iowa, University of
Assistance to ORNL researchers—
co-occurrence statistics (S. H. Stow)

**Iowa State University of Science
and Technology**
Support in selection of forage species
for energy crops in the Great Plains
(S. B. McLaughlin)

Breeding clones for intensive culture
of biomass for energy (part of DOE's
Short Rotation Woody Crops Program)
(G. A. Tuskan)

JAYCOR
Provide regulatory assistance to the
Environmental Compliance Group
(C. F. Baes)

Provide support in the category of Biology
(Task Title: Environmental Regulatory
Analysis) (C. F. Baes)

Provide regulatory information
management support (C. F. Baes)

Provide assistance in planning, reviewing
and performing ecological risk assessments
(L. W. Barnthouse)

Support in preparing publications related
to environmental, biological, energy-
related, and global-change-related tasks
undertaken by Energy Systems to fulfill
its commitments to the USDOE
(R. M. Cushman)

Provide wildlife survey of threatened and
endangered animals on the reservation
(C. A. Gabrielsen)

Provide technical support for
laboratory and data management for the
Biological Monitoring and Abatement
Program and the Remedial Investigation of

ORNL Waste Area Grouping (WAG 2 RI)
(S. E. Herbes)

Provide technical support for field,
laboratory, and data management aspects
of the reservation-wide waterfowl program
(S. E. Herbes, B. G. Blaylock, and
R. B. Cook)

Process benthic macroinvertebrate samples
collected from McCoy Branch near the
Y-12 Plant and several streams near the
Paducah Gaseous Diffusion Plant
(J. M. Loar)

Provide on-site support in the category of
Environmental Biology (Task Title: Y-12
Backlog) (J. M. Loar)

Process benthic macroinvertebrate samples
collected from East Fork Poplar Creek and
Bear Creek near the Y-12 Plant and
several reference streams on and off the
Oak Ridge Reservation (J. M. Loar and
J. G. Smith)

Process benthic macroinvertebrate
samples collected from Mitchell Branch
at the K-25 Site (J. M. Loar and
J. G. Smith)

Provide technical assistance to the
Ecosystem Studies Section for field and
laboratory analyses of stream water
chemistry (P. J. Mulholland)

Effort of receiving, coordinating,
documenting, and conducting
environmental survey requests for rare
plant and wetland surveys on the
Oak Ridge Reservation (P. D. Parr and
R. L. Graham)

Provide ESD with on-site support in the
category of Bioaccumulation Studies
(M. J. Peterson)

Provide support in the category of Environmental Biology (Task Title: Fish Support Studies) (M. G. Ryon)

Provide on-site support in the category of Environmental Biology. Process benthic macroinvertebrate samples collected from 15 sites on five streams near ORNL as part of the Biological Monitoring and Abatement Program (J. G. Smith)

Provide on-site support in the category of Environmental Biology (Task Title: ORNL Macrobenthos Analyses) (J. G. Smith)

Provide on-site support in the category of Environmental Biology, processing benthic macroinvertebrate samples collected from Bear Creek as part of the Biological Monitoring Program (J. G. Smith)

Provide on-site support in the category of Environmental Biology, assisting with implementation of QA procedures/measures, and data management and analysis associated with the benthic macroinvertebrate monitoring of the biological monitoring program (J. G. Smith)

Provide technical support to ecophysiological research studies (T. J. Tschaplinski)

Kentucky, University of
Conduct field study on biomass production by fescue and switchgrass alone and in mixed swards with legumes (J. H. Cushman)

Lumina Decision Systems, Inc.
Develop tracking and analysis framework and DEMOS software selected by NAPAP as the strawman for the NAPAP assessment (V. H. Dale)

Michigan State University
Conduct leaching test to remove uranium from uranium-contaminated soil (C. W. Francis)

Support for Early Selection Criteria and Clonal Propagation as part of DOE's Short-Rotation Woody Crops Program (G. A. Tuskan)

Minnesota, University of
Allow the Biofuels Feedstock Development Program (BFDP) to participate in the Aspen Genetics Cooperative, thereby gaining access for the BFDP and its subcontractors to data on hybrid aspen growth and performance and to superior clones of aspen for research purposes (G. A. Tuskan)

Mississippi State University
Technical support in early selection criteria and clonal propagation systems (G. A. Tuskan)

National Audubon Society
Evaluate bird diversity in energy plantations and investigate policy options that will encourage biodiversity of these plantations throughout the United States (J. W. Ranney and V. R. Tolbert)

National Oceanic and Atmospheric Administration
Provide for tasks related to Data Base Support to assist in quantifying the link between changes in Atmospheric composition and climate change (R. M. Cushman)

Provide support for research project entitled "Atmospheric Surface Exchange of Mercury in Forests and Lakes" (S. E. Lindberg)

North Dakota State University

Support on the selection of forage species for energy crops in the Great Plains (J. H. Cushman)

Oak Ridge Associated Universities

Provide postdoctoral services for ESD to support short-term programmatic needs in areas where staff capability and/or funding uncertainties preclude ORNL staff commitments (S. E. Herbes)

Provide support for the Savannah River integrated demonstration of TCE degradation by assisting in the monitoring of bioremediation (T. J. Phelps)

Oak Ridge Research Institute

Assist the Environmental Compliance Group in regulatory tracking, identification and analysis of state regulations, and maintaining databases of regulatory information and other environmental guidance materials related to DOE Office of Environmental Guidance (C. F. Baes)

Provide analytical support for research project investigating removal of mercury from solid waste and other environmental engineering group projects (D. D. Gates)

Conduct laboratory studies on the adsorption and stability of volatile and semi-volatile organic compounds in soils (B. Gu)

Instream monitoring and technical support in the field of aquatic bioassays (L. A. Kszos)

Conduct laboratory and field experiments, perform gas chromatography analysis, and provide full documentation of the results (L. Liang)

Oklahoma State University

Breeding and selection of new switchgrass varieties for increased biomass production (S. B. McLaughlin)

Oregon Graduate Institute

Analyze survival characteristics of microbial cultures isolated from DOE sampling sites. Analyses will examine the oligotrophic survival and metabolism of thermophilic sulfate-reducing and iron-reducing bacteria in nutrient starved conditions, similar to those encountered in deep subsurface environments (T. J. Phelps)

Purdue University

Perform water quality modeling for one or more counties in Indiana to evaluate effects of energy crops (C. T. Hunsaker)

Research Triangle Institute

Provide personnel to develop and present training materials on the economic procedures involved in Natural Resource Damage Assessment for a series of workshops on Natural Resource Trusteeship and Ecological Evaluation (F. E. Sharples)

Roane State Community College

Student support for fieldwork (R. J. Norby)

Rochester, University of

Analysis of tritium and helium isotopes in groundwater (D. D. Huff)

Sandia National Laboratory

Geochemical analysis of ORR brines. Data will help to establish the activity level of the deep groundwater system underlying the ORR (G. R. Moline)

Science & Technology, Inc.

Technical services for Environmental Training and Analysis of regulations (C. F. Baes)

Science Applications International Corporation

Provide services of one scientific database manager in the Data Systems Group of the Carbon Dioxide Information Analysis Center (R. M. Cushman)

Provide on-site junior-level data management support (M. A. Huston)

Conduct nonroutine data processing to restructure environmental data from simple tables to relational data base table in OREIS (R. A. McCord)

Provide off-site programming support for enhancements to and preparation of documentation for the Carbon Dioxide Information Analysis Center's Request-Response-Record Database System (T. R. Nelson)

Participate in the development of the National Acid Lakes Registry Plan which consists of reviewing literature, statistical design, data processing and report writing (R. J. Olson)

Selma University

Support measurement of bacterial respiration in samples from the DOE/OHER SSP heterogeneity field site in Oyster, VA (A. V. Palumbo)

Shirshov Institute of Oceanology

Covers rental cost of oceanographic research vessel for the Institute of Oceanology, Moscow, Russia, optical data collections data report, and final report in relation to ORNL-supported research in the Black Sea in 1993 (S. E. Lindberg)

South Alabama, University of
Coordination of the Striped Bass and Bay Anchovy Key Species Projects (W. Van Winkle)

Southern Illinois University at Carbondale

Provide expertise and support for the great Blue Heron Sampling and Analysis and Mink Reproductive and Biomarker Effects Study of the Clinch River Environmental Restoration Program (R. B. Cook)

Systematic Management Services, Inc.

Participate in a University/Industrial Consortium for the production of bioenergy from hybrid willow plantations; specific subcontracting for the nursery scale-up of improved hybrid willow clones (G. A. Tuskan)

Tennessee at Knoxville, The University of
Undergraduate Student Support (S. M. Adams)

Provide for undergraduate assistant support (S. M. Adams and C. W. Gehrs)

Analyze samples of fish from streams surrounding DOE Kansas City Plant (T. L. Ashwood)

Provide for an Oceanographic Data Analyst with training and experience aboard oceanographic research vessels and handling of oceanographic measurements (T. A. Boden)

Processing and QA Inspection of Hydrologic Data (R. B. Clapp)

Provide for an interdisciplinary expert in ecology, sampling theory, and modeling with analysis of existing information to determine appropriate sampling schemes and integration of two existing computer models (R. B. Cook and L. J. Luxmoore)

Provide assistance in limnological, sedimentological, and water-quality-related data collection, sample preparation and analysis, task coordination, and reporting in

relation to the Clinch River Environmental Restoration Program (R. B. Cook)

Provide assistance for Clinch River RCRA Facility (R. B. Cook)

Provide the services of an Information Assistant based on specific training in the areas of database computer applications and communication work (R. M. Cushman)

Provide the services of an Information Assistant based on specific training in the areas of database computer applications, global change scientific information, and communications work (R. M. Cushman)

Provide the services of an Information Specialist based on specific training in the areas of scientific data publication and information science (R. M. Cushman)

Provide the services of a Scientific Data Coordinator based on training in the areas of development and analysis of environmental data bases (R. M. Cushman)

Provide the services of a Scientific Data Coordinator (three separate contracts) based on training in the areas of development and analysis of environmental data bases (R. M. Cushman)

Provide the services of a Personal Computing Specialist based on training and experience in the area of personal computer hardware and software systems (R. M. Cushman)

Provide research programs with computer programming support in ESD (D. L. DeAngelis)

Technical support on groundwater monitoring compliance at Y-12 and the Oak Ridge Reservation (R. B. Dreier)

Provide services for projects related to groundwater monitoring compliance at the Oak Ridge Y-12 Plant and to the Oak Ridge Reservation Hydrologic and Geologic Study (ORRHAGS) (R. B. Dreier)

Provide UT support services for projects related to groundwater monitoring compliance at the Oak Ridge Y-12 Plant and to the Oak Ridge Reservation Hydrologic and Geologic Study (ORRHAGS) (R. B. Dreier and D. D. Huff)

Support graduate student research on fracture characterization of the Conasauga Group, and the influence of fractures on the regional hydrologic system of the Oak Ridge Reservation (R. B. Dreier)

Provide geological technical services to Y-12 HSEA and WAG 2 Project (R. B. Dreier)

Provide ESD with the opportunity to procure research product for short-term and exploratory programmatic needs in areas where staff capability and/or funding uncertainty preclude ORNL staff commitment (D. E. Fowler)

Conduct experiments to determine impact of chemical oxidation on metal co-contaminants (D. D. Gates)

Life Sciences Distinguished Scientist, David White (C. W. Gehrs)

Estimate changes in regional agricultural crops, fertilizer and pesticide use, and erosion with the introduction of biomass energy crops at three locations in the Midwest using a linear program model designed to maximize regional net return (R. L. Graham)

Modify existing national interregional model to include biomass energy crop activities (R. L. Graham)

Evaluation of factors controlling microbial degradation of trichloroethylene (TCE), and for modification, operation, and scaled-up design of an innovative bench-scale bioreactor for TCE degradation (S. E. Herbes)

Maintain and adapt a hydrogeologic data base for the Oak Ridge Reservation and assist the Y-12 groundwater monitoring program (D. D. Huff)

Analytical preparation and determination of $^{18}\text{O}/^{16}\text{O}$ ratio on subsurface storm water using mass spectrophotometry and hydro-geochemical evaluation of deep groundwater flow (D. D. Huff)

Perform seismic imaging of the ISV Melt (G. K. Jacobs)

Perform computational science in support of earth science research activities (G. K. Jacobs)

Allow the investigation of adsorption of heavy metals and radioelements on minerals and rocks from aqueous solutions (P. M. Jardine)

Provide for the analysis of storm effluent samples via novel ion chromatograph techniques. The techniques use state-of-the-art electrochemical detection coupled with spectral array detection to quantify reactive tracers in complex aqueous solutions (P. M. Jardine)

Physiochemical and mineralogical characterization of uranium contaminated soils for remediation technology development (S. Y. Lee)

Support for DOE project on groundwater colloids (J. F. McCarthy)

Development of in vitro culture systems for switchgrass (S. B. McLaughlin)

Conduct research on the role of algal and microbial communities in streams on phosphorus cycling and total metabolism. The work will be conducted in natural streams on the Oak Ridge DOE Reservation and in laboratory streams at ORNL (P. J. Mulholland)

Develop DNA and RNA probes for measurement of methanotrophic bacterial populations of the integrated demonstration at the Savannah River Site (A. V. Palumbo)

Expand the number of environmental samples to be analyzed from the SRS Integrated Demonstration (A. V. Palumbo)

Support sampling efforts at Oyster, VA and continue heterogeneity experiments (A. V. Palumbo)

Perform microbial characterization activities on sediment samples and isolates from Oyster, VA generating information of the heterogeneity, microbial community structure, physiology and ecology of the resident microbial community and relations with surface microorganisms (A. V. Palumbo)

Assessment of bald eagle habitat sustainability of Melton Hill Reservoir and adjacent areas on ORR, including the proposed ANS site (P. D. Parr)

Microbiological and biochemical characterization of subsurface samples from DOE sites (T. J. Phelps)

Analyze microbial cultures from DOE sampling sites. Analyses will be on the thermophilic anaerobic microorganism isolated from Taylorsville Triassic Basin sediments and include characterization of the physiological types of microorganisms observed (T. J. Phelps)

Provide assistance in sedimentological and oceanographic related data collection, sample preparation and analyses, data analysis, task coordination, and reporting in relation to an Office of Naval Research Project (D. S. Shriner)

Provide support to analyze chlorine dynamics in Upper East Fork Poplar Creek and in White Oak Creek (A. J. Stewart)

Development and application of soil tests (A. J. Stewart)

Development and application of soil tests and assistance with QA/QC documentation for projects supporting Biological Monitoring and Abatement Program (A. J. Stewart)

Periphyton analyses in biomonitoring (A. J. Stewart)

Lipid and lipid-class analyses in biomonitoring (A. J. Stewart)

Provide for historical earthquake studies as part of the Advanced Neutron Source Project (S. H. Stow)

Life Sciences Distinguished Scientist, Robert Hatcher (S. H. Stow)

Provide research assistance support in soil chemistry (S. H. Stow)

Support of Rare Isotope Measurement Laboratory and obtain krypton-85 data on groundwater (S. H. Stow)

Conduct monitoring of lows and water levels during storms for a test of geophysical techniques to estimate stormflow at the Melton Branch weir (L. Toran)

Conduct soil and water characterization studies for the wetlands component of the Bear Creek BMAP Program (C. C. Trettin)

Provide on-site data management support for the Distributed Active Archive Center Project (L. D. Voorhees)

Conduct experimental research on the interaction of polycyclic aromatic hydrocarbons and microbial communities in the plant rhizosphere (B. T. Walton)

Tennessee Technological University
Assist in the study of East Tennessee Seismic Zone for ANS project (S. H. Stow)

Tennessee Valley Authority
Below ground tree and mycorrhizal responses to altered hydrologic inputs (P. J. Hanson)

Genetic variation among switchgrasses for agronomic traits, forage quality and biomass fuel production (S. B. McLaughlin)

Dynamic responses of mature forest trees to chemical and physical environmental changes (S. B. McLaughlin)

Texas A&M University
Analyze samples of fish from streams surrounding DOE Kansas City Plant (T. L. Ashwood)

Evaluation of switchgrass cultivars and cultural methods for biomass production in the southcentral United States (S. B. McLaughlin)

U.S. Department of Agriculture

Genetic variation among switchgrasses for agronomic traits, forage quality, and biomass fuel production (J. H. Cushman)

Bird and mammal usage of hybrid poplar plantations (J. W. Ranney)

Energy crop chemical fate and nutrient cycling study (V. R. Tolbert)

Short rotation woody crop trials for energy production in North Central United States (G. A. Tuskan)

Tree physiology research to improve biomass yields of hybrid poplar (G. A. Tuskan)

Increasing yields of *Populus* energy plantations on Woody Biomass Program (G. A. Tuskan)

Increasing the biomass production of cottonwood and alder plantations in the Pacific Northwest (G. A. Tuskan)

U.S. Department of Commerce (NTIS)
ORNL access to electronic media production (T. R. Nelson)

U.S. Department of the Interior
Collect surface water discharge data (D. D. Huff and D. M. Borders)

U.S. Environmental Protection Agency
Collaborative research on bioremediation of mercury in aquatic systems (R. R. Turner)

ORNL Access to EPA Water Quality Data Base—ORNL will be responsible for furnishing, maintaining, and operating the computer terminal for its own use (M. A. Wood)

Utah, University of

Conduct a noble gas nonreactive tracer study in support of DOE-sponsored field experiment (J. F. McCarthy)

Vanderbilt University

Organizing, conducting and analyzing data from the focus groups and survey and interacting with ORNL scientists in analyzing and publishing results of the study (V. H. Dale)

Develop new techniques for chemical analysis of plant tissues (S. B. McLaughlin)

Virginia Polytechnic Institute and State University

Switchgrass as a biofuels crop for the upper Southeast: Variety trials and cultural improvements (S. B. McLaughlin)

Washington, University of

Physiological assessment of two F2 hybrid poplar plantations designed to link genetic traits with molecular markers (G. A. Tuskan)

Molecular physiological and host/pathogen interactions of hybrid poplar (G. A. Tuskan)

Waterloo, University of

Provide modifications, pre- and post-processing modules, an example input file and updated documentation of three dimensional flow and solute transport model for fractured, porous media (D. D. Huff)

WesMin Resource Conservation and Development Council

To organize, monitor, and transfer results from the planting of about 1,000 acres of hybrid poplar as a scale-up trial of wood energy crops (J. W. Ranney)

Technology Transfer

I. L. Larsen

Representatives from DOE, the U.S. Environmental Protection Agency, the U.S. Department of Defense (DOD), industry, and academia have agreed to collaborate on a demonstration project at DOD sites for biodegradation of trichloroethylene. DOE's Office of Technology Development is cosponsoring the project, which uses microbial monitoring technology that was developed by A. V. Palumbo in collaboration with personnel at The University of Tennessee.

L. W. Cooper, I. L. Larsen, K. B. Ravina, and J. M. Grebmeier are participating in data and sample exchange with Russian scientists involved in studies of radionuclide contamination of the Arctic Ocean from sources in the former Soviet Union.

J. M. Grebmeier, L. R. Shugart, L. W. Cooper, C. W. Theodorakis, and J. G. Mural are involved with Russian scientists in a cooperative project to develop submersible devices that measure ultraviolet radiation. After exchange visits take place and calibration exercises are completed, the ESD team plans to help commercialize the Russian technology for use in oceanographic studies.

J. F. McCarthy and A. V. Palumbo have joined staff of the Oak Ridge Y-12 Plant to participate in a cooperative research and development agreement with the National Center for Manufacturing Science (NCMS). In collaboration with NCMS partners at Ford Motor Company, General Motors, and Texaco, the ESD researchers

will develop and demonstrate approaches to improving in situ bioremediation of contaminated aquifers.

J. M. Strong-Gunderson and A. V. Palumbo are working with investigators at ORNL and in industry to develop and test a new real-time, sensitive colloid tracer for use in groundwater. The tracer was demonstrated on-site at Oyster, Virginia, in FY 1994; additional demonstrations are scheduled for FY 1995.

J. M. Strong-Gunderson and A. V. Palumbo are collaborating with a small business firm in North Carolina to test bioenhancing agents for use in field demonstrations of groundwater contaminant degradation.

Staff at the U.S. Department of Agriculture office in Tifton, Georgia, requested that J. M. Strong-Gunderson assist them in microbial characterization of crop fields. In an experiment, one field was treated with a traditional synthetic pesticide and another with a biological pest-control agent. Results from the preliminary analysis were summarized in a grant proposal.

Virginia State University, one of the historically black colleges and universities in the United States, asked J. M. Strong-Gunderson to help prepare a research grant proposal to conduct microbial degradation experiments. Her expertise in trichloroethylene degradation research was highly beneficial to the university in its pursuit of funding.

Education Activities

J. A. Watts and J. L. Seiber

ESD develops and maintains strong relationships with many educational institutions. The division provides opportunities for student and faculty guests to participate in ongoing ESD research activities for varying periods of time. In addition, staff are encouraged to develop collaborative research programs with university and college researchers.

Guest appointments for high school students, college students, individuals who have completed master's or doctoral programs, science teachers, and university faculty are administered by the ORNL Office of Science, Education, and External Relations and the Oak Ridge Institute for Science and Education.

Subcontracts initiated by ESD with individual universities and colleges, and the Environmental Careers Organization are other mechanisms used to develop collaborative research activities with ESD researchers. Table 1 summarizes the FY 1994 participation by ESD in educational programs. More than 1300 individuals, mostly students, visited the ESD facilities during the year.

Precollege

In addition to offering research opportunities for undergraduate and graduate students, ESD pays particular attention to precollege students and science teachers.

The DOE High School Science Honors Program, hosted by ESD, completed its seventh year in 1994. A total of 57 students from 48 states, the District of Columbia, Puerto Rico, and 6 foreign countries (France, Germany, Italy, Japan,

Mexico, and Northern Ireland) participated in a 2-week workshop. During the workshop, students worked on projects concerning wildlife ecology, geochemistry, water resources, environmental toxicology, geographic information systems, human genome, biotechnology, and forestry with 56 scientists from ESD; the Chemical and Analytical Sciences, Chemical Technology, Energy, and Health Sciences Research divisions; and the Office of Environmental Compliance and Documentation. Students also participated in "theme groups" in which they explored all sides of a national or global issue and role-played opposing factions in public forums. Each group prepared a written report and gave an oral presentation.

ESD hosted high school students from Puerto Rico and the East Tennessee region who were participating in the Summer Education Experience for the Disadvantaged program. The program was sponsored by the American Chemical Society. ESD also hosted an Oak Ridge High School student from the South Eastern Consortium for Minorities in Engineering program. In addition, six science teachers from across the nation participated in a summer research experience through the DOE Teacher Research Associates program.

Telementoring is a new avenue for ESD staff to interact with students. A telementoring project, initiated with Wartburg High School, involved 12-15 students and 6 ESD staff, who collaborated on developing computer models in various areas of environmental sciences. The students presented their project results at a meeting in Nashville and then visited ESD,

meeting with their telementors and touring the ESD facilities.

Nineteen ESD staff members and guests participated in the EnvironMENTAL Fair, sponsored by the DOE Environmental Restoration and Waste Management Division (ERWM), in October 1993. During the fair, hands-on activities and

exhibits were seen by more than 3000 area sixth graders. ESD staff and guests also organized the Water Quality component of the Science Olympiad for middle school students.

Thirty-six children of ESD staff participated in the ORNL "Take Your Child to Work" Day. ESD collaborated

A group of students survey the species and density of vegetation in research plots to determine the adequacy of habitat for the field sparrow, downy woodpecker, barred owl, and eastern cottontail on the Oak Ridge Reservation. The group includes Rich Stevens, Graduate Student Research Participant from Tennessee Technological University; Sarah Condit, Science and Engineering Research Semester student from Trinity University; and DOE High School Science Honors Program students Sarah Vickman (Minnesota), Jared Underwood (Hawaii), Rebecca Hufft (Kentucky), and Tara Schroeder (New Hampshire).

with ORNL's Plant and Equipment, Instrumentation and Controls, and Robotics divisions to provide hands-on activities for these children.

College

ESD increased its efforts to attract guests from underrepresented groups in FY 1994. These efforts primarily addressed three areas: (1) increasing the participation of minority and female students in ESD education programs, (2) encouraging minority faculty to collaborate with ESD researchers and to participate in faculty research programs in ESD, and (3) providing opportunities for undergraduate and graduate minority students to work with ESD researchers.

As part of a DOE ERWM program, ESD hosted three students (of which two were minority females and one was a non-minority female) in collaboration with Xavier University of Louisiana and Tulane University in a 10-week summer internship. A DOE ERWM scholarship awardee from Xavier University of Louisiana completed a required summer internship with ESD's Environmental Engineering Group.

The Environmental Biotechnology Program, part of a consortium between the state of Louisiana and the DOE Experimental Program to Stimulate Competitive Research, supported five students (of which three were minorities and four were female) who completed summer internships at ORNL. Three of these students worked within the division, and two students were placed by ESD in other divisions at ORNL.

ESD staff attended career fairs and career days at minority institutions and recruited three minority students (of which two were

female) from Fort Valley State College in Georgia for a 12-week internship appointment. We will continue to follow these students in their graduate programs and encourage them to return to ESD for additional internships. Plans are under way to expand the programs with Xavier, Tulane, and Fort Valley in FY 1994.

ESD hosted two students representing the Montana Native American consortium through the Science and Technology Alliance program, sponsored by DOE. Collaborations with other historically black colleges and universities and minority educational institutions are also being explored for future years.

Fifty-seven students spent a semester or a summer conducting research as a part of DOE-sponsored student internship programs.

Postgraduate

One student participant from the 1993 Minority Careers in Environmental Sciences Conference, hosted by ESD and seven cooperating research divisions, returned for an 8-month internship in 1994. A postdoctoral student participant from the Careers Conference visited ORNL and presented a seminar. Overall, ESD hosted 47 postdoctoral researchers during FY 1994, representing approximately 25% of the ORNL postdoctoral population.

Our educational guests bring enthusiasm, fresh insight and creativity, and expertise that benefits the division and research sponsors. In return, ESD research provides our guests with opportunities to apply their textbook knowledge, expand their areas of expertise, and play a role in solving environmental problems.

Table 1. Educational programs supporting students and faculty in ESD during FY 1994

Program ^a	Participants
DOE High School Science Honors Program	57
DOE-Teacher Research Associates	6
Environmental Management Career Opportunities for Minorities	1
Environmental Restoration and Waste Management	2
Fort Valley State College	3
Faculty Research Program	3
Great Lakes College Association	8
Graduate Student Research Participation	4
Legal Internship Program	2
MMES Summer Clerical	4
MMES Summer Technical	8
Professional Internship Program	15
Postgraduate Research Training	23
Science and Engineering Research Semester Program	12
Science and Technology Alliance	2
South Eastern Consortium for Minorities in Engineering	1
State of Louisiana/DOE-EPSCOR	3
Summer Education Experience for the Disadvantaged	1
Summer Research Program	4
Tulane/Xavier of Louisiana Environmental Biotechnology Program	3
Total	162

^aDOE = U.S. Department of Energy; EPSCOR = Experimental Program to Stimulate Competitive Research; MMES = Martin Marietta Energy Systems, Inc.

Visitors Hosted

J. L. Seiber

During FY 1994 a total of 1416 people visited the ESD facilities as members of tour groups. The diversity of visitors reflects continuing interest in the many areas of environmental research that the division conducts.

Tour groups hosted by ESD during FY 1994

Institution ^a	Date	Number in tour	Institution ^a	Date	Number in tour
Appalachian State University	10/01/93	24	The Institute for College Research, Development, and Support, Project Taps	12/01-03/93	15
HBCU/MEI Water Resources and Environmental Management Consortium	10/08/93	25	East Tennessee Foundation Diversity of Leadership Training Class	12/09/93	23
Wesleyan College	10/13/93	6	Northeast State Technical Community College, American Chemical Society Chapter	12/16/93	20
Dr. John Peters, The University of Tennessee	10/18/93	1	SERS Students	1/10/94	39
ORNL Plant and Equipment Division	10/21/93	28	Tennessee Technological University, Physics Club	1/13/94	13
Southwest Virginia Community College	10/22/93	31	Tulane-Xavier	1/26/94	4
Knoxville State Technical School	10/28/93	15	Centre College of Kentucky, Science Technology Class	1/26/94	14
Tennessee School for the Deaf, Chemistry Class	11/15/93	11	Farragut High School, Science Honor Society	1/27/94	28
Western Carolina University, Physics Class	11/16/93	19	Leadership Knoxville	2/24/94	46
Fulton High School, Chemistry Class	11/17/93	22	Little Creek Academy, Chemistry Class	2/24/94	11
Norwood Junior High School, Eighth-Grade Junior Achievement Class	11/17/93	21	29th Annual Junior Science and Humanities Symposium	3/04/94	25
Georgia Institute of Technology, Science and Engineering Majors	11/23/93	18	Tennessee State University, Biology Majors	3/17/94	42
Tennessee Technological University, Society of Women Engineers (Chemical)	11/30/93	17	West Davidson High School, Advanced Biology, Anatomy, and Physiology Class	3/18/94	25

Tour groups hosted by ESD during FY 1994 (continued)

Institution ^a	Date	Number in tour	Institution ^a	Date	Number in tour
Visitors from International Atomic Energy Agency Meeting and Chinese Visitors to ESD Environmental Analyses Section	3/23/94	19	Rotary Club Exchange Group, Canadian Delegation	5/05/94	8
Singleton Center	3/24/94	15	Adopt-a-School Coordinators K-12 Teachers	5/10/94	23
Paducah Tilghman High School, Chemistry Class	3/25/94	14	"Take Your Child/Children to Work" Day	5/19/94	44
Leadership Roane County	4/06/94	14	Nuclear Energy Training Institute, HBCU Interns	5/23/94	12
Women in Science and Technology	4/07/94	30	Middle Tennessee State University, Environmental Problems Class	5/25/94	13
Springs Textiles Visitors	4/08/94	10	Aloca High School, Women in Technology	5/26/94	25
Russian Academy of Sciences Visitors	4/08/94	3	Appalachian Educational Laboratory Regional Institute Eisenhower Math Science Consortium	6/09/94	40
Maryville College	4/11/94	9	Visitor from Swedish Embassy	6/15/94	1
Faith Christian School, Eighth-Grade English Class	4/12/94	14	Dr. Michael Stotzel, Deputy Director for Cooperation with Western Europe	6/21/94	1
HAZWRAP Visitors	4/15/94	5	TRAC Program	6/22/94	50
Institute of Paper Science and Technology	4/18/94	18	Berea College, "Upward Bound" Program	6/23/94	20
Columbia State Community College	4/19/94	24	HAZWRAP Visitors, Student Interns	6/23/94	11
Dennis Gound and DOE Site Office Secretaries	4/26/94	7	Appalachian Regional Commission	6/24/94	52
Floyd Des Champs, Office of Technology Development	4/26/94	1	Confederated Salish and Kootenai Tribes	6/27/94	4
Helen Bird	4/28/94	1	Summer Enrichment Program, Central High School, Science Class	6/28/94	9
Seventh International Symposium on Gaseous Dielectrics	4/28/94	14	Tennessee Board of Regents	6/28/94	30
DOE Inspector General's Office	5/02/94	3	Energy Systems Co-op Program	6/29/94	8

Tour groups hosted by ESD during FY 1994 (continued)

Institution ^a	Date	Number in tour	Institution ^a	Date	Number in tour
SEED Program Students	7/01/94	15	National Association for the Advancement of Colored People Students	8/04/94	18
ORAU/SEED Program	7/14/94	20	Gary Briggs, Program Manager for Environmental Compliance in Europe	8/05/94	1
The University of Tennessee "Science Alliance" McNair Program	7/15/94	35	Russian Visitors	8/08/94	5
Fred Bernthal, President, Universities Research Association, Inc.	7/19/94	1	American Institute of Biological Sciences, Women and Minorities Program	8/11/94	20
Wesleysan College (Macon, Ga.), "Spectacles" Program	7/19/95	30	Knoxville Economic Development Group	8/16/94	3
Mountain Empire Community College	7/20/94	25	SERS/GLCA	8/23/94	52
Portland <i>Oregonian</i> Reporters	7/20/94	2	Dr. Martin P. Fricke and Oak Ridge Chamber of Commerce Visitors	8/25/94	3
Region 5 Governor's School, Gifted Botany/Biology Students	7/27/94	15	Bill Campbell, Governor's Science and Technology Advisory Board	9/08/94	1
Science Alliance Summer Research Program	7/28/94	18	Museum Consortium	9/19/94	8
Agnes Dover, Deputy for Technology Transfer and Procurement, Office of General Counsel, DOE, Washington, D.C.	7/28/94	3	Mia Anderson, Staff Member, Office of Special Assistant to Secretary of Energy	9/29/94	1
Teaching Nuclear Science Teachers Grades 6-12	7/28/94	21	Total		1416
DOE Procurement and Contract Employees	8/04/94	24			

^aDOE = U.S. Department of Energy; Energy Systems = Martin Marietta Energy Systems, Inc.; DOE-HQ = DOE Headquarters; ESD = Environmental Sciences Division; GLCA = Great Lakes Colleges Association; HAZWRAP = Hazardous Waste Remedial Actions Program; HBCU = Historically Black Colleges and Universities; MEI = minority educational institution; ORAU = Oak Ridge Associated Universities; ORISE = Oak Ridge Institute for Science and Education; SERS = Science and Engineering Research Semester; SEED = Summer Education Experience for the Disadvantaged; and TRAC = Teacher Research Associates.

Note: All educational fellowships, GLCA, and the SERS Program are administered through ORISE.

Conferences Organized or Chaired

During the past year, ESD staff members actively participated in numerous conferences. Listed below are conferences organized or chaired by members of the division.

Napa Conference on Genetic and Molecular Ecotoxicology, sponsored by National Institute of Environmental Health Sciences, Yountsville, California, October 1993. Chair and organizer: Shugart, L. R.

Southeastern Regional ACS Meeting of Analytical and Environmental Aspects of Chemicals, sponsored by American Chemical Society, Johnson City, Tennessee, October 1993. Chair and organizer: White, D. C.

Developing the Framework for the NAPAP Assessment Workshop, sponsored by National Acid Precipitation Assessment Program, Oak Ridge, Tennessee, November 1993. Organizer: Dale, V. H.

Integrated Assessment Workshop, sponsored by National Acid Precipitation Assessment Program, Oak Ridge, Tennessee, November 1993. Co-chair and organizer: Turner, R. S.

Colloquium on Water Resources in the Southeast, sponsored by Joint Institute on Energy and Environment, Knoxville, Tennessee, January 1994. Organizer: Sale, M. J.

Information Exchange on Biofuels Research Conference, sponsored by DOE Biofuels Feedstock Development Program, Oak Ridge, Tennessee, January 1994. Chair and organizer: Cushman, J. H.

Artificial Magma Program Workshop, sponsored by DOE Environmental Restoration, and DOE Office of Basic

Energy Sciences, Oak Ridge, Tennessee, March 1994. Co-organizers: Jacobs, G. K. and M. T. Naney

Oak Ridge Climate Change Symposium, sponsored by DOE and U.S. Forest Service, Oak Ridge, Tennessee, March 1994. Chair and organizer: Huston, M. A.

ORNL Distributed Action Archive Center User Working Group Meetings, sponsored by National Aeronautics and Space Administration, Oak Ridge, Tennessee, March 1994; Airlie, Virginia, August 1994. Chair and organizer: Turner, R. S.

Workshop for COMPMECH Staff, sponsored by Electric Power Research Institute, Dauphin Island, Alabama, March 1994. Chair and organizer: Van Winkle, W.

American Water Resources Association National Meeting, sponsored by American Water Resources Association, Nashville, Tennessee, April 1994. Chair and organizer: Huff, D. D.

Fifth Annual Women in Science and Technology Conference, sponsored by ORNL and Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, April 1994. Chair and organizer: Sharples, F. E.

Responses to Changing Multiple-Use Demands, sponsored by American Water Resources Association, Nashville, Tennessee, April 1994. Chair and organizer: Sale, M. J.

Non-Polluting, Antifouling Marine Coatings Conference, sponsored by Office of Naval Research, Cashiers, North Carolina, May 1994. Chair and organizer: White, D. C.

First International Symposium on Ecosystem Health and Medicine, sponsored by International Society of Ecosystem Health and Medicine, Ottawa, Canada, June 1994. Organizer: Adams, S. M.

Geographic Information Systems Information Exchange, sponsored by DOE Environmental Restoration, Richland, Washington, June 1994. Organizer: McCord, R. A.

IEEE Metadata Conference, sponsored by Institute of Electrical and Electronics Engineers, Inc., Washington, D.C., July 1994. Organizer: Kanciruk, P.

Workshop on the COMPMECH Percid Project, sponsored by Electric Power Research Institute, Syracuse, New York, July 1994. Co-organizer: Van Winkle, W.

Ad Hoc Committee on Accreditation, sponsored by American Geological Institute, Alexandria, Virginia, August 1994. Chair: Hatcher, R. D., Jr.

Interscale Relationships in Forest-Atmosphere Processes, sponsored by International Union of Forest Research Organizations, St. John's, Newfoundland, Canada, August 1994. Chair and organizer: Luxmoore, R. J.

Colloquium on Watershed Ecological Risk Assessment Issues, sponsored by U.S. Environmental Protection Agency, Alexandria, Virginia, September 1994. Chair: Hunsaker, C. T.

ESD staff and guest assignees cleared the following with the ORNL Laboratory Records Department for publication during FY 1994.

Books and Whole Periodicals

Broecker, W. S., and T.-H. Peng. 1993. *Greenhouse Puzzles, Part I: Keeling's World: Is CO₂ Greening the Earth?* Eldigio Press, Palisades, N.Y.

Dale, V. H. (ed.). 1994. *Effects of Land Use Change on Atmospheric CO₂ Concentrations: South and Southeast Asia as a Case Study.* Springer-Verlag, New York.

Sale, M. J., and R. O. Wadlington (eds.). 1994. *Proceedings of Extended Abstracts for Responses to Changing Multiple-Use Demands: New Directions in Water Resource Planning and Management, American Water Resources Association Annual Spring Symposium, Nashville, Tennessee, April 17-20, 1994.* American Water Resources Association, Washington, D.C.

Wright, L. L. (ed.). 1994. *Biomass Bioenergy 6(3). (Dedicated Feedstock Supply Systems: Their Current Status in the U.S.A.)*

Journal Articles

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Apps, M. J., W. A. Kurz, R. J. Luxmoore, L. O. Nilsson, R. A. Sedjo, R. Schmidt, L. G. Simpson, and T. S. Vinson. 1993.

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ESD staff cleared the following with the ORNL Laboratory Records Department for presentation during FY 1994.

Adams, S. M., and J. M. Loar. 1994. "Integrative Approaches for Assessing Effects of Environmental Stressors on Aquatic Ecosystem Health." First Annual Conference on Environmental Monitoring and Assessment in the Mid-Atlantic Highlands Area, Hershey, Pa., February.

Adams, S. M., M. S. Greeley, and L. R. Shugart. 1993. "Linking the Effects of Industrial Effluents on Aquatic Ecosystems and Human Populations: A Holistic Approach." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Ally, M. R., J. H. Wilson, and C. W. Francis. 1993. "Secondary Wastes and Treatment of Effluents from Leaching of Uranium from Soils." Eighth Symposium on Separation Science and Technology for Energy Applications, Gatlinburg, Tenn., October.

Andres, R. J. 1994. "The Role of Volcanic Emissions in Affecting Weather and Climate." Fifth ORNL/ORISE Annual Women in Science and Technology Conference, Oak Ridge, Tenn., April.

Andres, R. J., and G. Marland. 1994. "Historic Patterns of CO₂ Emissions from Fossil Fuels: Implications for Stabilization of Emissions." 87th Annual Meeting and Exhibition of Air and Waste Management Association, Cincinnati, June.

Andres, R. J., G. Marland, and I. Fung. 1993. "One Degree by One Degree Distribution of Carbon Dioxide Emissions from Fossil Fuel Consumption and Cement

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Baes, C. F., III. 1994. "Regulatory Requirements: Where From? Where To?" DOE Training Coordination Program Information Exchange Workshop, Knoxville, Tenn., June.

Barnett, M. O., R. R. Turner, L. A. Harris, T. J. Henson, R. C. Melton, and R. J. Stevenson. 1994. "Characterization of Mercury Forms in Contaminated Floodplain Soils." International Conference on Mercury as a Global Pollutant, Whistler, British Columbia, Canada, August.

Barnett, M. O., R. R. Turner, L. A. Harris, T. J. Henson, R. C. Melton, and R. J. Stevenson. 1994. "Characterization of Mercury in Contaminated Floodplain Soils." American Chemical Society, Atlanta, September.

Barnthouse, L. W. 1993. "Using Risk Assessment to Achieve Sustainable Development." Keynote Address, San Diego Chapter, Society of Environmental Toxicology and Chemistry, San Diego, October.

Barnthouse, L. W. 1993. "Empirical and Mechanistic Approaches to Geological

Risk Quantification." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

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Barnthouse, L. W. 1994. "Environmental Management in the Next Millennium: Can EMAP Contribute?" Ecological Society of America, Knoxville, Tenn., August.

Barnthouse, L. W., J. Bascietto, T. Joseph, and G. Bilyard. 1993. "A Survey of Ecological Risk Assessment at DOE Facilities." Ninth Annual DOE Model Conference on Waste Management and Environmental Restoration, Oak Ridge, Tenn., October.

Beard, L. P., and A. C. Tripp. 1994. "Investigating the Resolution of Resistivity Arrays Using Inverse Theory." Symposium on Application of Geophysics to Environmental and Engineering Problems (SAGEEP '94), Boston, March.

Beard, L. P., J. E. Nyquist, W. E. Doll, and T. J. Gamey. 1993. "Interpretation of AEM Data at Oak Ridge Reservation." Fall Meeting, American Geophysical Union, San Francisco, December.

Beeler, D. A. 1994. "Automated Sample Management Using Bar Code Technology." Environmental Computing and Information Technology '94, Arlington, Va., June.

Beeler, D. A., L. A. Hook, and A. S. Masvidal. 1993. "Environmental Sample Management." Environmental Restoration '93, Augusta, Ga., October.

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Blake, A. A., C. Brandt, I. L. Larsen, D. P. Bozarth, and H. M. Anderson, Jr. 1994. "Overview of a Laboratory Information System." Canberra Users Group Meeting, Charlotte, N.C., June.

Blaylock, B. G., B. R. O'Neal, and M. L. Frank. 1994. "Human Health Risk Assessment and Remediation Activities at White Oak Creek Embayment at Oak Ridge National Laboratory." 19th Annual Conference and Exposition, National Association of Environmental Professionals, New Orleans, June.

Boden, T. A. 1993. "Carbon Emissions Estimates Work at ORNL: Present and Future." 18th Working Group VIII Annual Meeting, Asheville, N.C., October.

Boden, T. A. 1994. "Archival, Distribution, and Advertisement Activities." Ninth Advanced Global Atmospheric Gases Experiment Meeting, Hilton Head, S.C., May.

Boden, T. A., and F. W. Stoss. 1993. "The Carbon Dioxide Information Analysis Center (CDIAC) Providing Information Support for DOE's Global Change Research Program." Second Consortium for International Earth Science Information Network Users Workshop on Sharing Data Through the Information Cooperative, Atlanta, October.

Bonczek, R. R., R. N. Hull, and G. W. Suter II. 1993. "A Strategy for Ecological Risk Assessment at a Large,

Complex DOE Site." Annual Meeting, Society for Risk Analysis, Savannah, Ga., December.

Borders, D. M., and D. J. Pridmore. 1994. "Soluble Contaminant Concentration Versus Discharge Relationships in First-Order Tributaries Draining Waste Disposal Sites at the Oak Ridge National Laboratory." 14th Annual Hydrology Days Conference, American Geophysical Union, Colorado State University, Fort Collins, April.

Burgoa, B., and T. A. Fontaine. 1994. "Sediment Samples from Weir Pools as Indicators of Upgradient Contaminant Releases." Annual Summer Symposium on Effects of Human-Induced Changes on Hydraulic Systems, American Water Resources Association, Jackson Hole, Wyo., June.

Burlage, R. S. 1993. "Exploitation of Molecular Technology for Detecting Microorganisms in Environmental Samples." DOE Workshop on Intermediate-Scale Experiments, Norfolk, Va., October.

Burlage, R. S., A. V. Palumbo, and J. F. McCarthy. 1993. "Field Tests of Bacterial Transport in Groundwater." DOE Workshop on Transport in the Subsurface, Norfolk, Va., November.

Burlage, R. S., A. V. Palumbo, and J. F. McCarthy. 1994. "Application of Molecular Techniques to Determine the Mobility of Microorganisms at the Field Scale." DOE Office of Health and Environmental Research Subsurface Science Program, Bacterial Transport Subprogram Review, Gaithersburg, Md., February.

Burlage, R. S., Z. Yang, A. V. Palumbo, and J. F. McCarthy. 1994. "Groundwater Transport of Multiple Bacterial Strains at a Field Site is Detected by PCR Analysis." 93rd General Meeting, American Society of Microbiology, Las Vegas, May.

Cada, G. F. 1994. "An Examination of the Benefits of Fish Passage Mitigation at Sixteen Hydroelectric Projects." Annual Meeting, American Fisheries Society, Halifax, Nova Scotia, Canada, August.

Cardwell, H. E., H. I. Jager, and M. J. Sale. 1994. "Instream Releases, Fish Populations, and Water Supply Planning—Linking the Issues." Annual Spring Symposium on Responses to Changing Multiple-Use Demands: New Directions in Water Resources Planning and Management, Nashville, Tenn., April.

Cardwell, H. E., H. I. Jager, and M. J. Sale. 1994. "Models for Maximizing Fish Populations While Minimizing Instream Flows." 1994 Water Resources Planning and Management Conference, American Society of Civil Engineers, Denver, May.

Carpenter, M. D., J. S. Gierke, R. L. Siegrist, and O. R. West. 1993. "Vapor Phase VOC Transport in Physically Mixed Clay Soils." Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Restoration, Houghton, Mich., November.

Carpenter, P. J., W. E. Doll, and B. E. Phillips. 1994. "Ground-Penetrating Radar Surveys Over an Alluvial DNAPL Site, Paducah Gaseous Diffusion Plant, Kentucky." Symposium on Application of Geophysics to Engineering and Environmental Problems, Boston, March.

Christensen, S. W. 1994. "The Internet Technologies Users Group at Martin Marietta Energy Systems, Incorporated: A Call to Grass Roots Action." Internet Technologies Users Group, ORNL Environmental Sciences Division, Oak Ridge, Tenn., May.

Christensen, S. W. 1994. "The Life and Times of an Environmental Scientist at Oak Ridge National Laboratory." Adventures in Supercomputing Class, Central High School, Wartburg, Tenn., May.

Christensen, S. W., and E. J. Nall. 1993. "An Overview of the Internet." Meeting of East Tennessee PC Users Group, Internet Special Interest Group, The University of Tennessee College of Veterinary Medicine, Knoxville, November.

Clapp, R. B., S. P. Timmins, D. K. Reece, M. A. Huston, and T. A. Fontaine. 1994. "A Topography-Based Hydrologic Model." Annual Meeting, American Water Resources Association, Nashville, Tenn., April.

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Cline, S. R., B. E. Reed, R. E. Moore, and M. R. Matsumoto. 1993. "Soil Washing of Various Forms of Lead and Organically Contaminated Soils." 66th Annual Conference and Exposition, Water Environment Federation, Anaheim, Calif., October.

Cook, P. G., R. G. Shropshire, D. K. Solomon, W. E. Sanford, E. Busenberg, and L. N. Plummer. 1994. "Estimating Groundwater Recharge Using Chlorofluorocarbons." Spring Meeting, American Geophysical Union, Baltimore, May.

Cooper, L. W., J. M. Grebmeier, and I. L. Larsen. 1994. "Arctic Polynyas and Sediment Beryllium-7 Inventories: A Tracer for Pelagic-Benthic Coupling in the Bering Sea?" Meeting, American Geophysical Union, San Diego, February.

Cooper, L. W., J. M. Grebmeier, I. L. Larsen, and E. A. Jerde. 1994. "Distribution of Cesium-137 in Bering and Chukchi Sea Marine Sediments." 45th Arctic Science Conference on Bridges of Science Between North America and the Russian Far East, Anchorage, Alaska, August.

Cooper, L. W., J. M. Grebmeier, I. L. Larsen, C. Solis, and C. R. Olsen. 1993. "Evidence for Redistribution and Transport of ¹³⁷Cs in Alaskan Tundra, Lake, and Marine Sediments." International Symposium on Ecological Effects of Arctic Airborne Contaminants, Reykjavik, Iceland, October.

Cushman, R. M. 1993. "Retrospective of CDIAC Activities." 18th Working Group VIII Annual Meeting, Asheville, N.C., October.

Cushman, R. M. 1994. "The Origins of Greenhouse Gases—The Need and Possibilities for Abatement." Greenhouse Gas Technology Information Exchange, Liaison Groups Meeting, Maastricht, The Netherlands, September.

Daniels, R. C., E. P. Flint, and J. F. Richards. 1994. "Deforestation and Carbon Estimates for South and Southeast Asia: 1880-1980."

90th Annual Meeting, Association of American Geographers, San Francisco, March-April.

Daugherty, P. F. 1993. "Information Management Group Meeting, Hampton, Virginia." User Services Working Group Meeting, Hampton, Va., November-December.

Dees, C., D. Ringleberg, T. C. Scott, and T. J. Phelps. 1994. "Taxonomic Characterization of the Cellulose-Degrading Bacterium NCIMB 10462." 16th Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, Tenn., May.

DePaoli, D. W., S. E. Herbes, D. W. Greene, and A. D. Walzel. 1994. "A Negative Bioventing Feasibility Test." Spring National Meeting, American Institute of Chemical Engineers, Atlanta, April.

Doll, W. E., J. E. Nyquist, and T. J. Gamey. 1993. "Noise Characterization in Airborne Environmental Magnetic Surveys." Fall Meeting, American Geophysical Union, San Francisco, December.

Dreier, R. B. 1993. "Use of Borehole Geophysics to Identify Porosity Changes and Fractures in Carbonate Rocks at the Oak Ridge Reservation." 105th Annual Meeting, Geological Society of America, Boston, October.

Early, T. O., R. B. Dreier, J. Clausen, and B. Kueper. 1994. "DNAPL Discovery, Characterization, and Remediation Strategies at Two

Contrasting Sites." Sixth National Technology Information Exchange Workshop, Kennewick, Wash., May.

Eddlemon, G. K. 1994. "A Retrospective Examination of the Predicted and Observed Effects of Alcohol Fuel Projects on Aquatic Resources." Annual Meeting, American Fisheries Society, Halifax, Nova Scotia, Canada, August.

Edwards, N. T. 1994. "Effects of Various Uranium Leaching Techniques on Vegetative Support Capacity of Soil." Uranium Soils ID Mid-Year Review Meeting, Washington, D.C., June.

Edwards, N. T. 1994. "Evaluation of Pilot-Scale Thermally Treated Soils from East Fork Poplar Creek Using Soil Characterization and Phytotoxicity Techniques." Technical Information Briefing, East Fork Poplar Creek—Approaching a Decision, Oak Ridge, Tenn., September.

Edwards, N. T., and P. J. Hanson. 1994. "Bole Respiration in a Closed-Canopy Upland Oak Forest." Oak Ridge Conference on Global Change, Oak Ridge, Tenn., March.

Edwards, N. T., and P. J. Hanson. 1994. "Bole Respiration in a Closed-Canopy Upland Oak Forest Before and After Soil Moisture Manipulations." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Elless, M. P., S. Y. Lee, and M. E. Timpson. 1994. "Physicochemical and Mineralogical Characterization of Uranium-Contaminated Soils from the Fernald Integrated Demonstration Site." Waste Management '94 Meeting, Tucson, Ariz., February.

Elless, M. P., M. E. Timpson, S. Y. Lee, and C. W. Francis. 1993. "Artificial Weathering of Soil Minerals by Uranium Extraction Techniques." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.

Fontaine, T. A., K. W. Potter, and C. A. Rodgers. 1993. "Estimating Extreme Flood Probabilities." Fourth DOE Natural Phenomena Hazards Mitigation Conference, Atlanta, October.

Francis, C. W., J. R. Brainard, D. J. Chaiko, G. Matthern, and D. A. York. 1994. "Uranium Removal from Soils: An Overview from the Uranium Soils Integrated Demonstration Program." Waste Management '94 Meeting, Tucson, Ariz., February-March.

Francis, C. W., M. E. Timpson, M. P. Elless, and S. Y. Lee. 1993. "The Effect of Uranium Decontamination Techniques on Soil Properties." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.

Francis, C. W., M. E. Timpson, S. Y. Lee, and M. P. Elless. 1994. "Factors Affecting Sodium Carbonate Extractions of Uranium from Soils." 18th Annual Actinide Separations Conference, Durango, Colo., May.

Gabrielsen, C. A. 1994. "Formulation of a Viable Work Plan for the Assessment of Threatened and Endangered Animal Species at the Oak Ridge National Environmental Research Park." Meeting of Association of Southeastern Biologists, Orlando, Fla., April.

Gardner, R. H., and E. J. Gustafson. 1994. "Patterns of Dispersal in Heterogeneous Landscapes." Ninth Annual U.S. Landscape Ecology Symposium, University of Arizona, Tucson, March.

Gardner, R. H., W. W. Hargrove, M. G. Turner, and W. H. Romme. 1994. "Global Change, Disturbances and Landscape Dynamics." First Global Change and Terrestrial Ecosystems Science Conference, Woods Hole, Mass., May.

Garten, C. T., Jr., H. Van Miegroet, A. B. Schwab, and T. L. Shirshac. 1994. "Applications of Stable Isotope Measurements to Monitoring the Nitrogen Dynamics of High-Elevation Forest Ecosystems." 19th Annual Meeting on Scientific Research, Gatlinburg, Tenn., May.

Gates, D. D. 1993. "In Situ Remediation Technologies." NSBPE, Technet, Los Angeles, October.

Gates, D. D., K. K. Chava, K. K. Chao, and M. Morrissey. 1994. "Mercury Removal from Solid Mixed Waste." Spectrum '94, Atlanta, August.

Gebre, G. M., J. R. Brandle, and M. R. Kuhns. 1994. "Differences in Solute Accumulation and Dehydration Tolerance of Three *Populus deltoides* Clones." 13th North American Forest Biology Workshop, Baton Rouge, La., June.

Goeltz, R. T., and T. F. Zondlo. 1994. "3-D Subsurface Modeling Within the Framework of an Environmental Restoration Information System: Prototype Results Using EarthVision." Federal Geographic Technology '94, Washington, D.C., September.

- Goldstrand, P. M., and R. B. Dreier. 1993. "Stratabound Porosity in the Maynardville Limestone, Bear Creek Valley, Oak Ridge, Tennessee." 105th Annual Meeting, Geological Society of America, Boston, October.
- Gonzalez, A. M. 1994. "Sediment Toxicity Testing in the Clinch River and Poplar Creek-Watts Bar Reservoir." NALMS: Third Annual Southeastern Lakes Management Conference on Watershed Management: From Concept to Implementation, Columbia, S.C., March.
- Graham, R. L. 1994. "The Regional Environmental Impact of Biomass Production." Potential of Biomass Products Energy Utilization Forum, Taipei, Taiwan, June.
- Graham, R. L., and M. Downing. 1994. "Impacts of Biomass Energy Plantations." Oak Ridge Conference on Global Change, Oak Ridge, Tenn., March.
- Graham, R. L., M. Downing, and B. C. English. 1993. "The Environmental Implications of Energy Crops." Conference on Southern Appalachian Man and the Biosphere, Gatlinburg, Tenn., November.
- Grebmeier, J. M., and L. W. Cooper. 1994. "A Decade of Benthic Research on the Contaminated Shelves of the Bering Sea: Lessons Learned." 45th Arctic Science Conference, Anchorage, Alaska, and Vladivostok, Russia, August-September.
- Greeley, M. S., Jr., S. M. Adams, W. D. Crumby, R. G. Epler, D. L. Harris, K. L. Lee, M. K. McCracken, J. G. Mural, S. L. Niemela, and R. McPherson. 1993. "Bioindicator Assessment of Fish Health in Lake Hartwell, a PCB-Contaminated Reservoir." Integrated Ecological Risk Assessment: Lessons Learned?, 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.
- Gu, B., L. Liang, and J. F. McCarthy. 1994. "Adsorption and Desorption of Natural Organic Matter on Iron Oxide-Coated Quartz Surfaces." National Meeting, American Chemical Society, San Diego, March.
- Gu, B., J. Schmitt, Z. Chen, L. Liang, and J. F. McCarthy. 1993. "Interaction of the Fractionated Natural Organic Matter with Iron Oxide." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.
- Gunderson, C. A., J. M. Kostuk, M. H. Gibbs, G. E. Napolitano, L. F. Wicker, J. E. Richmond, and A. J. Stewart. 1994. "Ecological Validation of a New Remediation Technology: Does Composting TNT-Contaminated Soil Make It Suitable for Land Application?" 20th Environmental Symposium and Exhibition on Department of Defense Environmental Security—Strategies for the 21st Century, San Antonio, Tex., March.
- Gunderson, C. A., R. J. Norby, T. J. Tschaplinski, and S. D. Wulschleger. 1994. "Coppicing of Yellow-Poplars Does Not Enhance the Growth Response to Elevated CO₂." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.
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Elevated CO₂." 13th North American Forest Biology Workshop, Baton Rouge, La., June.

Gwo, J.-P. 1994. "Hillslope Subsurface Storm Flow Modeling with Sensitivity Analysis and Risk Assessment." Environmental Sciences Division Program Managers, ORNL, Oak Ridge, Tenn., January; Oak Ridge Reservation Hydrology and Geology Study, ORNL, Oak Ridge, Tenn., February.

Gwo, J.-P. 1994. "Supercomputer Groundwater Modeling." Tuskegee pre-college students, ORNL, Oak Ridge, Tenn., July.

Gwo, J.-P. 1994. "Advanced Supercomputer Groundwater Modeling." U.S. Environmental Protection Agency, Washington, D.C., September.

Gwo, J.-P., P. M. Jardine, G. V. Wilson, and G.-T. Yeh. 1993. "Advective and Diffusive Mass Exchange in a Structured Soil During Fluid and Solute Transport: A Sensitivity Analysis." Fall Meeting, American Geophysical Union, San Francisco, December.

Gwo, J.-P., P. M. Jardine, G. V. Wilson, and G.-T. Yeh. 1994. "Modeling Small-Scale Physical Non-Equilibrium and Large-Scale Preferential Fluid and Solute Transport in a Structured Soil." Tenth International Conference on Computational Methods in Water Resources, Heidelberg, Germany, July.

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Halbrook, R. S., G. W. Suter II, A. J. Aulerich, S. J. Bursian, and L. A. Lewis. 1993. "Using Mink Reproductive and Physiological Response to Diets Supplemented by Fish Collected from a Superfund Site in Ecological Risk Assessment." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Ham, K. D., and S. M. Adams. 1993. "The Effect of Temperature, Feeding, and pH on Respiratory Responses of Bluegill to Gradual Hypoxic Challenge." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Ham, K. D., and S. M. Adams. 1994. "Field Trial of Metabolic Indicators of Stress in Fish." Annual Meeting, American Fisheries Society, Halifax, Nova Scotia, Canada, August.

Hanson, P. J., S. E. Lindberg, K.-H. Kim, J. G. Owens, and T. A. Tabberer. 1994. "Air/Surface Exchange of Mercury Vapor in the Forest Canopy-II. Laboratory Studies of Foliar Hg Vapor Exchange." International Conference on Mercury as a Global Pollutant, Whistler, British Columbia, Canada, July.

Hargrove, W. W., R. H. Gardner, M. G. Turner, and W. H. Romme. 1994. "Fire-Induced Changes in the Yellowstone Landscape Simulated Under Alternative Future Climate Trends." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Hargrove, W. W., R. H. Gardner, M. G. Turner, W. H. Romme, and D. G. Despain. 1993. "Simulating Fire Patterns in Heterogeneous Landscapes." 12th Conference on Fire and Forest Meteorology, Jekyll Island, Ga., October.

- Hart, D., P. J. Mulholland, E. R. Marzolf, D. L. DeAngelis, and S. P. Hendricks. 1994. "Effects of Flow, Leaves, and Algal Biomass on the Hydraulic Features of Natural and Artificial Streams." 42nd Annual Meeting, North American Benthological Society, Orlando, Fla., May.
- Hatcher, R. D., Jr. 1993. "Geology of the Southern Appalachians." Southern Forest Hydrology and Soils Workshop, University of Georgia, Helen, October.
- Hatcher, R. D., Jr. 1994. "The Appalachian Orogen—Product of Arc, Terrane, and Continent-Continent Collision." Joint Meeting of German Geologische Vereinigung and Czech Geological Society, Mainz, Germany, February.
- Hatcher, R. D., Jr. 1994. "Short Course on Anatomy of Mountain Chains." Invited Speaker, University of Oulu, Finland, February.
- Hatcher, R. D., Jr. 1994. "The Impasse Over Disposal of Hazardous and Radioactive Waste, and Environmental Degradation—Political Juggernaut or Opportunity for Geological Scientists?" Charles Joseph Norwood Distinguished Lecture, Kentucky Geological Survey, Lexington, Ky., March.
- Hatcher, R. D., Jr. 1994. "Foreland Deformation and Hydrocarbon Potential Resulting from Rotational-Oblique, Then Head-On Continent-Continent Collision in the Appalachian Orogen." 1994 Convention, Association of Petroleum Geologists, Denver, June.
- Hendricks, S. P., and P. J. Mulholland. 1994. "Phosphorus (P) Uptake Within Subsurface Stream Sediments as Determined from Short-Term Radiotracer Injections to Surface Water in Walker Branch, Tennessee, U.S.A." Second International Conference on Ground Water Ecology, Atlanta, March.
- Hicks, D. S. 1994. "Identification of Contaminant Releases Within a Watershed." Annual Summer Symposium on Effects of Human-Induced Changes on Hydraulic Systems, American Water Resources Association, Jackson Hole, Wyo., June.
- Hinzman, R. L., E. M. Schilling, and M. G. Ryon. 1993. "Effects of Total Residual Chlorine on Mortality Rates of the Central Stoneroller and Striped Shiner." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.
- Hoffman, F. M. 1994. "How Do I Connect to the Internet? Let Me Count the Ways." 21st Annual Welding and Testing Technology Exhibition and Conference (WATtec '94), Knoxville, Tenn., February; East Tennessee PC Users' Group, Internet Special Interest Group, University of Tennessee Veterinary Hospital, Knoxville, Tenn., March.
- Hoffman, F. M. 1994. "Mosaic and the World Wide Web." Administrative Computing Steering Council, ORNL, Oak Ridge, Tenn., March.
- Hoffman, F. M. 1994. "The ORNL Environmental Sciences Division World Wide Web." Executive Committee, ORNL, Oak Ridge, Tenn., March.
- Hoffman, F. M. 1994. "Using the Internet's World Wide Web." ORNL UNIX Workstation Users' Group Meeting, ORNL, Oak Ridge, Tenn., March.

Homer, V. J., P. M. Jardine, and R. J. Luxmoore. 1994. "Scaling Up in Percolation Modelling for Fluid/Solute Transport." Chapman Conference on Hydrogeologic Processes, Lincoln, N.H., June.

Homer, V. J., P. M. Jardine, R. J. Luxmoore, and P. Jenssen. 1994. "Mapping Soil Pore Heterogeneities for Percolation Fluid/Solute Transport Models." Spring Meeting, American Geophysical Union, Baltimore, May.

Homer, V. J., J. F. McCarthy, P. M. Jardine, and Z. H. Chen. 1994. "Scattering Approaches to Monitoring Humic Acid Aggregation: Fractal Dimensions, Absolute Scattering Intensities." Seventh International Humic Substances Society Meeting, University of West Indies, Trinidad, July.

Huff, D. D., D. S. Hicks, D. K. Solomon, L. A. Shevenell, G. K. Moore, and R. B. Clapp. 1994. "Contaminant Transport at Low-Level Radioactive Waste Sites on the Oak Ridge Reservation." National Meeting, American Institute of Hydrology, Austin, Tex., April.

Hull, R. N., G. W. Suter II, and R. R. Bonczek. 1993. "Analysis of Results of a Preliminary Ecological Risk Assessment to Guide Baseline Ecological Risk Assessment Efforts at a Large, Complex DOE Site." Annual Meeting, Society for Risk Analysis, Savannah, Ga., December.

Hunsaker, C. T. 1993. "Characterization of Landscape Pattern for Regional Assessments." Fourth Annual Conference on Southern Appalachian Man and the Biosphere, Gatlinburg, Tenn., November.

Hunsaker, C. T. 1994. "Ecological Indicators Require Context." First International Symposium on Ecosystem Health and Medicine, Ottawa, June.

Hunsaker, C. T., and R. V. O'Neill. 1994. "Characterization of Landscape Pattern for Regional Assessments." First Annual Conference on Environmental Monitoring and Assessment in the Mid-Atlantic Highlands Area, Hershey, Pa., February.

Hunsaker, C. T., and R. V. O'Neill. 1994. "Understanding Factors That Influence Pattern Metrics for Monitoring Landscapes." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Hunsaker, C. T., R. O'Neill, B. Jackson, and S. Timmins. 1994. "Quantifying Landscape Status at the Regional Scale." Ninth Annual U.S. Landscape Ecology Symposium, Tucson, Ariz., March.

Jacobs, G. K., M. T. Naney, and N. W. Dunbar. 1993. "Evidence for Convection in a Large, Artificial Magma: Thermal Oscillations Recorded During Cooling and Crystallization." Annual Meeting, Geological Society of America, Boston, October.

Jager, H. I., M. J. Sale, H. E. Cardwell, D. L. DeAngelis, M. S. Bevelhimer, and C. C. Coutant. 1994. "Streamflow Effects on Spawning, Rearing, and Outmigration of Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*) Predicted by a Spatial and Individual-Based Model." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

James, B. R., and S. M. Gorelick. 1994. "When Enough is Enough: The Worth of Monitoring Data in Aquifer

Remediation." Spring Meeting, American Geophysical Union, Baltimore, May.

James, B. R., and S. M. Gorelick. 1994. "How Many Observation Wells Does It Take to Find a Groundwater Contamination Plume?" First American Society of Civil Engineers Conference on Computing in Civil Engineering, Washington, D.C., June.

Jardine, P. M., and D. L. Taylor. 1993. "On the Kinetics of Cobalt(II)EDTA²⁻ Oxidation by Pyrolusite." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.

Jardine, P. M., and D. L. Taylor. 1994. "Reactive Transport of Cobalt-EDTA Complexes in Subsurface Environments: Remedial Challenges." Industrial and Engineering Chemistry Special Symposium, American Chemical Society, Atlanta, September.

Joslin, J. D. 1994. "Belowground Responses to Altered Hydrologia Inputs." Oak Ridge Conference on Global Environmental Change, ORNL, Oak Ridge, Tenn., March.

Joslin, J. D., F. C. Thornton, H. Van Miegroet, and S. B. McLaughlin. 1994. "Evidence for Nutritional Deficiencies in High-Elevation Red Spruce." Multiple Stressors to the High-Elevation Spruce-Fir Ecosystem, Ecological Society of America, Knoxville, Tenn., August.

Kaiser, D. P., and R. S. Vose. 1994. "Climatic Variability in Eastern China During the Twentieth Century." 90th Annual Meeting, Association of American Geographers, San Francisco, March-April.

Kearl, P. M. 1993. "Field Comparison of Micropurging Versus Traditional Groundwater Sampling." Environmental Restoration '93, Augusta, Ga., October.

Kearl, P. M. 1993. "Colloidal Borescope." Technical Information Exchange, Denver, November.

Kearl, P. M. 1994. "Numerical Simulations of Well Bore Flow." PORFLOW Users Conference, Santa Barbara, Calif., September.

Kim, K.-H., and S. E. Lindberg. 1994. "Design and Initial Tests of a Dynamic Enclosure Chamber for Measurements of Vapor-Phase Mercury Fluxes Over Soils." International Conference on Mercury as a Global Pollutant, Whistler, British Columbia, Canada, July.

King, A. W., W. M. Post, and S. D. Wulschleger. 1993. "Net Carbon Exchange Between Global Terrestrial Ecosystems and the Atmosphere Under Conditions of Global Change." Fall Meeting, American Geophysical Union, San Francisco, December.

King, A. W., W. M. Post, and S. D. Wulschleger. 1994. "A Model of Global Terrestrial Ecosystem Response to Changes in Climate and Atmospheric CO₂." Oak Ridge Conference on Global Environmental Change, Oak Ridge, Tenn., March.

King, A. W., W. M. Post, and S. D. Wulschleger. 1994. "The Response of Global NPP and Carbon Storage in Vegetation to Changes in Climate and Atmospheric CO₂." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Kohring, L. L., G. E. Napolitano, A. J. Stewart, and D. C. White. 1993. "Quantitative Multi-Species Toxicity Assessment by Analysis of Freshwater Stream Periphyton Pigments and Lipids." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Kooner, Z. S., and P. M. Jardine. 1993. "Competitive Surface Complexation Reactions of SO_4 and Natural Organic Carbon." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.

Korte, N. E., and P. M. Kearl. 1993. "A Field Comparison of Micropurging and Traditional Groundwater Sampling Using Analytical Data and Observation With the Colloidal Borescope." Groundwater Sampling Workshop, U.S. Environmental Protection Agency, Dallas, November-December.

Korte, N. E., R. L. Siegrist, and P. M. Kearl. 1994. "In Situ Treatment of Mixed Contaminants in Groundwater." American Chemical Society, Atlanta, September.

Laase, A. D., P. M. Kearl, and J. L. Baker. 1994. "Application of the Colloidal Borescope in Site Characterization." Second International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Budapest, Hungary, September.

Lee, S. R., M. P. Elless, S. Y. Lee, and M. E. Timpson. 1994. "The Occurrence of Uranophane and Schoepite in Uranium-Contaminated Soils." Clay Minerals Society Meeting, Saskatoon, Saskatchewan, Canada, August.

Lee, S. R., S. Y. Lee, M. E. Timpson, and M. P. Elless. 1994. "Geochemical and Mineralogical Characterization of Uranium-Contaminated Soils from Oak Ridge Uranium Gaseous Plant Site." Meeting, American Geophysical Union, Baltimore, May.

Lee, S. R., S. Y. Lee, M. E. Timpson, and M. P. Elless. 1994. "Geochemical/Mineralogical Characterization of Uranium-Contaminated Soils for Electrokinetic Remediation." Clay Minerals Society Meeting, Saskatoon, Saskatchewan, Canada, August.

Lee, S. Y., M. P. Elless, and M. E. Timpson. 1993. "Physicochemical and Mineralogical Characterization of Transuranic Contaminated Soils for Uranium Soil ID." Uranium Soil ID FY '94 Kick-Off Meeting, San Antonio, Tex., October.

Lemiszki, P. J., J. E. Nyquist, L. P. Beard, R. D. Hatcher, Jr., and B. K. Thompson. 1994. "Digital Geologic Maps and Airborne Geophysical Maps: Applications to Environmental Restoration on the Oak Ridge Reservation, Tennessee." Meeting, Southeastern Geological Society of America, Blacksburg, Va., April.

Lemiszki, P. J., J. E. Nyquist, and W. E. Doll. 1993. "Environmental Restoration Activities at the Oak Ridge Gaseous Diffusion Plant, East Tennessee: Surface Geologic and Airborne Geophysical Mapping." Annual Meeting, Geological Society of America, Boston, October.

Levine, D. A. 1994. "Sediment Characterization of Watts Bar Reservoir/Clinch River Tennessee: An Overview." Third Annual Conference of

Southeast Lakes Management Society,
Columbia, S.C., March.

Liang, L., B. Gu, and J. F. McCarthy.
1994. "Effects of Natural Organic Matter
on Hematite Transport in Laboratory and
Field Studies." Spring Meeting, American
Chemical Society, San Diego, March.

Liang, L., B. Gu, R. L. Siegrist, and
J. D. Goodlaxson. 1994. "Removal of
Heavy Metals from Groundwater by Peat
Materials." Emerging Technologies in
Hazardous Waste Management VI,
Atlanta, September.

Liang, L., J. A. McNabb, B. Gu, and
J. F. McCarthy. 1993. "Transport of Iron
Oxide Colloid in Laboratory Columns and
in a Sandy Aquifer." Annual Meeting,
American Society of Agronomy, Crop
Science Society of America, and Soil
Science Society of America, Cincinnati,
November.

Lindberg, S. E. 1993. "Mercury Emissions
from Trees: Results of Field and
Chambers Studies." Annual Meeting of
the National Atmospheric Deposition
Program, Nashville, Tenn., October.

Lindberg, S. E. 1994.
"Micrometeorological and Chamber
Measurements of the Air/Surface Exchange
of Mercury." Air Toxics Lab, School of
Public Health, University of Michigan,
Ann Arbor, January.

Lindberg, S. E. 1994. "Development of
Micrometeorological Methods to Quantify
Air/Surface Exchange of Mercury Over
Forest Soils and Canopies." Department
of Inorganic Chemistry at Chalmers
Technical University, Goteborg, Sweden,
May.

Lindberg, S. E. 1994. "A Review of
Recent Research on Mercury at
Oak Ridge National Laboratory."
International Review of Mercury Research
at Geesthacht Physics Research Center,
Hamburg, Germany, May.

Lindberg, S. E. 1994. "The Role of
Surface Re-emission in the Global Hg
Cycle." Meteorological Institute of
Stockholm, University Seminar Series,
Stockholm, May.

Loar, J. M. 1993. "Implementation of
Biological Monitoring Programs at DOE
Oak Ridge Facilities." The University of
Tennessee Center for Environmental
Technology/Czechoslovakia Collaboration,
Knoxville, Tenn., October.

Loar, J. M. 1994. "Applications of
Biological Monitoring for Environmental
Restoration." Tulane University,
New Orleans, May.

Loar, J. M., and R. L. Hinzman. 1994.
"Biological Monitoring Program for the
Paducah Gaseous Diffusion Plant." State
of Kentucky Regulators Meeting, Paducah,
June.

Loar, J. M., S. M. Adams, M. G. Ryon,
G. R. Southworth, J. G. Smith, and
A. J. Stewart. 1994. "Monitoring
Ecological Change in Aquatic Ecosystems."
First Annual Conference on Environmental
Monitoring and Assessment in the
Mid-Atlantic Highlands Area, Hershey, Pa.,
February.

Lotts, J. W., Jr., and A. J. Stewart. 1993.
"Acclimation of Striped Shiners to Total
Residual Chlorine." 14th Annual Meeting,
Society of Environmental Toxicology and
Chemistry, Houston, November.

Luxmoore, R. J. 1994. "Scaling Up Forest Processes by Linking Models." Interscale Relationships in Forest-Atmosphere Processes, St. John's, Canada, August.

Mann, L. K., G. Martin, J. Abrell, and D. Meriwether. 1994. "Selection Criteria for Adding Management Units to the SAMAB Regional Biosphere Reserve." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Marland, G. 1994. "Greenhouse Gas Emissions Related to Ethanol Produced from Corn." Renewable Oxygenate Requirement for Reformulated Gasoline, Public Hearing, U.S. Environmental Protection Agency, Arlington, Va., January.

McCarthy, J. F. 1994. "Natural Analogue Studies of the Role of Colloids, Natural Organics and Microorganisms on Radionuclide Transport." Sixth Commission of European Countries Natural Analogue Working Group Meeting, Santa Fe, N.M., September.

McCold, L. N., J. T. Ensminger, and J. W. Webb. 1994. "Environmental Impact Assessment for the U.S. Antarctic Program: NEPA and the Antarctic Treaty." 19th Annual Conference, National Association of Environmental Professionals, New Orleans, June.

McConnell, J. W., Jr., R. D. Rogers, J. D. Jastrow, W. E. Sanford, and T. M. Sullivan. 1993. "Results After Eight Years of Field Testing Low-Level Waste Forms Using Lysimeters." 15th DOE Low-Level Radioactive Waste Management Conference, Phoenix, Ariz., December.

McCord, R. A. 1994. "An Overview of the Oak Ridge Environmental Information System (OREIS)." Presentation to the Dynamic Graphic Eastern User's Group, Hazardous Waste Remedial Actions Program, Oliver Springs, Tenn., April.

McCord, R. A., and R. Durfee. 1994. "GIS and ER Information Management at Oak Ridge." Fourth Geographic Information System, Information Exchange Meeting, Richland, Wash., June.

McLetchie, N., and G. A. Tuskan. 1994. "In Search of Gender Associated Markers in *Populus*." Task VIII Meeting for Activity Groups on Genetic Improvement, Pest/Disease Control and Exchange, Evaluation and Joint Testing, Biri, Norway, September.

Minocha, U., J. M. Strong-Gunderson, A. V. Palumbo, and J. F. McCarthy. 1994. "Comparison of the Availability of Dissolved Organic Carbon in Uncontaminated Surface and Groundwater." 93rd General Meeting, American Society of Microbiology, Las Vegas, May.

Mitch, M. E., and P. J. Mulholland. 1994. "Nitrogen Transformations and Fluxes in the Riparian Zone of Small, Forested Watersheds." Oak Ridge Conference on Global Environmental Change, Oak Ridge, Tenn., March.

Mitch, M. E., and P. J. Mulholland. 1994. "The Influence of Riparian Nitrogen Cycling on the Flux of Inorganic Nitrogen to Streamwater in a High-Elevation Spruce-Fir Forest." 19th Annual Science Meeting, Great Smoky Mountains National Park, Tenn., May.

Mitch, M. E., K. N. Eshleman, and P. J. Mulholland. 1993. "Riparian

Controls on the Flux of Inorganic Nitrogen to Streamwater in a High-Elevation Spruce-Fir Forest: The Role of Denitrification." Fall Meeting, American Geophysical Union, San Francisco, December.

Moline, G. R. 1994. "Core- to Basin-Scale Parameterization: Bridging the Gap Through Electrofacies Classification." Chapman Conference on Hydrogeologic Processes, Lincoln, N.H., June.

Moline, G. R., and J. M. Bahr. 1993. "Regionalized Classification for Estimation of Heterogeneous Hydraulic Parameters." Silver Anniversary Meeting, International Association of Mathematical Geology, Prague, Czech Republic, October.

Moore, T. D., and T. A. Fontaine. 1994. "Contaminated Sediment Movement: A Case Study of Field Sampling and Laboratory Technique." Annual Summer Symposium on Effects of Human-Induced Changes on Hydraulic Systems, American Water Resources Association, Jackson Hole, Wyo., June.

Morris, M. I., R. L. Siegrist, and D. T. Davenport. 1994. "Environmental Technology Demonstrations at U.S. DOE Facilities: Observations Regarding the Current Process and Methods for Improvement." Waste Management '94, Tucson, Ariz., February-March.

Mulholland, P. J. 1993. "Regulation of Stream Chemistry: Effects of Hydrological, Geochemical, and Biological Processes." Civil Engineering Seminar Series, Georgia Institute of Technology, Atlanta, October.

Mulholland, P. J. 1994. "Regulation of Stream Chemistry: Effects of Hydrological, Geochemical, and Biological Processes."

Seminar Series, Horn Point Laboratory, University of Maryland, Cambridge, February; Seminar Series, University of Quebec, Montreal, March.

Mulholland, P. J., E. R. Marzolf, S. P. Hendricks, A. K. Baybayan, and R. V. Wilkerson. 1994. "Longitudinal Patterns in Biomass, Productivity, and Nutrient Cycling in Autotrophic Laboratory Streams." 42nd Annual Meeting, North American Benthological Society, Orlando, Fla., May.

Napolitano, G. E., W. R. Hill, and A. J. Stewart. 1994. "Anatomical Distribution of Lipids and Polychlorinated Biphenyls (PCBs) in Stoneroller Minnows (*Camptostoma anomalum*)." 42nd Annual Meeting, North American Benthological Society, Orlando, Fla., April.

Napolitano, G. E., J. E. Richmond, and A. J. Stewart. 1993. "Natural Foam Formations Concentrate Lipids, Hydrocarbons, and PCBs." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Niemela, S. L., and M. S. Greeley, Jr. 1994. "The Effects of Bleached Kraft Mill Effluent (BKME) on Embryonic Development in Fish." Annual Meeting, American Fisheries Society, Halifax, Nova Scotia, Canada, August.

Niemela, S. L., M. S. Greeley, Jr., and M. K. McCracken. 1993. "Application of a Japanese Medaka Embryo-Larval Toxicity Test in a River Receiving Pulp and Paper Mill Effluent." Integrated Ecological Risk Assessment: Lessons Learned?, 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

- Norby, R. J. 1993. "Trees and Forests in a CO₂-Enriched Atmosphere." University of Michigan Global Change Program, Ann Arbor, November.
- Norby, R. J. 1994. "Tree Growth in Elevated CO₂—Fitting Seedling and Sapling Data to Ecosystem Questions." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.
- Norby, R. J. 1994. "*Quercus alba* in a CO₂-Enriched Atmosphere: Seedlings, Saplings, and Implication for the Forest." Environmental Constraints and Oaks: Ecological and Physiological Aspects, Nancy, France, August–September.
- Norby, R. J. 1994. "Tree and Forests in a CO₂-Enriched Atmosphere." Université de Paris-Sud, Orsay, France, September.
- Norby, R. J., and S. D. Wullschlegel. 1994. "Growth Efficiency of Trees Increases in CO₂-Enriched Atmospheres." The First Global Change and Terrestrial Ecosystems Science Conference, Woods Hole, Mass., May.
- Norby, R. J., S. D. Wullschlegel, and C. A. Gunderson. 1993. "Tree Responses to Elevated CO₂ and the Implications for Forests." Global Change and Terrestrial Ecosystems Symposium, Terrestrial Ecosystem Response to Elevated CO₂, San Miniato, Italy, October.
- Nourse, B. D., S. E. Stinnette, C. W. McGinn, and D. R. Watkins. 1994. "Characterization of Risk from Uncontaminated Background Soils on the Oak Ridge Reservation." Sixth National Technology Information Exchange Workshop, Kennewick, Wash., May.
- Nyquist, J. E. 1994. "A 'Model' Geophysics Program." Symposium on Application of Geophysics to Environmental and Engineering Problems (SAGEEP '94), Boston, March.
- O'Brien, R., P. M. Jardine, and R. Shropshire. 1994. "Experimental Characterization of Mass Transport Processes in Undisturbed Macroporous Media." Spring Meeting, American Geophysical Union, Baltimore, May.
- Olson, R. J., R. S. Turner, and C. T. Garten, Jr. 1994. "Integrating Ground-Based and Remotely Sensed Data to Support Global Studies of Environmental Change." 14th International Committee on Data for Science and Technology Conference, Chambéry, France, September.
- O'Neill, E. G., and R. J. Norby. 1993. "Decomposition of Foliar Hardwood Litter Produced Under CO₂ Enrichment." International Geosphere-Biosphere Programme, Core Project Global Change and Terrestrial Ecosystems Symposium on Terrestrial Ecosystem Response to Elevated CO₂, San Miniato, Italy, October.
- O'Neill, E. G., and R. J. Norby. 1994. "Litter Quality and Decomposition of Hardwood Litter Produced at Elevated CO₂: Some Results and Methodological Considerations." Oak Ridge Conference on Global Environmental Change, Oak Ridge, Tenn., March.
- Paez, A., G. M. Gebre, and T. J. Tschaplinski. 1994. "The Relationship Between Growth and Soluble Sugar Concentrations of Aloe Vera Plants Grown Under Three Levels of Irradiance." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.
- Palumbo, A. V. 1993. "Heterogeneity Hypotheses." DOE Workshop on

Heterogeneity in the Subsurface, Virginia Beach, Va., October.

Palumbo, A. V. 1993. "Subsurface Science Program Sampling Needs and Examples of Results." Briefing for Maryland Department of Natural Resources, Annapolis, Md., October; Subsurface Science Program, Origins Subprogram Investigators Meeting, Annapolis, Md., December.

Palumbo, A. V. 1994. "Field Release of Genetically Bioluminescent Reporter Bacteria for PAH Bioremediation in Subsurface Soil: Lysimeters." U.S. Environmental Protection Agency and DOE Office of Technology Development, Washington, D.C., March.

Palumbo, A. V. 1994. "Uranium Leachate Lysimeter Facility: Applicability for GEMS Research." First Meeting of the Technical Advisory Team for the Project: Field Release of Genetically Engineered Bioluminescent Reporter Bacteria for PAH Bioremediation in Subsurface Soil, Oak Ridge, Tenn., September.

Palumbo, A. V., and J. M. Strong-Gunderson. 1994. "Project Summary: Adsorption/Desorption of Contaminants Relative to Applying Bioremediation to Organics." In Situ Remediation Integrated Program FY 1994 Project Review, Houston, February.

Palumbo, A. V., R. A. Burlage, S. P. Scarborough, and J. F. McCarthy. 1994. "Selection of Native Strains for Bacterial Transport Studies." 94th General Meeting, American Society of Microbiology, Las Vegas, May.

Palumbo, A. V., R. S. Burlage, and J. M. Strong-Gunderson. 1993. "Use of *lux* Technology in Environmental

Applications." University of North Carolina, Greensboro, October.

Palumbo, A. V., P. M. Jardine, T. J. Phelps, R. Gardner, and G. V. Wilson. 1993. "Characterization and Effects of Subsurface Heterogeneity at Humid Sites: Hypotheses and Tasks." DOE Subsurface Science Program Heterogeneity Subprogram Review, Virginia Beach, Va., October.

Palumbo, A. V., J. F. McCarthy, and R. S. Burlage. 1994. "Mobility of Bacteria in a Sandy Aquifer: Relationship to Oyster Site Work." Subsurface Science Program, Bacterial Transport Subprogram Review, DOE Office of Health and Environmental Research, Gaithersburg, Md., February.

Palumbo, A. V., J. F. McCarthy, R. S. Burlage, P. M. Jardine, and G. V. Wilson. 1994. "Mobility of Bacteria in a Sandy Aquifer: The Vadose Zone Study." Subsurface Science Program, Bacterial Transport Subprogram Review, DOE Office of Health and Environmental Research, Gaithersburg, Md., February.

Palumbo, A. V., S. P. Scarborough, S. M. Pfiffner, and T. J. Phelps. 1994. "Influence of Nitrogen and Phosphorous on the In-Situ Bioremediation of Trichloroethylene." 16th Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, Tenn., May.

Palumbo, A. V., J. M. Strong-Gunderson, U. Minocha, and J. F. McCarthy. 1994. "Bioavailability of Natural Organic Matter in Groundwater." Second International Conference on Ground Water Ecology, Atlanta, March.

Parr, P. D. 1994. "Oak Ridge National Laboratory-Landuse Changes: The Decision-Making Process Evolving for the

Oak Ridge Reservation." Meeting of Association of Southeastern Biologists, Orlando, Fla., April.

Parr, P. D., and L. K. Mann. 1994. "The Oak Ridge Reservation: A Nationally Valuable Natural Resource." Oak Ridge Rotary International, Oak Ridge, Tenn., August.

Pearson, S. M. 1994. "Predicting Habitat Availability from Maps: When Is Spatial Pattern Important?" Ninth Annual U.S. Landscape Ecology Symposium, Tucson, Ariz., March.

Pearson, S. M. and M. G. Turner. 1994. "Impacts of Land-Cover Change on Native Species in a Southern Appalachian Watershed." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Pearson, S. M., V. H. Dale, and H. L. Offerman. 1993. "Fragmentation of Habitats Used by Neotropical Migratory Birds in Southern Appalachians and the Neotropics." Meeting, Society of American Foresters, Indianapolis, November.

Pehlman, P. A., D. A. Wollert, R. H. Phillippi, J. M. Morris, J. L. Legg, M. A. Simek, P. A. Scofield, B. E. Bergenback, I. C. Datskou, A. C. Campbell, L. W. Barnhouse, and C. C. Travis. 1994. "Human Health and Ecological Risks from Environmental Restoration and Waste Management Activities." Waste Management '94, Tucson, Ariz., February-March.

Peng, T.-H. 1993. "Inventories of Bomb- ^{14}C in the Ocean and CO_2 Uptake Estimate from ^{14}C -Calibrated Ocean Model." University of Alaska, Fairbanks, December.

Peng, T.-H. 1993. "The Role of Ocean in Stabilizing Future Atmospheric CO_2 Level." Fall Meeting, American Geophysical Union, San Francisco, December.

Peng, T.-H. 1994. "Evaluation of the ^{13}C Constraint on the Oceanic Uptake of Fossil Fuel CO_2 ." The Kuroshio Edge Exchange Processes Study of World Ocean Circulation Experiment, Taiwan, February.

Peng, T.-H. 1994. "Global Carbon Cycle Based on the Distribution of Bomb-Produced ^{14}C in the Ocean." National Taiwan University, February.

Peng, T.-H., and W. S. Broecker. 1994. "The Global Bomb Radiocarbon Inventory." Ocean Sciences Meeting, American Geophysical Union, San Diego, February.

Peng, T.-H., and W. S. Broecker. 1994. "Revised Estimates of Bomb- ^{14}C Inventories in the Ocean." 15th International Radiocarbon Conference, Glasgow, Scotland, August.

Peterson, M. J., and G. R. Southworth. 1994. "Long-Term Bioaccumulation Monitoring of Organic Contamination in Some East Tennessee Streams." 42nd Annual Meeting, North American Benthological Society, Orlando, Fla., May.

Pfiffner, S. M., H. C. Pinkart, D. B. Ringelberg, D. C. White, and T. J. Phelps. 1994. "Changes in Microbial Populations, Activities and Biomass of Sediments Recovered During In Situ Nutrient-Amended Bioremediation of TCE." 93rd General Meeting, American Society of Microbiology, Las Vegas, May.

Phelps, T. J. 1993. "Application of Microbial and Biochemical Measures for

- Bioremediation Monitoring." Southeast Regional Meeting, American Chemical Society, East Tennessee State University, Johnson City, October.
- Phelps, T. J. 1993. "Characterization and Effects of Subsurface Heterogeneity at Humid Sites: Microbial Sampling and Characterization." DOE Subsurface Science Program Review, Virginia Beach, Va., October.
- Phelps, T. J. 1993. "Microbial Ecology of the Deep Subsurface and Implications for Bioremediation." Dartmouth College, Thayer School of Engineering, Hanover, N.H., November; U.S. Geological Survey, Boulder, Colo., November.
- Phelps, T. J. 1993. "Sampling and Quality Assurance Procedures Used in the Subsurface Science Program." Presentation at Rocky Flats, Colo., November.
- Phelps, T. J. 1993. "Evidence for In Situ Microbial Populations in the Taylorsville Triassic Basin—Summary of Results from the Triassic Basin Working Group." Subsurface Program Meeting, Annapolis, Md., December.
- Phelps, T. J. 1993. "Exploratory Origins Research Focusing on the Taylorsville Triassic Basin." Subsurface Science Program Meeting, Annapolis, Md., December.
- Phelps, T. J. 1994. "Exploratory Origins Research Focusing on the Taylorsville Triassic Basin." DOE Review, Annapolis, Md., April.
- Phelps, T. J. 1994. "Microorganisms from Deep Subsurface Environments." 93rd General Meeting, American Society of Microbiology, Las Vegas, May.
- Phelps, T. J., and S. M. Pfiffner. 1993. "Microbial Populations in Groundwater Ecosystems." Lecture at Dartmouth College, Lebanon, N.H., November.
- Phelps, T. J., and S. M. Pfiffner. 1994. "Factors Constraining Microbial Populations in Groundwater Ecosystems." Second International Conference on Ground Water Ecology, Atlanta, March.
- Phelps, T. J., and B. F. Russell. 1993. "Sampling and Quality Assurance Procedures Used Within the U.S. DOE Subsurface Science Program." DOE Workshop, Boulder, Colo., November.
- Phelps, T. J., P. M. Jardine, and G. V. Wilson. 1993. "Spatial and Temporal Heterogeneity of Microbial Communities in the Subsurface." Heterogeneity Review, Norfolk, Va., October.
- Phelps, T. J., T. C. Onstott, F. S. Colwell, H. Y. Tseng, R. E. Benoit, D. B. Ringelberg, and D. C. White. 1994. "Environmental and Ecological Evidence Supporting the Long Term Entrapment of Microorganisms in Triassic Basin Rocks." 93rd General Meeting, American Society of Microbiology, Las Vegas, May.
- Phelps, T. J., A. V. Palumbo, S. M. Pfiffner, and D. C. White. 1993. "Fall 1993 Update of Biological Monitoring of Critical Populations—TTPs OR 111101 and OR 111103." Task Summary Group Meeting, Westinghouse Savannah River Site, Atlanta, October.
- Post, W. M., III. 1994. "Soil Data Requirements for Global Change Studies." Annual Meeting, International Society Ecological Modeling, North American Chapter, Knoxville, Tenn., August.

Post, W. M., III, A. W. King, and S. D. Wulschleger. 1994. "Response of Global Carbon Storage in Soils and Net Ecosystem Production to Changes in Climate and Atmospheric CO₂." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Pridmore, D. J., R. B. Clapp, and S.-P. Miaou. 1993. "Surface Water Contaminant Fluxes in First-Order Tributaries: A Case Study in the White Oak Creek Basin of the Oak Ridge National Laboratory." Meeting, American Geological Society, Boston, October.

Pridmore, D. J., R. B. Clapp, and S.-P. Miaou. 1994. "Evaluation of Impermeable Caps by Comparing Concentration Discharge Relationship in Streamflow Before and After Remedial Construction." Sixth Annual Technology Information Exchange Conference, Hanford, Wash., May.

Rashleigh, B. 1994. "Factors Maintaining Diversity in Freshwater Mussels in the Upper Clinch River, Virginia/Tennessee." 60th Annual Meeting, American Malacological Union, Houston, July.

Reedy, O. C., P. M. Jardine, and H. M. Selim. 1994. "Flow Interruption: A Proposed Remediation Technique to Enhance Subsurface Contaminant Removal." Emerging Technologies for Hazardous Waste Management, American Chemical Society, Atlanta, September.

Renshaw, A. W. 1994. "Water Resources and Environmental Management Consortium." Freshwater Imperative Coordinating Council, Washington, D.C., July.

Riciptui, L. R., D. R. Cole, and H. G. Machel. 1993. "Sulfur Isotope

Variations in Devonian Carbonates of the Western Canada Sedimentary Basin, Alberta, Canada: An Ion Microprobe Study." 105th Annual Meeting, Geological Society of America, Boston, October.

Rose, K. A. 1994. "Numerical Aspects of Individual-Based Modelling." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Sample, B. E., R. J. Cooper, R. C. Whitmore, and L. Butler. 1993. "Indirect Effects of Two Insecticides Applied for Gypsy Moth Control." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Sanford, W. E., D. K. Solomon, and H. M. Ingracia. 1993. "Dye Tracer and Point Dilution Tests Used to Determine Permeable Zones Near the Water Table in Fractured Shales." Annual Meeting, Geological Society of America, Boston, October.

Sanford, W. E., D. K. Solomon, and R. G. Shropshire. 1994. "Noble Gases as Groundwater Tracers in Fractured Saprolite." Spring Meeting, American Geophysical Union, Baltimore, May.

Schramm, W. E. 1993. "Environmental Constraints on Mexican Industry: Effects of NAFTA." North American Meeting, International Association for Impact Assessment, Seattle, December.

Shevenell, L. A. 1993. "Chemical Variability of Waters in a Karst Aquifer at the Oak Ridge Y-12 Plant, Oak Ridge, Tenn." Annual Meeting, Geological Society of America, Boston, October.

Shirshac, T. L., A. B. Schwab, and C. T. Garten, Jr. 1993. "Foliar Uptake of

- Nitrogen-15 Tracers in High-Elevation Spruce-Fir and Low-Elevation Deciduous Forest Ecosystems." National Convention, Society of American Foresters, Indianapolis, November.
- Shugart, L. R., and C. Theodorakis. 1993. "Environmental Genotoxicity: Probing the Underlying Mechanisms." Napa Conference on Genetic and Molecular Ecotoxicology, Berkeley, Calif., October.
- Shugart, L. R., and C. Theodorakis. 1994. "Genetic Ecotoxicology: Approaches and Future Directions." 15th Conference of European Society for Comparative Physiology and Biochemistry, Genova, Italy, September.
- Siegrist, R. L., S. R. Cline, T. M. Gilliam, and J. R. Conner. 1993. "In-Situ Stabilization of Mixed Waste Contaminated Soil." International Symposium on Stabilization/Solidification of Hazardous, Radioactive, and Mixed Wastes, Williamsburg, Va., November.
- Sigmon, C. F. 1994. "Air Combat Command Hazardous Waste Training Seminar." Air Combat Command Hazardous Waste Training Seminar, Langley Air Force Base, Va., March.
- Sigmon, C. F., and J. S. Fackenthal. 1993. "U.S. Department of Energy Resource Conservation and Recovery Act (RCRA) Orientation Workshop." DOE, Albuquerque, N.M., October.
- Singley, P. T., J. D. Bell, P. F. Daugherty, C. A. Hubbs, and J. G. Tuggle. 1993. "User Interface Development and Metadata Considerations for the Atmospheric Radiation Measurement (ARM) Archive." Goddard Conference on Mass Storage Systems and Technologies, College Park, Md., October.
- Smuin, D. R., and R. M. Schlosser. 1993. "Integrated Approach to Field Analytical Techniques." Sixth National Technology Information Exchange Workshop, Kennewick, Wash., May.
- Solis, C., and L. W. Cooper. 1994. "Carbon, Hydrogen, and Oxygen Isotope Compositions of Organic Matter and Water in Heliophytes of a Tropical Deciduous Forest in Mexico." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.
- Solomon, D. K., and J. A. Cherry. 1993. "Drive Point Profiling of Contaminant Distribution in Groundwater." Chlorinated Volatile Organic Compounds in Groundwater, Kansas City, Mo., October.
- Stair, D. M., T. L. Ashwood, G. W. Suter II, and B. E. Sample. 1994. "Sampling of Resident Earthworms to Evaluate Ecological Risk at a Hazardous Waste Site." Sixth National Technology Information Exchange Workshop, Kennewick, Wash., May.
- Stoss, F. W. 1994. "Information Management for Global Environmental Change, Including the Carbon Dioxide Information Analysis Center." 87th Annual Meeting and Exhibition, Air and Waste Management Association, Cincinnati, June.
- Stoss, F. W., and S. B. Jones. 1993. "Performance of the Carbon Dioxide Information Analysis Center (CDIAC)." INFOTECH Meeting, Oak Ridge, Tenn., October.
- Strong-Gunderson, J. M., and A. V. Palumbo. 1994. "Organic Contaminant Bioavailability." 93rd General Meeting, American Society of Microbiology, Las Vegas, May.

Strong-Gunderson, J. M., B. M. Applegate, and A. V. Palumbo. 1993. "Biosurfactants and Increased Bioavailability of Sorbed Organic Contaminants: Measurements Using a Biosensor." Institute of Gas Technology Symposium on Gas, Oil, and Environmental Biotechnology, Colorado Springs, Colo., November-December.

Suter, G. W., II. 1993. "Ecological Risk Assessment Prospects for the End of the 1990s." 20th Annual Aquatic Toxicity Workshop, Quebec, October.

Suter, G. W., II. 1993. "Uncertainties in Ecological Epidemiology: A Cautionary Tale Featuring Kit Foxes and Oil Fields." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Suter, G. W., II. 1994. "Measuring Stress: Uses and Limitations." Extent, Significance, and Policy Implications of Global Marine Environmental Change, University of New Hampshire, Whispering Pines Conference Center, Durham, May.

Suter, G. W., II, M. E. Stack, R. N. Hull, G. W. McGinn, B. W. Cornaby, C. T. Hadden, and F. A. Zafran. 1993. "A Logic for Balancing Human Health Risk-Based and Ecological Risk-Based Remedial Goals and Assessments." Annual Meeting, Society for Risk Analysis, Savannah, Ga., December.

Swanson, J. L., L. D. Voorhees, P. F. Daugherty, S. V. Jennings, J. W. Curry, C. T. Garten, Jr., M. J. Gentry, J. Grubb, P. Kanciruk, J. B. Lambert, R. J. Olson, A. K. Sexton, D. E. Sill, A. W. Smith, R. S. Turner, and T. G. Yow. 1994. "ORNL Distributed Active Archive Center." Community Day, Oak Ridge, Tenn., June.

Theodorakis, C. W., and L. R. Shugart. 1993. "DNA Polymorphisms Revealed by the RAPD Technique Show Differences Between Radionuclide-Contaminated and Uncontaminated Mosquitofish Populations." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Theodorakis, C. W., B. G. Blaylock, and L. R. Shugart. 1993. "Radiation-Induced DNA Strand Breaks and the Relationship Between Strand Breaks and Fecundity in Mosquitofish." 14th Annual Meeting, Society of Environmental Toxicology and Chemistry, Houston, November.

Tidwell, V., C. Francis, and A. Armstrong. 1994. "An Integrated Approach to the Characterization and Decontamination of Uranium Contaminated Soils." Waste Management '94, Tucson, Ariz., February-March.

Timpson, M. E., M. P. Elless, and C. W. Francis. 1994. "The Influence of Attrition Scrubbing, Ultrasonic Treatment and Oxidant Additions on Uranium Removal from Contaminated Soils." Waste Management '94 Meetings, Tucson, Ariz., February.

Timpson, M. E., C. W. Francis, and M. P. Elless. 1993. "Bench-Scale Leachability Studies: Attrition Scrubbing." Uranium Soils ID FY 1994 Kick-Off Meeting, San Antonio, Tex., October.

Timpson, M. E., C. W. Francis, J. Wilson, and M. P. Elless. 1994. "Bench- and Pilot-Scale Studies FY '94." Uranium Soils ID FY 1994 Mid-Year Review Meeting, Washington, D.C., June.

Toran, L. E., G. R. Moline, J.-P. Gwo, and M. Yambert. 1994. "Understanding Groundwater Flow at a Low-Level

Radioactive Waste Site Using a Supercomputer." Spring Meeting, American Geophysical Union, Baltimore, May.

Toran, L. E., A. Sjoreen, and M. Morris. 1994. "Sensitivity Analysis of Groundwater Transport in Fractured Porous Media." American Geophysical Union Chapman Conference on Aqueous Phase and Multiphase Transport in Fractured Rock, Burlington, Vt., September.

Toran, L. E., A. Sjoreen, and R. B. Dreier. 1993. "Modeling of a Density-Dependent Contaminant Plume Located in a Regional Discharge Area on the Oak Ridge Reservation." Annual Meeting, Geological Society of America, Boston, October.

Trettin, C. C. 1994. "Biogeochemical Effects of Silvicultural Practices in Northern Wetlands." Plant and Soil Science Department, The University of Tennessee, Knoxville, March.

Trettin, C. C. 1994. "Hydrologic Response of Northern Wetlands to Silvicultural Water Management Systems." Water Management in Forest Wetlands Workshop, Atlanta, April.

Tschapinski, T. J., G. M. Gebre, J. E. Dahl, G. T. Roberts, and G. A. Tuskan. 1994. "Growth and Solute Adjustment in Calli of Populus Clones Cultured on Nutrient Medium Containing Polyethylene Glycol." 13th Annual North American Forest Biology Workshop, Baton Rouge, La., June; Joint Meeting of Western Mensuration-Western Forest Genetics Association, Vancouver, Wash., June.

Turner, R. R., and M. Barnett. 1994. "Mercury Speciation in East Fork Poplar

Creek Floodplain Soils." Lower East Fork Poplar Creek Citizens Working Group, Oak Ridge, Tenn., February.

Turner, R. R., and N. S. Bloom. 1994. "Reconstruction of Historical Atmospheric Hg Releases Using Analysis of Tree Rings in Red Cedar (*Juniperus virginiana*)." International Conference on Mercury as a Global Pollutant, Whistler, British Columbia, Canada, July.

Turner, R. R., and A. A. Kriger. 1994. "Rapid Field Analysis of Mercury in Water, Soil and Sediment." International Conference on Mercury as a Global Pollutant, Whistler, British Columbia, Canada, July.

Turner, R. S. 1994. "Ecosystems, Climate Change, and Integrated Assessment: Where Do We Go From Here?" Oak Ridge Conference on Global Environmental Change, Oak Ridge, Tenn., March.

Turner, R. S. 1994. "Integrated Environmental Assessment: Issues, Stakeholders, Challenges." Indicators of Environmental Performance and Ecosystem Condition, Third Annual Workshop on Industrial Ecology, Woods Hole, Mass., June.

Turner, R. S., V. H. Dale, and R. J. Olson. 1994. "Ecology and the Integrated Assessment Process." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.

Turner, R. S., V. H. Dale, R. J. Olson, C. T. Hunsaker, and L. W. Barnhouse. 1994. "The Integrated Assessment Process." First Annual Conference on Environmental Monitoring and Assessment in the Mid-Atlantic Highlands Area, Hershey, Pa., February.

Tuskan, G. A. 1994. "Heritabilities, Selection Differentials, and Calculation of Genetic Gains." Western Gulf Forest Tree Improvement Contactmens' Meeting, Shreveport, La., August.

Tuskan, G. A., M. E. Downing, and L. L. Wright. 1994. "Current Status and Future Directions for the U.S. Department of Energy's Short-Rotation Woody Crop Research." Task IX, Activity 1 Meeting, International Energy Agency, Mobile, Ala., March.

Tuskan, G. A., K. Francis, M. Plaza, K. E. Segert, D. Roberson, S. L. Russ, and M. G. Turner. 1994. "Genetic Diversity Among Aspen Populations in Yellowstone National Park." North American Forest Biology Workshop, Baton Rouge, La., June.

Van Miegroet, H., and C. T. Garten, Jr. 1993. "Relationship Between Site N Status and Foliar N-15 Abundance in the Great Smoky Mountains National Park." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.

Van Winkle, W., H. I. Jager, B. D. Holcomb, B. Shuter, and S. Y. Whitaker. 1994. "Partitioning Surplus Energy Between Soma and Reproduction in Trout: An Individual-Based Approach." Annual Meeting, American Fisheries Society, Halifax, Nova Scotia, Canada, August.

Van Winkle, W., H. I. Jager, and B. Shuter. 1994. "Conceptual Framework for Regulation of Energy Allocation to Respiration, Growth, and Reproduction." 18th Annual Larval Fish Conference, St. Andrews, New Brunswick, Canada, June.

Vose, R. S., T. C. Peterson, J. K. Eischeid, and R. L. Schmoyer. 1994. "The Global Historical Climatology Network, Version 2." 90th Annual Meeting of Association of American Geographers, San Francisco, March-April.

Wang, Y. C., G. A. Tuskan, and T. J. Tschaplinski. 1994. "Optimization of *Agrobacterium tumefaciens*—Mediated Transformation and Regeneration Conditions of *Populus*." 13th Annual North American Forest Biology Workshop, Baton Rouge, La., June.

Watkins, D. R., S. Y. Lee, T. L. Hatmaker, C. W. McGinn, B. D. Nourse, R. L. Schmoyer, B. B. Burgoa, and D. A. Lietzke. 1994. "Oak Ridge Background Soils Project Provides Data for Remedial Action Evaluation." Waste Management '94, Tucson, Ariz., February-March.

Watkins, D. R., S. Y. Lee, T. L. Hatmaker, C. W. McGinn, B. D. Nourse, R. L. Schmoyer, B. B. Burgoa, and D. A. Lietzke. 1994. "Background Soil Characterization for Site Assessment at Oak Ridge." Sixth National Technology Information Exchange Workshop, Kennewick, Wash., May.

Webb, O. F., R. L. Siegrist, M. R. Ally, W. E. Sanford, and J. L. Zutman. 1994. "In Situ Treatment of VOCs by Recirculation Technologies." American Society of Civil Engineers, National Council on Environmental Engineering on Critical Issues in Water and Waste Water Treatment, Boulder, Colo., July.

West, O. R. 1994. "Measurement and Spatial Modeling of Soil VOC Contamination." Geoenvironmental Seminar Series, Massachusetts Institute of Technology, Cambridge, March.

- West, O. R., and R. L. Siegrist. 1993. "Measurement and Spatial Modeling of VOC Contamination in Soils." 34th ORNL-DOE Conference on Analytical Chemistry in Energy Technologies, Gatlinburg, Tenn., October.
- White, D. C., H. C. Pinkart, S. M. Pfiffner, and D. B. Ringelberg. 1994. "Monitoring Changes in Subsurface Microbiota by Analysis of Polar-Lipid Fatty Acid Profiles." Second International Conference on Ground Water Ecology, Atlanta, March.
- Winterfield, R. F. 1994. "Decision Support for Environmental Restoration Managers at the Oak Ridge National Laboratory Through Improved Geospatial Data and Tools." Decision Support—2001, Toronto, September.
- Winters, S. L. 1994. "Background Groundwater Quality Characterization Study of the Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee: Preliminary Analysis." Annual Spring Symposium, American Water Resources Association, Nashville, Tenn., April; Bridging the Gaps in Environmental Management, Sixth National Technology Information Exchange Workshop, Kennewick, Wash., May.
- With, K. A. 1994. "The Hazards of Nesting Near Shrubs for a Grassland Bird." 112th Stated Meeting of American Ornithologists' Union, University of Montana, Missoula, June.
- With, K. A., and T. O. Crist. 1994. "Critical Thresholds in Landscape Structure: Implications for the Spatial Structure of Populations." Ninth Annual U.S. Landscape Ecology Symposium on International Spatial and Temporal Models for Analyzing Pattern and Process in Landscapes, University of Arizona, Tucson, March.
- Wulschleger, S. D., and S. B. McLaughlin. 1994. "Switchgrass as a Herbaceous Energy Crop in the Southeast United States." Meeting, Southern Branch, American Society of Agronomy, Nashville, Tenn., February.
- Wulschleger, S. D., and M. A. Sanderson. 1993. "Ecotypic Differences in the Photosynthetic Rates of Switchgrass." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.
- Wulschleger, S. D., D. D. Baldocchi, A. W. King, and W. M. Post. 1994. "Models— Another Tool for Use in Global Change Research." Annual Meeting, Ecological Society of America, Knoxville, Tenn., August.
- Wulschleger, S. D., C. A. Gunderson, and R. J. Norby. 1993. "Growth and Physiology of Forest Trees Exposed to Carbon Dioxide Enrichment." Annual Meeting, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Cincinnati, November.

Other Professional Activities

ADAMS, S. M.

Organizer: Panel on Ecosystem Health as a Diagnostic Tool for Human Health, First International Symposium on Ecosystem Health and Medicine, sponsored by International Society of Ecosystem Health and Medicine, Ottawa, June 1994.

Member: Publication Awards Committee, AFS, 1993-95; SETAC; Board of Directors, Aquatic Ecosystem Health Society, 1993-.

Participant: Symposium on Multiple Stressors in Ecosystems, sponsored by University of California, Davis, Sacramento, California, October 1993; annual meeting, SETAC, Houston, November 1993; Mid-Atlantic Highlands Conference, sponsored by EPA, Hershey, Pennsylvania, February 1994; invited seminars in Brazil, sponsored by Brazilian EPA, University of Sao Paulo, and Federal University of Brazil, Sao Paulo, and Sao Carlos, August 1994.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology and Graduate Program in Environmental Toxicology, The University of Tennessee; Adjunct Faculty, School of Environment, Duke University.

Advisor: Kenneth Ham, Ph.D. candidate, The University of Tennessee (Chairman of Graduate Committee); Lori Moilanen, Ph.D. candidate, Duke University; Brian Carrico, Susan Nadig, Stan Sharp, and Jenny Wainwright, M.S. candidates, The University of Tennessee; Brian Beach, Julie Tindell, Candice Wilson, and Matthew Wood, B.S. candidates, The University of Tennessee.

Editor: Associate Editor, *Journal of Aquatic Ecosystem Health*, 1994-; Associate Book Editor, *Biodiversity of the Southeastern United States: Aquatic Ecosystems*, 1994.

Ad Hoc Reviewer: Erosion World Monograph Series, Aquatic Ecosystem

Health Society; *Journal of Aquatic Ecosystem Health*; *Ecology*; *Journal for American Society of Testing and Materials*; book, Duke University and EPA.

Other: Environmental Restoration project, science fair, Oak Ridge, Tennessee.

ASHWOOD, T. L.

Chair and organizer: Session on Issues and Initiatives in Wildlife Education, First Annual Wildlife Society Meeting, Albuquerque, New Mexico, September 1994.

Member: Wildlife Toxicology Working Group, The Wildlife Society; SETAC.

Advisor: Shyamala Ratnayake, Ph.D. candidate, The University of Tennessee; Richard T. Stevens, M.S. candidate, Tennessee Technological University.

Other: Local Oversight Committee for the remedial action program on ORR, state of Tennessee; docent, Knoxville Zoo, Tennessee; science fair judge, Roane County Science Fair, Tennessee.

BARNETT, M. O.

Faculty: Faculty, Civil and Environmental Engineering, Oak Ridge Graduate Program, The University of Tennessee.

BARNTHOUSE, L. W.

Member: Committee to Review the USFWS Best Program, NRC, 1994-.

Participant: annual meeting, SETAC, Houston, November 1993; Savannah River Watershed Symposium, sponsored by EPA, Savannah, Georgia, January 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994; Peer Review Meeting for EPA Issue Papers, Alexandria, Virginia, August 1994.

Advisor: Stephen Deppen and Jerry Johnston, M.S. candidates, Indiana University.

Editor: Hazard/Risk Assessment Editor, *Environmental Toxicology and Chemistry*, 1992-.

BEARD, L. P.

Member: Membership Committee, Environmental and Engineering Geophysics Society, 1993-.

Participant: Meeting, Society of Exploration Geophysicists, Washington, D.C., October 1993.

Advisor: Jennifer Helm, M.S. candidate, University of Utah.

Ad Hoc Reviewer: *Geophysics; Pure and Applied Geophysics.*

BEAUCHAMP, J. J.

Chair: Contributed Paper Session on Estimation in Reliability, Joint Statistical Society Meetings, sponsored by American Statistical Association, Toronto, August 1994.

Participant: Regional Ozone Vegetation Effects Program, sponsored by EPRI, Knoxville, Tennessee, April 1994.

Advisor: Ruth Ann Kern, Ph.D. candidate, Duke University; Anthony McWhorter, M.S. candidate, The University of Tennessee.

Ad Hoc Reviewer: *Environmental Toxicology and Chemistry.*

BEVELHIMER, M. S.

Organizer: Legislative Session, Annual Meeting, Tennessee Chapter, AFS, Murfreesboro, Tennessee, January 1994.

Officer: President, Tennessee Chapter, AFS, 1993-94.

Member: Southern Division Representative, Nominating Committee, and Chair, Environmental Concerns Committee, Southern Division, AFS, 1994-95.

Participant: Ft. Loudoun Lake Toxics Mass Balance Workshop, sponsored by TVA, Muscle Shoals, Alabama, December 1993; Mid-year Technical

Meeting of the Southern Division, AFS, Little Rock, Arkansas, February 1994.

Ad Hoc Reviewer: *Transactions of the American Fisheries Society.*

BODEN T. A.

Participant: Carbon Monoxide Expert Meeting, sponsored by World Meteorological Organization, Boulder, Colorado, February 1994.

Ad Hoc Reviewer: Research proposal submitted to the Division of Ocean Sciences, NSF.

BOGLE, M. A.

Member: AWIS.

Participant: Regulator Meeting on Upper East Fork Poplar Creek OU 1, sponsored by Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, May 1994.

Other: Judge, Odyssey of the Mind, Maryville College, Maryville, Tennessee.

BORDERS, D. M.

Member: Associate Member, ASCE; AWRA.

Participant: Fourteenth Annual Hydrology Days Conference, sponsored by AGU, Fort Collins, Colorado, April 1994.

Ad Hoc Reviewer: *Journal of Hydraulic Engineering.*

BURLAGE, R. S.

Participant: Intramediate Scale Experiment, sponsored by DOE, Norfolk, Virginia, October 1993; Transport in the Subsurface, sponsored by DOE, Norfolk, Virginia, November 1993.

Faculty: Adjunct Professor, Department of Chemical Engineering, The University of Tennessee.

Editor: *Journal of Microbiological Methods*, 1992-.

Other: Science fair judge, Jefferson Junior High School, Oak Ridge, Tennessee; guest lecturer, Oliver Springs High School, Tennessee.

CADA, G. F.

Participant: Mainstem Passage Hypotheses Workshop, sponsored by Northwest Power Planning Council, Portland, Oregon, February 1994; Workshop on Integrated Assessment of Caribbean Coastal Zones, sponsored by ORNL and University of Puerto Rico, Mayaguez, September 1994.

Ad Hoc Reviewer: *Transactions of the American Fisheries Society; Hydroreview; Canadian Journal of Fisheries and Aquatic Sciences.*

Other: Environmental Quality Committee, Farragut, Tennessee.

CARDWELL, H. E.

Organizer: Videotape sessions on Water Resources, Responses to Changing Multiple-Use Demands: New Directions in Water Resources Planning and Management, sponsored by AWRA, Nashville, Tennessee, April 1994.

Member: 1994 Water Law, Science, and Policy Committee, AWRA, 1994-95; Systems Committee and Social and Environmental Objectives Committee, Water Resources Planning and Management Division, ASCE, 1994-95.

Participant: Multiple Objectives in Water Resources Management and Planning, sponsored by AWRA, Nashville, Tennessee, April 1994; 1994 Water Resources Planning and Management Conference, sponsored by ASCE, Denver, May 1994; Integrated Assessment for Global Climate Change: The Key Policy Issues, sponsored by DOE, Washington, D.C., June 1994; Integrated Assessment in the NAPAP Process, sponsored by NAPAP, Oak Ridge, Tennessee, November 1994.

CHRISTENSEN, S. W.

Member: Sigma Xi; ESA; SETAC; AFS; AAAS.

Participant: Developing the NAPAP Assessment Plan Workshop, Oak Ridge, Tennessee, November 1993; Adventures in Supercomputing Exposition, sponsored by DOE, Nashville, Tennessee, April 1994; Ecological Risk Assessment Modeling Systems Workshop, sponsored by SETAC Foundation for Environmental Education, Inc., Pellston, Michigan, August 1994.

Ad Hoc Reviewer: *Ecotoxicology; Ecological Applications.*

Other: Convener, Internet Special Interest Group, East Tennessee PC Users Group.

CLAPP, R. B.

Chair: Session on Flood Management, Responses to Changing Multiple-Use Demands: New Directions for Water Resources Planning and Management, sponsored by AWRA, Nashville, Tennessee, April 1994; Session on Innovations in Determination of Recharge to the Water Table, annual spring meeting, AGU, Baltimore, May 1994.

Member: Groundwater Committee, AGU.

Faculty: Adjunct Professor, Department of Civil and Environmental Engineering, The University of Tennessee.

Advisor: Donna Pridmore and Andrew Clevenger, M.S. candidates, The University of Tennessee.

Ad Hoc Reviewer: *Water Resources Review.*

Other: Board of Trustees, Eagles Nest Foundation, Pisqah Forest, North Carolina.

CLINE, S. R.

Member: Water Environment Federation; Associate Member, ASCE.

Participant: 66th Annual Conference and Exposition, Water Environment Federation, Anaheim, California, October 1993; International Symposium on

Stabilization/Solidification of Hazardous, Radioactive, and Mixed Wastes, sponsored by ASTM, Williamsburg, Virginia, November 1993; Innovative Solutions for Contaminated Site Management, sponsored by Water Environment Federation, Miami, March 1994; 87th Annual Meeting and Exposition, Air and Waste Management Association, Cincinnati, June 1994.

Advisor: Torrence Saulsberry, B.S. candidate, Xavier University; Weston Twigg, B.S. candidate, Albion College.

COOK, R. B.

Ad Hoc Reviewer: Proposal for National Undersea Research Center, NOAA; *Limnology and Oceanography; Water, Air, and Soil Pollution; International Decade for the East African Lakes; Biogeochemistry; Canadian Journal of Fisheries and Aquatic Sciences.*

COOPER, L. W.

Participant: International Symposium on the Ecological Effects of Arctic Air Contaminants, Reykjavik, Iceland, October 1993; Ocean Sciences Meeting, sponsored by AGU, San Diego, February 1994; 45th Arctic Science Conference, sponsored by AAAS, Anchorage, Alaska, and Vladivostok, Russia, August–September 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994; Workshop on Use of Nuclear Submarine as a Scientific Research Vessel, Washington, D.C., September 1994.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee.

Ad Hoc Reviewer: Proposals for NSF; Radiocarbon.

COUTANT, C. C.

Chair: Session on Columbia River, annual spring meeting, AWRA, Nashville,

Tennessee, April 1994; Working Group Meeting on Gas Bubble Disease, sponsored by National Marine Fisheries Service, Seattle, June 1994.

Officer: Second Vice President, AFS, August 1993–94; First Vice President, AFS, August 1994–95.

Member: Scientific Review Group of the Columbia River Fish and Wildlife Program, Bonneville Power Administration, 1989–; Cochair, Upper Illinois River Waterway Task Force, Commonwealth Edison Company and Illinois EPA, 1991–; Huntley Power Station Technical Group Electricity Corporation of New Zealand, 1991–93; Chair, Nominating Committee, Southern Division, AFS, October 1993–94; Southeast U.S. and Gulf of Mexico Regional Working Group, Freshwater Ecosystems and Climate Change in North America, ASLO, 1994–.

Participant: Pacific Salmon and Their Ecosystems, sponsored by University of Washington, Seattle, January 1994; annual meeting, Tennessee Chapter, AFS, Murfreesboro, Tennessee, January 1994; Conference on Evolution and the Aquatic Ecosystem, sponsored by AFS, Monterey, California, May 1994; annual meeting, AFS, Halifax, Nova Scotia, Canada, August 1994.

Faculty: Adjunct Professor, Graduate Program in Ecology, The University of Tennessee.

Advisor: Kenneth Ham, Ph.D. candidate, The University of Tennessee; Sandra Davis, M.S. candidate, The University of Tennessee.

Editor: Coeditor, *Transactions of the American Fisheries Society*, 1991–94.

Ad Hoc Reviewer: *Estuaries; Pacific Salmon and Their Ecosystems.*

Other: Judge, science fair, Jefferson Junior High School, Oak Ridge, Tennessee; advisor, Children's Museum of Oak Ridge, Tennessee.

CUSHMAN, J. H.

Chair and organizer: Information Exchange on Biofuels Research, sponsored by DOE BFD, Oak Ridge, Tennessee, January 1994.

Member: Technical Planning Committee, Southeastern Regional Biomass Energy Program, 1987-96; Policy Advisory Panel, Tree Genetic Research Consortium, 1994-.

Participant: 1993 Research Symposium, sponsored by CPBR, Chicago, November 1993; National Biofuels Roundtable, sponsored by EPRI and National Audubon Society, Portland, Oregon, January 1994; Mechanization in Short Rotation Intensive Culture Forestry, sponsored by International Energy Agency, Mobile, Alabama, February 1994; End Use Sector Coordinating Meeting, sponsored by DOE Regional Biomass Energy Program, Washington, D.C., February 1994; National Forum on Environment and Natural Resources Research and Development, sponsored by Office of Science and Technology Policy, Washington, D.C., March 1994; Biomass/Electric Power Generation Meeting, sponsored by Louisiana Department of Natural Resources, Baton Rouge, Louisiana, March 1994; Project Selection Meeting, Energy from Biomass Competition, sponsored by CPBR, Chicago, May 1994; Biomass and Waste-to-Energy Working Group, sponsored by EPRI, Arlington, Virginia, May 1994; Biomass Energy Infrastructure Workshop, sponsored by Wisconsin Department of Natural Resources, Madison, Wisconsin, June 1994; Power Supply Systems Task Force, sponsored by National Rural Electric Cooperative Association, Sheffield, Alabama, July 1994.

Editor: Editorial Board, *Bioresource Technology*, 1990-.

Ad Hoc Reviewer: Reports for DOE Southeastern Regional Biomass Energy Program; proposals for CPBR.

CUSHMAN, R. M.

Participant: Annual meeting, Working Group VIII of the U.S.-Russian Agreement on Protection of the Environment, sponsored by NOAA, Asheville, North Carolina, October 1993; Experts Meeting on Aerosol Optical Depth Data, sponsored by World Meteorological Organization, Silver Spring, Maryland, December 1993; annual meeting, Committee on Geophysical and Environmental Data, sponsored by NAS, Washington, D.C., February 1994; annual meeting, Climate Monitoring and Diagnostics Laboratory, sponsored by NOAA, Boulder, Colorado, March 1994; Global Change Conference, sponsored by Air and Waste Management Association, Phoenix, Arizona, April 1994; Data Center Directors' Meeting, sponsored by NAS, Greenbelt, Maryland, July 1994; GREENTIE Liaison Groups Meeting, sponsored by Netherlands Agency for Energy and the Environment, Maastricht, The Netherlands, September 1994.

Ad Hoc Reviewer: *Ecotoxicology*; GLoED Software, EPA; proposals for Great Plains Regional Center for Global Environmental Change; National Environmental Watch Prototype CD-ROM, NOAA; Prototype CD-ROM, World Data Center for Greenhouse Gases (Japan).

DALE, V. H.

Organizer: Developing the Framework for the NAPAP Assessment Workshop, Oak Ridge, Tennessee, November 1993.

Officer: Treasurer, Oak Ridge Chapter, Sigma Xi.

Member: Panel Member, Human Dimensions of Global Change, NSF; Scientific Advisory Board, Ecological Processes and Effects Committee, EPA.

Participant: EPA Science Advisory Board Executive Committee, October 1993; NSF Human Dimensions of Global

Change Review Panel, December 1993, May 1994; Sand County Foundation Workshop, Green Bay, Wisconsin, January 1994; EPA Science Advisory Board Review of Futures, February 1994; ESA Sustainable Biosphere Initiative Workshop on Vulnerability Studies, Raleigh, North Carolina, March 1994; American Association for Geographers Symposium on Land Use in Amazonia, San Francisco, March 1994; Women in Science and Technology Conference, Oak Ridge, Tennessee, April 1994; The University of Tennessee and University of Amazonas Workshop on Sustainability, Knoxville, Tennessee, May 1994; EPA Science Advisory Board Review of Ecological and Economic Sustainability, June 1994; Integrated Assessment for Global Climate Change: The Key Policy Issues, sponsored by DOE, Washington, D.C., June 1994; International Society of Ecological Modeling Symposium on Risk Assessment, Knoxville, Tennessee, August 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994; EPA Science Advisory Board Review of EMAP, July 1994.

Faculty: Exchange Faculty to University of Amazonas; Adjunct Faculty, Graduate Program in Ecology, The University of Tennessee.

Advisor: Robert Frohn, Ph.D. candidate, University of California at Santa Barbara; Ruth Ann Kern, Ph.D. candidate, Duke University; Holly Offerman, M.S. candidate, University of Maryland; Brad McRae, M.S. candidate, University of Wisconsin.

Editor: Associate Editor, *Environmental Reviews*, NRC of Canada, 1992-93.

Ad Hoc Reviewer: Proposals for NASA and NSF.

DANIELS, R. C.

Member: Judge, student papers on Coastal and Marine Processes

competitions, sponsored by Coastal and Marine Special Group, Association of American Geographers, 1994.

Participant: 90th Annual Meeting of the Association of American Geographers, San Francisco, March-April 1994; Workshop in Integrated Assessment of the Caribbean Coastal Zone, sponsored by University of Puerto Rico, Mayagüez, September 1994; Program Review, ORNL Capabilities for Research on Ecological Impacts of Global Change, Program for Ecosystem Research, sponsored by DOE, Oak Ridge, Tennessee, September 1994.

Ad Hoc Reviewer: Research plan for Netherlands Institute for Sea Research.

DICKERMAN, J. A.

Chair: Consensus-Building Session on Sustainable Development, 19th Annual Conference, NAEP, New Orleans, June 1994.

Organizer: Track with five sessions on Sustainable Development, 19th Annual Conference, NAEP, New Orleans, June 1994.

Member: Committee Member and Track Advisor, NAEP 1994 and 1995 conference committees, 1993-95; Chair, NAEP Sustainable Development Working Group, 1994-96.

Ad Hoc Reviewer: *Water, Air, and Soil Pollution*; portions—SNF EIS, DOE; SEIS for Defense Waste Processing Facility at Savannah River Site, DOE; Clean-up Alternatives Study/Corrective Measures Study Report for Portsmouth Gaseous Diffusion Plant Site, DOE.

Other: Science advisor and curriculum development, 2nd grade, Glenwood Elementary School, Oak Ridge, Tennessee.

DIEFENDORF, A. F.

Organizer: Moderated Microwave Technology Seminar, sponsored by ORNL ESD, Oak Ridge, Tennessee, September 1994.

Officer: President, Wisconsin section, American Institute of Professional Geologists, 1993-94.

Member: Advisory/Development Board, Geology Department, University of Missouri, 1992-1996; Advisory Board, Department of Geological Sciences, Syracuse University, 1993-; Association of Engineer Geologists.

Participant: Lasagna Consortium Committee, Paducah, Kentucky, St. Louis, and Cincinnati, quarterly meetings.

DOLL, W. E.

Member: Research Committee, Environmental and Engineering Geophysics Society, 1994-; Chair, Hazardous Waste Committee, Near Surface Section, Society of Exploration Geophysicists, 1994-95.

DREIER, R. B.

Participant: Methods of Characterizing Fluid Movement and Chemical Transport in Fractured Rock, sponsored by GSA, Mirror Lake, New Hampshire, October 1993; American Women in Science Conference, sponsored by DOE, Oak Ridge, Tennessee, April 1994.

Faculty: Adjunct Assistant Professor, Department of Geological Sciences, The University of Tennessee.

Advisor: Joachim Dorsh, postdoctoral fellow, ORISE; Peter Lemiszki, postdoctoral fellow, The University of Tennessee; Paige Stafford, M.S. candidate, The University of Tennessee; Kathryn Demarais, M.S. candidate, Duke University.

Ad Hoc Reviewer: Proposals for DOE EPSCOR and the DOE-The University of Tennessee Joint Educational Program in ERWM.

EARLY, T. O.

Chair and organizer: Session No. 6. Progress in Remediation: New Technologies in Groundwater, Spectrum '94, sponsored by American Nuclear Society, DOE, IAEA, Canadian Nuclear Society, Atomic Energy Society of Japan, and European Nuclear Society, Atlanta, August 1994.

Participant: Environmental Restoration '93, sponsored by DOE, Augusta, Georgia, October 1993; In Situ Electrochemical Soil and Water Remediation, sponsored by EPRI, Palo Alto, California, February 1994; Remediation Technologies Development Forum, sponsored by EPA, Arlington, Virginia, February 1994; Technology Information Exchange Workshop, sponsored by DOE, Richland, Washington, May 1994.

Other: Recording for the Blind, Oak Ridge, Tennessee.

EDDLEMON, G. K.

Participant: Comment Resolution Meeting, SNF EIS, sponsored by DOE, Idaho Falls, Idaho, March 1994; Shield Alloy EIS Site Visit, sponsored by Nuclear Regulatory Commission, Cambridge, Ohio, April 1994; Atlas Moab EIS Site Visit, sponsored by Nuclear Regulatory Commission, Moab, Utah, May 1994; Technical Concurrence Review, SNF EIS, sponsored by DOE, Idaho Falls, Idaho, May 1994.

Other: Environmental Quality Committee, Farragut, Tennessee.

EDWARDS, N. T.

Advisor: Don Joshua Johnson, B.S. candidate, The University of Tennessee.

Editor: Editorial Review Board, *Tree Physiology*, 1994-96.

Ad Hoc Reviewer: *Tree Physiology*; *Ecotoxicology*; *Canadian Journal of Forest Research*; proposals for USDA.

ELLESS, M. P.

Member: S-9 Soil Mineralogy Lab Manual Committee, Soil Mineralogy Division of SSSA, November 1993-.

Participant: Uranium Soil ID FY 1994 Kick-off Meeting, sponsored by DOE, San Antonio, Texas, October 1993; SSSA meetings, sponsored by ASA, CSSA, and SSSA, Cincinnati, November 1993; Waste Management '94 Meetings, Tucson, Arizona, February 1994; spring meeting, AGU, Baltimore, May 1994; 18th Annual Actinide Separations Conference, Durango, Colorado, May 1994; Uranium Soils ID FY 1994 Mid-year Review Meeting, sponsored by DOE, Washington, D.C., June 1994; annual meeting, CMS, Saskatoon, Saskatchewan, Canada, August 1994.

FORD, C. J.

Participant: Third Annual Southeastern Lakes Management Conference, sponsored by NALMS, Columbia, South Carolina, March 1994; ASLO and PSA 1994 Joint Meeting, sponsored by ASLO, Miami, June 1994.

Ad Hoc Reviewer: *Sediment Samples from Weir Ponds as Indicators of Upgradient Historical Contaminant Releases*, proceedings paper, AWRA.

FRANCIS, C. W.

Participant: Uranium Soils ID Program, sponsored by DOE OTD, Washington, D.C., July 1994.

Advisor: Michael E. Timpson, Ph.D. candidate, The University of Tennessee.

Ad Hoc Reviewer: *Health Physics; Separation Science and Technology; Waste Management and Research; Journal of Environmental Engineering*; research proposal for DOE EPSCOR.

GABRIELSEN, C. A.

Participant: Colloquium on Mammals, sponsored by University of Georgia,

Athens, March 1994; meeting, Association of Southeastern Biologists, Orlando, Florida, April 1994.

Other: Science fair judge, Harriman, Tennessee; zoo volunteer, Knoxville, Tennessee.

GARTEN, C. T., JR.

Participant: NASA First ISLSCP Field Experiment Science Workshop, Kansas State University, Manhattan, Kansas, October 1993; NASA BOREAS Workshop, Coolfont Resort, Berkeley Springs, West Virginia, October 1993; EPA Workshop on Nitrogen Dynamics in Forest Watersheds for the Chesapeake Bay Watershed Model, Annapolis, Maryland, February 1994; Net Primary Productivity Modeling Comparison Workshop, sponsored by IGBP, Potsdam, Germany, July 1994; Meeting on the Exchange of Trace Gases Between Land and Atmosphere, sponsored by The Royal Society, London, July 1994; BOREAS Modeling Workshop, sponsored by NASA, Prince Albert, Saskatchewan, Canada, July 1994.

Editor: Associate Editor, *Journal of Environmental Radioactivity*, 1993-96.

Ad Hoc Reviewer: *Ecology; Journal of Environmental Quality*; proposal for USDA National Research Initiative Competitive Grants Program; *Advances in Environmental Science; Journal of Environmental Radioactivity*.

GATES, D. D.

Member: ASCE.

Participant: Technology Commercialization Workshop, sponsored by DOE, Salt Lake City, July 1994; In Situ Remediation Integrated Program Mid-year Program Review, sponsored by DOE, Houston, February 1994; roundtable member, Women in Science Conference, sponsored by AWIS, Oak Ridge, Tennessee, April 1994.

Advisor: Krishna Chava, M.S. candidate, Wayne State University; Weston Twigg, B.S. candidate, Albion College; Chanda Robinson, Carter High School; Keyondra Armstrong, Farragut High School.

Ad Hoc Reviewer: Physical/Chemical Treatment Monograph, American Academy of Environmental Engineers; proposal for DOE EPSCOR.

GRAHAM, R. L.

Chair: Technical Steering Committee for USFS Center for Forest Environmental Studies, 1992-94.

Member: Activity Leader, Systems Studies Activity: Bioenergy Agreement, International Energy Agency, 1994-98.

Participant: Program Review, Ozone Impacts to Forests, sponsored by EPA, Corvallis, Oregon, December 1993; Subcontractors Meeting of Biofuels Feedstock Program, sponsored by BFDP, Auburn University, Alabama, October 1993; Potential of Biomass Products Energy Utilization, sponsored by Ding-Nan Chen, Taiwanese senator, Taipei, Taiwan, June 1994.

Faculty: Adjunct, Department of Ecology, The University of Tennessee.

Advisor: Mark Downing, postdoctoral fellow, Texas A&M.

Ad Hoc Reviewer: EPA-Corvallis Research Lab; *Soil Science Society of America Journal*; *Biomass and Bioenergy*.

Other: Farragut 2004 Environmental Committee, Tennessee; classroom science teacher, Farragut Intermediate School, Tennessee.

GREBMEIER, J. M.

Chair: Poster Session on Arctic Shelf Processes, Ocean Sciences Meeting, sponsored by ASLO, San Diego, March 1994.

Member: Bering Sea Committee, NRC, 1993-94.

Participant: Arctic Meeting, sponsored by AAAS, Anchorage, Alaska, and Vladivostak, Russia, August-September 1994; Greenland Ice Sheet Project 2 Workshop, sponsored by NSF, Silver Spring, Maryland, September 1994.

Faculty: Research Assistant Professor, Graduate Program in Ecology, The University of Tennessee.

Advisor: Mary Muchani, postdoctoral fellow, The University of Tennessee.

Ad Hoc Reviewer: *Marine Ecology Progress Series*; proposals for NOAA and NSF.

GREELEY, M. S.

Participant: 14th Annual Meeting, SETAC, Houston, November 1994.

Advisor: Stan Sharp, M.S. candidate, The University of Tennessee; Eric Garcia, M.S. candidate, Clarion University of Pennsylvania; Brian Kortess, Candice Wilson, and Matthew Wood, B.S. candidates, The University of Tennessee.

Ad Hoc Reviewer: *Environmental Toxicology and Chemistry*; *Ecotoxicology*; *Transactions of the American Fisheries Society*.

GUNDERSON, C. A.

Participant: 20th Environmental Symposium and Exhibition, sponsored by American Defense Preparedness Association, San Antonio, Texas, March 1994; North American Forest Biology Workshop, sponsored by Louisiana State University and Society of American Foresters, Baton Rouge, Louisiana, June 1994; 79th Annual Ecological Society of America Meeting, Knoxville, Tennessee, August 1994.

Advisor: Emily A. Childs, B.S. candidate, Roane State Community College and The University of Tennessee.

Ad Hoc Reviewer: *Plant Cell and Environment*; *Ecotoxicology*.

GWO, J. P.

Participant: 1993 Fall Meeting, AGU, San Francisco, December 1993; 1994 Spring Meeting, AWRA, Nashville, Tennessee, April 1994; Computational Method in Water Resources, sponsored by IBM Germany, and Universitat Heidelberg, Germany, July 1994; ORNL High Performance Supercomputing, sponsored by ORNL and EPA, Washington, D.C., September 1994, and sponsored by ORNL and University of Puerto Rico, San Juan, September 1994.

Ad Hoc Reviewer: *Water Resources Research*; *Ground Water*.

HANSON, P. J.

Chair: Session on Ecology and Growth of Oak Stands, International Conference on Environmental Constraints and Oaks: Ecological and Physiological Aspects, sponsored by INRA, IUFRO, and EUROSILVA, August–September 1994, Nancy, France.

Member: AAAS; ASA; American Society of Plant Physiologists; ESA.

Participant: USFS Meeting on Large-Scale Forest Climate Change Studies, Aiken, South Carolina, October 1993; NAPAP Workshop: Developing the NAPAP Assessment Plan, Oak Ridge, Tennessee, November 1993; DOE's NIGEC Southeast Regional Center Peer Review Panel, Tuscaloosa, Alabama, January 1994; 1994 Air Pollution Workshop, sponsored by Boyce Thompson Institute, Ithaca, New York, March 1994; Oak Ridge Conference on Global Environmental Change, sponsored by ORNL, NIGEC, and DOE, Oak Ridge, Tennessee, March 1994; USDA, NRICGP Peer Review Panel: Plant Response to Stress, Washington, D.C., April 1994; TVA, EPRI ROVE Review, Knoxville, Tennessee, April 1994; International Conference on Mercury as a Global Pollutant, sponsored by EPRI, Whistler,

British Columbia, Canada, July 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994.

Faculty: Adjunct Associate Professor, Department of Ecology, The University of Tennessee.

Advisor: Lala S. Chambers, M.S. candidate, The University of Tennessee; Todd Tabberer and Kristin Harter, Professional Internship Program, ORISE.

Editor: Editorial Review Board, *Tree Physiology*, 1994–95.

Ad Hoc Reviewer: *Acta Oecologica*; *American Journal of Botany*; *Journal of Environmental Quality*; *Ecological Applications*; *Plant Physiology*; *Tree Physiology*; manuscript for USDA ARS; proposals for USDA NRICGP, NSF, and EPA.

HATCHER, R. D., Jr.

Chair: Ad hoc Committee on Accreditation, sponsored by American Geological Institute, Alexandria, Virginia, August 1994.

Chair and organizer: Session on President's Student Forum, annual meeting, GSA, Boston, October 1993.

Officer: President, GSA, October 1992–1993; Past President, GSA, October 1993–94; President Elect, American Geological Institute, September 1994–January 1995.

Member: Consortium for Continental Reflection Profiling Site Selection Advisory Committee, Cornell University, 1979–; Board on Radioactive Waste Management, NAS NRC, 1990–96; Committee to Establish a National Geologic and Geophysical Data Repository, American Geological Institute, 1993–94; Nuclear Reactor Safety Research Review Committee, Nuclear Regulatory Commission, 1993–96; 1994 Annual Meeting Host and Program committees, Association of Earth Science Editors, 1993–94; Executive Director, Search

Committee, GSA, 1993-94; Chair, Committee to Investigate Need for and Wisdom of Accreditation of the Professional Degree in Geosciences, American Geological Institute, 1993-94; Board on Radioactive Waste Management, New York State Low Level Radioactive Waste Review, NAS NRC, 1994-96; Board on Radioactive Waste Management Review of Specific Scientific and Technical Safety Issues Related to the Ward Valley, California, Low Level Radioactive Waste Site, NAS NRC, 1994-95; U.S. National Committee on Geology, NAS NRC, 1994-96.

Participant: Annual meeting, GSA, Boston, October 1993; Carolina Geological Society 1993 Field Trip, Hendersonville, North Carolina, November 1993; Nuclear Safety Review Committee, sponsored by Nuclear Regulatory Commission, Bethesda, Maryland, January 1994; New York State Low Level Radioactive Waste Review Committee, sponsored by NAS Board on Radioactive Waste Management, Albany, New York, January 1994, Ithaca, New York, March 1994, Washington, D. C., May-June 1994, Syracuse, New York, August 1994; Discussion of Alpine Geology, sponsored by University of Basel, Switzerland, February 1994; Joint Meeting of German Geologische Vereinigung and Czech Geological Society, Mainz, Germany, February 1994; invited speaker, Comparative Anatomy of Mountain Chains (20 hours of lectures), sponsored by University of Oulu, Finland, February 1994; Savannah River Site, sponsored by NAS Board on Radioactive Waste Management, Augusta, Georgia, March 1994; GSA Northeastern Section meeting, Binghamton, New York, March 1994; GSA Southeastern Section and Late Precambrian Rift and Drift Sequences and Structure Field Trip, Blacksburg, Virginia, April 1994; GSA Council Meeting, Boulder, Colorado,

May 1994; Advisory Committee on Nuclear Waste, sponsored by Nuclear Regulatory Commission, Washington, D.C., May 1994; Nuclear Safety Research Review Committee, sponsored by Nuclear Regulatory Commission, Washington, D.C., May 1994; spring meeting, AGU, Baltimore, May 1994; Review of Specific Scientific and Technical Safety Issues Related to the Ward Valley, California, Low Level Radioactive Waste Site, sponsored by NAS Board on Radioactive Waste Management, Needles, California, July 1994, August-September 1994; American Association of Petroleum Geologists' Annual Meeting, Denver, June 1994; Board on Radioactive Waste Management Council Meeting, sponsored by NAS NRC, Washington, D.C., September 1994.

Faculty: Professor, Department of Geological Sciences, and Distinguished Scientist, The University of Tennessee and ORNL.

Advisor: Peter J. Lemiski, postdoctoral fellow, The University of Tennessee; Janet Hopson, Ph.D. candidate, The University of Tennessee; Russell A. Anthony, Mark W. Carter, Donald J. Geddes, Dwight D. Lamb, Steven L. Martin, Camilo Montes, and Gregory M. Yanagihara, M.S. candidates, The University of Tennessee.

Ad Hoc Reviewer: Proposals for ACS, NSF, and National Geographic Society; *Canadian Journal of Earth Sciences*; applications from U.S. scientists for candidates from the former Soviet Union to participate in the 1994 Radioactive Waste Management Program, NRC; *Geology*; *Southeastern Geology*; *Journal of Geology*.

Other: Lecture to Quail Unlimited Chapter, Oak Ridge, Tennessee.

HERBES, S. E.

Faculty: Adjunct Professor, Graduate Program in Ecology, The University of Tennessee.

HILDEBRAND, S. G.

Member: Advisory Committee, ORNL Energy Division, 1994-96; Advisory Committee, The University of Tennessee Waste Management Research and Education Institute, the state of Tennessee, 1994-97; Science Alliance Review Panel, The University of Tennessee, 1994-.

Participant: Annual meeting, AAAS, San Francisco, February 1994; spring symposium, AWRA, Nashville, Tennessee, April 1994; 45th Annual Meeting, AIBS, Knoxville, Tennessee, June 1994.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee.

Other: Chair, Environmental Quality Strategic Plan Focus Group, Farragut, Tennessee.

HILL, W. R.

Advisor: Elena Guasch, Ph.D. candidate, University of Barcelona; Sarah Dimick, B.S. candidate, Earlham College.

Ad Hoc Reviewer: Proposals for NSF and USDA; *Ecotoxicology*; *Journal of the North American Benthological Society*; *New Zealand Journal of Marine and Freshwater Research*.

HINZMAN, R. L.

Participant: Annual meeting, SETAC, Houston, November 1993.

Other: Science fair judge, Kingston, Tennessee; Oak Ridge Research Institute, Saturday School, Oak Ridge, Tennessee.

HOFFMAN, F. M.

Participant: WATtec '94, Knoxville, Tennessee, February 1994; Ninth Forum

on Publishing and Documentation Technologies, sponsored by DOE, Gatlinburg, Tennessee, April 1994; NASA Cooperative Agreement Notice Proposal Review Panel on Public Access, sponsored by NASA High Performance Computing and Communications Office, May 1994.

Other: Science Olympiad, regional and statewide events, Tennessee.

HOOK, L. A.

Participant: Seventh Annual Workshop on QA for Environmental Measurements, sponsored by Interagency Steering Committee for QA for Environmental Measurements, New Orleans, December 1993; Subcommittee for Data Management, Data Needs Task Group, sponsored by Interagency Steering Committee for QA for Environmental Measurements, Oak Ridge, Tennessee, February 1994; Radiochemical Data Validation Workshop, sponsored by ER Data Quality Program, Oak Ridge, Tennessee, September 1994.

HUFF, D. D.

Chair and organizer: Chaired technical session and served on organization committee for AWRA National Meeting, Nashville, Tennessee, April 1994.

Officer: President, Tennessee Section, American Institute of Hydrology, 1993-; Treasurer, Tennessee Section, AWRA, 1993-94.

Member: Founding member, American Hydrological Society, 1994-.

Participant: National Meeting, American Institute of Hydrology, sponsored by ER, Austin, Texas, April 1994.

Faculty: Adjunct Professor, Department of Geological Sciences, The University of Tennessee.

Ad Hoc Reviewer: *Groundwater Monitoring Review*; research proposals for government of Saudi Arabia.

HULL, R. N.

Chair and organizer: Session on Cost Effectiveness and Risk-based Versus Criteria-based Remediation, Cost Efficient Acquisition and Utilization of Data in the Management of Hazardous Waste Sites, sponsored by Waste Policy Institute and Air and Waste Management Association, Herndon, Virginia, March 1994.

Member: SETAC; Canadian Society of Zoologists; SRA; ASTM.

Participant: ASTM Environmental Toxicology and Risk Assessment Meeting, Montreal, April 1994; Ecological Risk Assessment: Lessons Learned, sponsored by SETAC, Houston, November 1993; SRA Annual Meeting, Savannah, Georgia, December 1993.

Ad Hoc Reviewer: Papers for SETAC.

Other: Science fair judge, Harriman, Tennessee.

HUNSAKER, C. T.

Chair: Colloquium on Watershed Ecological Risk Assessment Issues, sponsored by EPA, Alexandria, Virginia, September 1994.

Member: Public Affairs and Women and Minorities committees, ESA, 1989-95; Chair, Applied Ecology Section, ESA, 1993-95; Advisory Council, The Committee on the National Institute for the Environment, 1993-; Ecology Committee and Director-at-Large, Board of Control, Water Environment Federation, 1993-96; lead item writer, Exam Advisory Panel, Institute for Professional Environmental Practice, 1994-95.

Faculty: Adjunct Associate Professor, Range Science, College of Natural Resources, Utah State University.

Advisor: Robert Washington-Allen, Ph.D. candidate, Utah State University.

Editor: Advisory Board, *The Environmental Professional*, NAEP, January 1989-.

Ad Hoc Reviewer: *Environmental Management; Water Resources Bulletin*; proposals for EPA and USDA; *Landscape Ecology*.

HUSTON, M. A.

Chair and organizer: Oak Ridge Climate Change Symposium, sponsored by DOE and USFS, Oak Ridge, Tennessee, March 1994.

Member: Review Panel for Savannah River Site Biodiversity Program, DOE and USFS, May 1994; Facilitator, Science Subgroup of South Florida Task Force, NBS, NPS, and Army Corps of Engineers, May 1994; NSF Site River Team for Ecological Synthesis, September 1994.

Participant: Everglades Landscape Modeling Workshop, sponsored by NBS and NPS, Homestead, Florida, June 1994.

Faculty: Associate Research Professor, Mathematics, The University of Tennessee; Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee.

Advisor: Melina Holmgren and Larry Pounds, Ph.D. candidates, The University of Tennessee; Charles LaFoz, M.S. candidate, The University of Tennessee.

Editor: Review Panel Member, *Tree Physiology*, 1993-.

JACKSON, B. L.

Participant: Southeastern SAS Users Group Conference, sponsored by SAS Institute, Inc., Charleston, South Carolina, September 1994.

JACOBS, G. K.

Coorganizer: AMP Workshop, sponsored by DOE ER and DOE OBES, Oak Ridge, Tennessee, March 1994.

Member: Advisory Board for Department of Geological Sciences, The University of Tennessee, 1993-95; Hanford Low-Level Waste Technical Advisory Panel, DOE, 1994-.

Participant: Annual meeting, GSA, Boston, October 1993; In Situ Remediation Program Review, sponsored by DOE OTD, Houston, February 1994.

Faculty: Adjunct Associate Professor, Department of Geological Sciences, The University of Tennessee.

Advisor: Suvasis Dixit, Ph.D. candidate, The University of Tennessee.

Ad Hoc Reviewer: Proposals for National Geographic Society, NRC, and NSF.

JAMES, B. R.

Ad Hoc Reviewer: *Water Resources Research*; *ASCE Journal of Environmental Engineering*.

JARDINE, P. M.

Member: SSSA; M.S. committee member, Department of Plant and Soil Science, The University of Tennessee.

Participant: Review of Subsurface Heterogeneity Initiative, sponsored by DOE, Norfolk, Virginia, October 1993; annual meeting, SSSA, sponsored by ASA, CSSA, and SSSA, Cincinnati, November 1993; Co-Contaminant Chemistry Annual Subprogram Meeting, sponsored by DOE, Portland, Oregon, January 1994; Review of Co-Contaminant Chemistry Subprogram, sponsored by DOE, Gaithersburg, Maryland, June 1994; ACS Special Symposium, Atlanta, September 1994.

Advisor: Zorawar Kooner, postdoctoral fellow, The University of Tennessee; Rachel O'Brien, postmasters participant, Washington State University; Oren Reedy, M.S. candidate, The University of Tennessee; Chandra Whitworth, B.S. candidate, The University of Tennessee.

Editor: Associate Editor, *Soil Science Society of America Journal*, 1991-94.

Ad Hoc Reviewer: *Environmental Science and Technology*; *GEODERMA*;

Water Resource Research; *Soil Science*; proposals for USDA.

JOSLIN, J. D., Jr.

Cochair and coorganizer: Eighth North American Forest Soils Conference, sponsored by SSSA, Society of American Foresters, and CSSA, Gainesville, Florida, May 1993.

Participant: Annual meeting, SSSA, sponsored by ASA, CSSA, and SSSA, Cincinnati, November 1993; Oak Ridge Conference on Global Environmental Change, Oak Ridge, Tennessee, March 1994; First Southern Appalachian Mountains Initiative Meeting, Knoxville, Tennessee, May 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994.

Advisor: April Stone, Ph.D. candidate, The University of Tennessee.

Ad Hoc Reviewer: *Canadian Journal of Forest Research*; *Environmental Pollution*; paper for USDA CSRS Program; *Science of the Total Environment*; *Soil Science Society of America Journal*; *Canadian Journal of Forest Research*; *Water, Air, and Soil Pollution*.

KAISER, D. P.

Member: American Meteorological Society.

Participant: Advisory Panel Meeting for Climate Services, sponsored by NOAA, Rockville, Maryland, November 1993; Annual Meeting of American Meteorological Society, Nashville, Tennessee, January 1994; Annual Meeting of the Association of American Geographers, San Francisco, March 1994.

KANCIRUK, P.

Organizer: IEEE Metadata Conference, Washington, D.C., May 1994.

Member: DOE Representative, Interagency Working on Data Management

for Global Change, January 1990-; DOE Liaison, NAS Committee on Data for Science and Technology, November 1992-.

KEARL, P. M.

Participant: Environment Restoration '93, sponsored by DOE, Augusta, Georgia, October 1993; VOC Arid Integrated Demo, sponsored by Hanford, Portland, Oregon, November 1993; TIE Conference, sponsored by DOE, Denver, November 1993.

Faculty: Adjunct Faculty, Geosciences, Mesa State College.

Ad Hoc Reviewer: *Ground Water Monitoring and Remediation; Physical Principal of Flow in Unsaturated Porous Media* (book).

KELLY, J. M.

Member: SSSA.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee; Adjunct Professor, Forestry and Natural Resources, Purdue University.

Editor: Associate Editor, *Soil Science Society of America Journal*, 1988-95.

Ad Hoc Reviewer: *Journal of Environmental Quality; Water, Air, and Soil Pollution*; proposals for USDA and NSF.

KIM, K.-H.

Participant: Spring meeting, AGU, Baltimore, May 1994; International Conference on Mercury as a Global Pollutant, sponsored by EPRI, Whistler, British Columbia, Canada, July 1994.

KING, A. W.

Officer: Vice President for Membership and 1995 Program Chair, North America Chapter, International Society for Ecological Modeling, September 1994.

Member: Special Committee on Participation of Under Represented Groups in Theoretical Ecology, Theoretical Ecology Section, ESA, August 1994-95.

Participant: 1993 Fall Meeting, AGU, San Francisco, December 1993; 1994 U.S. Chapter-International Association of Landscape Ecology Symposium, Tuscon, Arizona, March 1994; Oak Ridge Conference on Global Environmental Change, sponsored by DOE, Oak Ridge, Tennessee, March 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994.

Ad Hoc Reviewer: *Tellus; Global Biogeochemical Cycles*; proposals for NSF and USDA; *Landscape Ecology*.

KORTE, N. E.

Participant: Second Annual DOE Occupational Safety Conference, Chicago, October 1993; Ground Water Sampling Workshop, sponsored by EPA, Dallas, November-December 1993; annual meeting, AAAS, San Francisco, February 1994; DNAPL in Low Permeability Media Workshop, sponsored by DOE and American Petroleum Institute, Cincinnati, March 1994.

Faculty: Adjunct Professor, Department of Geology and Environmental Restoration, Mesa State College.

Editor: Editorial Board, *Ground Water Monitoring and Remediation*, 1994-96.

Ad Hoc Reviewer: *Environmental Management; Water Environment Research*.

KROODSMA, R. L.

Ad Hoc Reviewer: *Journal of Wildlife Management*.

KSZOS, L. A.

Member: Ecology Committee, Water Environment Federation, 1993-97; SETAC.

Participant: Multi-Regional Meeting on Water Quality, sponsored by EPA, Knoxville, Tennessee, July 1994.

Advisor: Michelle Cheran, B.S. candidate, The University of Tennessee.

LEE, S. Y.

Member: Program Development Committee, CMS, 1991-.

Faculty: Adjunct Associate Professor, Department of Plant and Soil Science, The University of Tennessee.

Advisor: Yul Roh, Ph.D. candidate, The University of Tennessee; Kerry Leach, M.S. candidate, The University of Tennessee.

Ad Hoc Reviewer: *Clays and Clay Minerals; Soil Science Society of America Journal.*

LEMISZKI, P. J.

Advisor: David Doolin, B.S. candidate, The University of Tennessee.

Other: Lectured on earthquakes, rocks, and fossils for Karns Primary School, Pryme Time after-school program, Karns, Tennessee.

LEVINE, D. A.

Chair and organizer: Session on Remedial Investigation of Watts Bar Reservoir/Clinch River, Tennessee, Third Annual Southeastern Lakes Management Conference, sponsored by NALMS, Columbia, South Carolina, March 1994.

LIANG, L.

Participant: Review of Scientific Research, sponsored by DOE Subsurface Science Program, Gaithersburg, Maryland, February 1994; Iron Wall Technology Exchange, sponsored by GE-CRD, Schenectady, New York, June 1994; Technetium Removal Technical Exchange Meeting, sponsored by Engineering-K-25, Paducah, Kentucky, July 1994.

Ad Hoc Reviewer: *Water Resources Research; TTP for DOE BWID.*

LINDBERG, S. E.

Organizer: International Conference on Mercury as a Global Pollutant, sponsored by EPRI, Environmental Canada, and EPA, Whistler, British Columbia, Canada, July 1994.

Member: Expert Panel, Atmospheric Chemistry of Mercury, EPRI, April 1994; Program Reviewer, Geestacht National Physics Research Center, Hamburg, Germany, May 1994.

Participant: Annual meeting, NADP, sponsored by USGS, Nashville, Tennessee, October 1993; NADP-EPA Workshop on Analysis of Long Term Trends in Deposition Data, Research Triangle Park, North Carolina, March 1994; Workshop on Atmospheric Chemistry of Mercury, sponsored by EPRI, Tampa, Florida, April 1994; Exploratory Workshop on Biogeochemistry in Transition, University of Lund Integrated Environmental Systems Research Program, Lund, Sweden, May 1994.

Faculty: Research Professor, Department of Forestry, Wildlife and Fisheries, The University of Tennessee; Visiting Professor, Meteorological Institute, University of Stockholm.

Advisor: Ki Kim, postdoctoral fellow, ORNL and ORISE; Marion Hoyer, Ph.D. candidate, University of Michigan.

Editor: Editorial Board, *Advances in Environmental Science*, Springer-Verlag book series, 1988-.

Ad Hoc Reviewer: *Atmospheric Environment; Water, Air, and Soil Pollution; Environmental Reviews; Journal of Geophysical Research.*

LOAR, J. M.

Participant: Colloquium on Water Resources in the Southeast, sponsored by Joint Institute for Energy and

Environment, Knoxville, Tennessee, January 1994; Mid-Atlantic Highlands Area Environmental Monitoring and Assessment Conference, sponsored by EPA, Hershey, Pennsylvania, February 1994.

Ad Hoc Reviewer: *North American Journal of Fisheries Management*.

Other: Environmental Quality Committee, Farragut, Tennessee.

LUXMOORE, R. J.

Chair and organizer: Interscale Relationships in Forest-Atmosphere Processes, sponsored by IUFRO, St. John's, Newfoundland, Canada, August 1994.

Member: Deputy Subject Group Coordinator, IUFRO, 1991-95; Scientific Council, Siberian International Centre for Ecological Research, 1993-.

Participant: Annual meeting, SSSA, sponsored by ASA, CSSA, and SSSA, Cincinnati, November 1993; Regional Soil Water Research Group, sponsored by USDA CSRS, Asheville, North Carolina, March 1994; annual meeting, Southern Global Change Program, sponsored by USDA Forest Service, New Orleans, March 1994; Review of SWSA 6 Performance Assessment Report, sponsored by DOE, Denver, May 1994; Ph.D. Thesis External Examiner, Department of Forestry, Swedish University of Agricultural Sciences, Umeå, June 1994.

Faculty: Adjunct Professor, Department of Plant and Soil Sciences, The University of Tennessee.

Editor: Editorial Advisory Board, *Modeling of Geo-Biosphere Processes*, 1990-.

Ad Hoc Reviewer: *Journal of Tropical Forest Service*; *Ecological Bulletin*, Swedish Environmental Protection Agency; *Water Resources Research*; *Forest Science*; proposals for NSF, National Geographic Society, USDA Forest Service, USDA

CSRS, and Natural Environment Research Council, United Kingdom; book chapter, University Corporation for Atmospheric Research; *Tree Physiology*; article for Intergovernmental Panel on Climate Change, United Kingdom.

MADIX, S. E.

Other: Environmental Fair Volunteer, Knox County Sixth Graders, Knoxville, Tennessee; Regional Science Olympiad Volunteer, East Tennessee Regional High Schools.

MANN, L. K.

Member: SAMAB Natural Resources Committee, 1991-; ESA; SSSA; Nature Conservancy.

Participant: Annual SAMAB Meeting, Gatlinburg, Tennessee, November 1993.

Ad Hoc Reviewer: *Water, Air, and Soil Pollution*.

Other: Judge, sidewalk chalk art, ecological theme, Oak Ridge, Tennessee.

MARLAND, G.

Chair: Session on The Role of Technology, Integrated Assessment of Climate Change, sponsored by International Institute for Applied Systems Analysis, Vienna, October 1993; Session on Greenhouse Gas Emissions and Trend, Global Climate Change, sponsored by Air and Waste Management Association, Phoenix, Arizona, April 1994.

Cochair and coorganizer: Session on Should We—Could We Engineer the Climate, annual meeting, AAAS, San Francisco, February 1994.

Member: National Technical Advisory Committee, NIGEC, 1991-.

Participant: Global Emissions Inventory Activity Workshop, sponsored by IGBP, Boulder, Colorado, November-December 1993, and Fuji-Yoshida, Japan, September 1994;

International Comparisons of Energy Efficiency, sponsored by Lawrence Berkeley Laboratory, Berkeley, California, March 1994; Joint U.S.-People's Republic of China Workshop on Atmospheric Chemistry, sponsored by NASA, Beijing, China, July-August 1994; Advanced Research Workshop, sponsored by North Atlantic Treaty Organization, Banff, Alberta, Canada, September 1994; Second Scientific Congress, sponsored by International Global Atmospheric Chemistry Project, Fuji-Yoshida, Japan, September 1994.

Advisor: Robert Andres, postdoctoral fellow, Michigan Technological University.

Editor: Editorial Board, *Mitigation and Adaptation Strategies for Global Change*, 1994-97.

MARSH, J. D.

Ad Hoc Reviewer: *Clay Minerals Society*.

McCORD, R. A.

Organizer: Member of Steering Committee, GIS Information Exchange, sponsored by DOE ER, Richland, Washington, June 1994.

Member: Chair, Auditing Committee, Association of Southeastern Biologists, 1993-95.

McCRACKEN, M. K.

Other: EnvironMENTAL Fair, Oak Ridge, Tennessee.

MOLINE, G. R.

Participant: Annual Meeting of the International Association for Mathematical Geology, Prague, Czech Republic.

Advisor: Madeline Schreiber, M.S. candidate, University of Wisconsin-Madison; Darlene Allred, B.S. candidate, The University of Tennessee.

Ad Hoc Reviewer: Proposal for DOE EPSCOR.

MULHOLLAND, P. J.

Officer: Executive Committee, North American Benthological Society, 1994-95.

Member: Award of Excellence Committee, North American Benthological Society, 1993-94.

Participant: Freshwater Ecosystems and Climate Change in North America Planning Workshop, sponsored by ASLO, Boulder, Colorado, February 1994; Workshop on Nitrogen Outputs from Forested Watersheds in the Chesapeake Bay Drainage Basin, sponsored by EPA, Annapolis, Maryland, February 1994; Oak Ridge Conference on Global Environmental Change, sponsored by DOE OHER, Oak Ridge, Tennessee, March 1994; annual meeting, North American Benthological Society, Orlando, Florida, May 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee.

Advisor: Terry Flum, Ph.D. candidate, The University of Tennessee; Mark Mitch, Ph.D. candidate, University of Virginia; Amy Halleran, M.S. candidate, The University of Tennessee; Alycia Baybayan, B.S. candidate, Coe College; Jennifer Vasile, B.S. candidate, Wesleyan College.

Editor: Editorial Boards, *Ecology* and *Ecological Monographs*, 1990-94.

Ad Hoc Reviewer: *Limnology and Oceanography*; *Journal of the North American Benthological Society*; *Water Resources Research*; *Estuarine, Coastal and Shelf Science*; *Hydrobiologia*; *Water, Air, and Soil Pollution*; *Archiv. fur Hydrobiologia*; proposals for U.S. Forest Service Competitive Grants Program and NSF; *Canadian Journal of Fisheries and Aquatic Sciences*.

NANEY, M. T.

Organizer: AMP Workshop, sponsored by DOE OBES, Oak Ridge, Tennessee, March 1994.

Participant: Annual meeting, GSA, Boston, October 1993.

NORBY, R. J.

Chair and organizer: Symposium on Trees and Forests in a CO₂-Enriched Atmosphere, sponsored by ESA, Knoxville, Tennessee, August 1994.

Member: Review Panel, Terrestrial Carbon Processes Program, DOE, July 1994; Review Panel, Forest Face Program, Duke University, DOE, August 1994.

Participant: Symposium on Terrestrial Ecosystem Response to Elevated CO₂, GCTE/IGBP, San Miniato, Italy, October 1993; First GCTE Science Conference, GCTE/IGBP, Woods Hole, Massachusetts, May 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994; International Symposium on Environmental Constraints and Oaks: Ecological and Physiological Aspects, sponsored by IUFRO and INRA, Nancy, France, August 1994; Effects of Multiple Stress on Trees and Forests Workshop, sponsored by Northern States Global Change Research Program of the USDA Forest Service, Houghton, Michigan, September 1994; Potential Ecological Consequences of Elevated Atmospheric CO₂ Workshop, sponsored by University of Michigan Biological Station, Pellston, Michigan, September 1994.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee.

Advisor: Jennifer Hartz, B.A. candidate, St. Olaf College; Lisa Wiggins, A.B. candidate, College of the Canyons.

Editor: Editorial Review Board, *Tree Physiology*, 1986-95.

Ad Hoc Reviewer: *Plant and Soil; Plant Physiology; Tree Physiology; Canadian*

Journal of Forest Research; Plant, Cell, and Environment; Ecological Applications; Urban Atmosphere; Annals of Botany; New Phytologist; Forest Science; proposals for NIGEC, U.S.-Israel Binational Science Foundation, U.S. Department of Agriculture, and U.K. National Environmental Research Council.

Other: Board of Directors, University of Tennessee Arboretum Society, Oak Ridge, Tennessee; science fair judge, Jefferson Junior High School, Oak Ridge, Tennessee.

NYQUIST, J. E.

Member: Research and Publication committees, Engineering and Environmental Geophysics Society, March 1993-; Chair, Groundwater Committee, Near Surface Section, Society for Exploration Geophysicists, 1993-94.

Participant: Annual meeting, GSA, Boston, October 1993; OTD Workshop, sponsored by DOE, Denver, February 1994; annual meeting, Engineering and Environmental Geophysics Society, Boston, March 1994; OTD Mid-year Review, sponsored by DOE, Denver, April 1994; Aerial Robotics Competition, sponsored by Association for Unmanned Vehicle Systems, Atlanta, May 1994.

Faculty: Adjunct Assistant Professor, Department of Geological Sciences, The University of Tennessee.

Advisor: Mark Goldman and Alexy Kolesnikov, M.S. candidates, The University of Tennessee.

OLSON, R. J.

Member: DOE Representative, Interagency Committee on Environmental Trends, CEQ, 1991-94.

Participant: Developing the Framework for the NAPAP Assessment, sponsored by DOE and NAPAP, Oak

Ridge, Tennessee, November 1993; ORNL DAAC User Working Group Meeting, Oak Ridge, Tennessee, March 1994 and August 1994; 14th International Committee on Data for Science and Technology Conference, sponsored by International Council of Scientific Unions, Chambéry, France, September 1994; OREIS Program Review, sponsored by DOE, Oak Ridge, Tennessee.

Other: EnvironMENTAL Fair, Oak Ridge, Tennessee.

O'NEILL, E. G.

Member: ESA; U.S. Soil Ecology Society; Peer Review Panel, DOE, NIGEC Southeastern Region, 1993-94.

Participant: Terrestrial Ecosystem Response to Elevated CO₂, sponsored by IGBP-GCTE, San Miniato, Italy, October 1993; Oak Ridge Conference on Global and Environmental Change, sponsored by DOE and NIGEC, Oak Ridge, Tennessee, March 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994.

Editor: Guest Editor, *Plant and Soil*, 1993-94.

Ad Hoc Reviewer: *Ecology; Nature; Plant and Soil*; proposals for DOE EPSCOR, DOE Program in Ecosystem Research, USDA Competitive Grants Program, and U.S.-Mexico Foundation for Science; manuscript for EPA.

O'NEILL, R. V.

Member: Chair, Awards Committee, U.S. Chapter of the International Association for Landscape Ecology, 1991-94.

Faculty: Adjunct Professor, Graduate Program in Ecology, The University of Tennessee.

Advisor: Jackie Little, Ph.D. candidate, The University of Tennessee.

PALUMBO, A. V.

Cochair and organizer: Session on Bioavailability of Contaminants, 94th General Meeting, American Society of Microbiology, Las Vegas.

Member: American Society of Microbiology; ASLO; Groundwater and Ecology committees, Water Environment Federation; SETAC; Society for Industrial Microbiology; Technology Support Group, DOE OTD; Advisory Committee for The University of Tennessee Center for Environmental Biotechnology.

Participant: Workshop on Heterogeneity in the Subsurface, sponsored by DOE Subsurface Science Program, Norfolk, Virginia, October 1993; Briefing for Maryland Department of Natural Resources, sponsored by DOE Subsurface Science Program, Annapolis, Maryland, October 1993; Meeting of the Biotechnology Support Group of the DOE OTD Non-Arid Site Integrated Demonstration, Atlanta, October 1993, and Salt Lake City, February 1994; Workshop on Transport of Bacteria in the Subsurface, sponsored by DOE Subsurface Science Program, Norfolk, Virginia, November 1993; invited participant, Workshop on Development of Ecological Tier Testing Schemes for Microbial Biotechnology Applications, sponsored by EPA, Arlington, Virginia, January 1994; Bacterial Transport Subprogram Review, sponsored by DOE OHER Subsurface Science Program, Gaithersburg, Maryland, February 1994; Second International Conference on Ground Water Ecology, Atlanta, March 1994; Meeting on Proposed Release of GEMS for Bioremediation, sponsored by DOE OHER and EPA, March 1994; Technical Task Plan Review, sponsored by DOE In Situ Remediation Program, April 1994; Meeting with DOE Kansas City Plant Site ER Representatives for Planning of Field Demonstration on

Bioremediation, April 1994; 94th Annual Meeting, American Society for Microbiology, Las Vegas, May 1994; Meeting of the DOE-American Petroleum Institute program in DNAPL in Tight Soils Remediation program, Cincinnati, May 1994; 16th Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, Tennessee, May 1994; Meeting of the Research Technology Development Forum, Bioremediation Group, Oscoda, Michigan, August 1994; Meeting of the National Center for Manufacturing Sciences, Bioremediation Group, Detroit, Michigan, August 1994; Meeting with OHER SSP program manager, Gaithersburg, Maryland, September 1994; Meeting of the Technical Advisory Team for the project: Field Release of Genetically Engineered Bioluminescent Reporter Bacteria for PAH Bioremediation in Subsurface Soil, sponsored by The University of Tennessee, Oak Ridge, Tennessee, September 1994.

Faculty: Adjunct Faculty, Graduate Program in Environmental Toxicology, The University of Tennessee.

Advisor: Udit Minocha, M.S. candidate, The University of Tennessee.

Editor: Editorial Board, *Ecotoxicology*.

Ad Hoc Reviewer: Proposals for United Nuclear Corporation, Maryland Sea Grant, DOE SBIR, and DOE EPSCOR; TTPs for DOE In Situ Integrated Remediation Program; 16th Symposium on Biotechnology for Fuels and Chemicals; *Ecotoxicology*.

Other: Coach, Odyssey of the Mind Team, St. Mary School, Oak Ridge, Tennessee.

PARR, P. D.

Officer: Vice President, 1994-95, and Treasurer, 1990-93, Association of Southeastern Biologists.

Member: Public Affairs Committee, SAMAB, 1993-; Natural Sciences Advisory

Board, Tennessee Wesleyan College, 1994-; ORNL Representative, Steering Committee, Common Ground: Future Use Project for the Oak Ridge Reservation, 1994-.

Participant: Annual conference, SAMAB, Gatlinburg, Tennessee, November 1993; U.S. Man and the Biosphere Action Plan, Denver, December 1993; Forest Health, sponsored by SAMAB, Chattanooga, Tennessee, February 1994; annual meeting, Association of Southeastern Biologists, Orlando, Florida, April 1994; annual meeting, AIBS, Knoxville, Tennessee, August 1994.

PENG, T.-H.

Member: Scientific Steering Committee, U.S. Joint Global Ocean Flux Studies, 1991-94; DOE CO₂ Survey Science Team, 1991-94; Universidad Nacional Antofagasta de México-ORNL Joint MOU Steering Committee, 1991-.

Ad Hoc Reviewer: *Journal of Geophysical Research*; *Earth and Planetary Sciences Letter*; *Global Biogeochemical Cycles*; *Geochemica Cosmochemica Acta*; *Science*; *Nature*; proposals for NSF, DOE, and NOAA.

PETERSON, M. J.

Member: Pollution Committee, Southern Division, AFS, 1992-; Southern States Mercury Task Force, September 1994-; North American Benthological Society; SETAC.

Participant: Mid-year Technical Meeting, sponsored by South Division, AFS, Little Rock, Arkansas, February 1994, 42nd Annual Meeting, North American Benthological Society, Orlando, Florida, May 1994; National Forum on Mercury in Fish, sponsored by EPA, New Orleans, September 1994.

Other: Career Day participant, Anderson County, Tennessee.

PHELPS, T. J.

Chair and organizer: Session on Groundwater Ecosystems, Second International Conference on Ground Water Ecology, sponsored by GWA and EPA, Atlanta, March 1994.

Member: Drilling Technology Steering Committee member and Evaluation Workshop attendee, Microbiology of Subsurface Environments Program, DOE OHER, 1986-; DOE OTD In Situ Treatment Technical Support Group, 1992-; Working Group Coordinator for Analyses of the Taylorsville Triassic Basin, Exploratory Origins Research, DOE OHER Subsurface Science Program, 1993-.

Participant: OTD Mid-year Review, sponsored by DOE, Houston, 1994.

Faculty: Adjunct Associate Professor, Department of Chemical Engineering, and Adjunct Professor, Biotechnology Program, The University of Tennessee.

Advisor: Christine Kelly, Laurel Elizabeth O'Connor, and Mei Sun, M.S. candidates, The University of Tennessee.

Editor: Editorial Board, *Journal of Microbiological Methods*, 1991-.

Ad Hoc Reviewer: Proposals for state of Idaho, Hudson River Foundation, DOE OTD, and DOE SBIR; *Applied and Environmental Microbiology*; *Canadian Journal of Microbiology*; *Microbial Ecology*.

POST, W. M., III

Participant: Role of Nonliving Organic Matter in the Earth's Carbon Cycle, sponsored by Dahlem Conferences, Berlin, October 1993; Global Change Postdoc Panel, sponsored by DOE, San Antonio, Texas, April 1994; International Panel on Climate Change Working Group II, Fort Collins, Colorado, July 1994; Global

Terrestrial Observing System, sponsored by World Meteorological Organization, Washington, D.C., August 1994.

Faculty: Adjunct Professor, Graduate Program in Ecology, The University of Tennessee.

Advisor: Kevin Harrison, postdoctoral fellow, DOE Global Change, ORNL; Mark Wiltberger, M.S. candidate, Pennsylvania State University; Lala Chambers, M.S. candidate, The University of Tennessee.

Editor: Associate Editor, *American Naturalist*, 1993-95.

Ad Hoc Reviewer: *Encyclopedia of Climate and Weather*; *Canadian Journal of Forest Research*; *Ecology*; *Global Biogeochemical Cycles*; *Vegetation*; *Nature*; proposals for EPA and DOE; *American Naturalist*.

RENSHAW, A. W.

Member: American Association of Artificial Intelligence; Oak Ridge Chapter, American Nuclear Society; Society of Black Physicists.

Participant: Acidic Deposition Workshop, sponsored by NAPAP, Easton, Maryland, November 1993; Assessment Workshop, sponsored by NAPAP, Oak Ridge, Tennessee, November 1993.

Other: National judge in Science and Technology category for NAACP Afro-Academic Cultural, Scientific and Technological Olympics, Chicago; Educational Foundation Chair, Knoxville American Association of University Women, Knoxville, Tennessee.

RICHMOND, J. E.

Participant: 14th Annual Meeting, SETAC, Houston, November 1993.

RIGHTMIRE, C. T.

Participant: Annual meeting, GSA, Boston, October 1994; Probability Statistics

and Geostatistics, sponsored by NGWA, Portland, Maine, August 1994; EPA Groundwater Sampling Workshop, Dallas, November 1994.

Other: EnvironMENTAL Fair, Oak Ridge, Tennessee.

ROSE, K. A.

Participant: Workshop on the COMPMECH Percids Model, sponsored by EPRI and Cornell University Field Station, Bridgeport, New York, July 1994.

Faculty: Adjunct Faculty Associate, Graduate Program in Ecology, The University of Tennessee.

Advisor: Mark Clark and Dennis Singh Dermot, Ph.D. candidates, The University of Tennessee; Shyh-Bin Wang, Ph.D. candidate, University of South Alabama; Sarah Hinckley, Ph.D. candidate, University of Washington; Kevin McCann, Ph.D. candidate, University of Guelph.

Editor: Associate Editor, *Transactions of the American Fisheries Society*, 1994-95.

Ad Hoc Reviewer: *Transactions of the American Fisheries Society*; *Copeia*; *Canadian Journal of Fisheries and Aquatic Sciences*.

ROSENSTEEL, B. A.

Ad Hoc Reviewer: *The Environmental Professional*.

ROY, W. K.

Other: EnvironMENTAL Fair, Oak Ridge, Tennessee.

RYON, M. G.

Advisor: Brian Carrico, M.S. candidate, The University of Tennessee.

Other: Environmental Quality Advisory Committee, Farragut, Tennessee.

SALE, M. J.

Chair and organizer: Responses to Changing Multiple-Use Demands,

sponsored by AWRA, Nashville, Tennessee, April 1994.

Organizer: Colloquium on Water Resources in the Southeast, sponsored by Joint Institute on Energy and Environment, Knoxville, Tennessee, January 1994.

Officer: President, Tennessee Section of AWRA, January-December 1994.

Member: Water Law, Science and Policy Committee, AWRA, 1993-; Liaison Committee for the Upper Tennessee River Basin NAWQA Study, USGS, 1994-; Steering Committee, Colloquium on Water Resources in the Southeast, Joint Institute on Energy and Environment, 1994.

Participant: DOE Hydropower Program Review, sponsored by DOE-Electrical Engineering, Idaho Falls, Idaho, November 1993; Public Scoping Meetings on Relicensing the Missouri-Madison Hydroelectric Project, sponsored by FERC, Great Falls, Helena, and Ennis, Montana, January 1994; Public Scoping Meetings on New Don Pedro Project Fish Flows, sponsored by FERC, Modesto, California, February 1994; Public Hearing on Lower Mokelumne Project FEIS, sponsored by FERC, Oak Ridge, Tennessee, February 1994; Advanced Hydropower Turbine Initiative Workshop, sponsored by DOE-Electrical Engineering, Denver, June 1994.

Advisor: Henry Cardwell, postdoctoral fellow, Johns Hopkins University; Steve Bao, postdoctoral fellow, The University of Texas.

Editor: *Proceedings, Responses to Changing Multiple-Use Demands*, AWRA.

Ad Hoc Reviewer: *American Fisheries Society*; proposal for Great Lakes Sea Grant Program.

Other: Environmental Quality Committee, Farragut, Tennessee.

SALK, M. S.

Participant: NEPA Compliance Officers Meeting, sponsored by DOE Office of NEPA Oversight (EH-25), Augusta, Georgia, February 1994, and Washington, D.C., June 1994.

SAMPLE, B. E.

Participant: Annual meeting, SETAC, Houston, November 1993.

Ad Hoc Reviewer: Draft Ecological Risk Assessment for the National Gypsy Moth Management Program, USDA Animal and Plant Health Inspection Service; *Risk Analysis; Environmental Toxicology and Chemistry; Great Basin Naturalist; The Condor.*

SANFORD, W. E.

Participant: Penrose Conference on Fractured, Unlithified Aquitards: Origins and Transport Processes, sponsored by GSA, Racine, Wisconsin, June 1994.

Ad Hoc Reviewer: *Environmental Geology; Journal of Hydrology.*

SCHILLING, E. M.

Member: Pollution Committee, Southern Division, AFS.

SCHRAMM, W. E.

Participant: North American Regional Meeting, International Association for Impact Assessment, Seattle, December 1993.

Ad Hoc Reviewer: *Journal of Ecological Economics; Forum for Applied Research and Public Policy.*

SHARPLES, F. E.

Chair: Session on New Tools for Environmental Information Management, 19th Annual Conference, NAEP, New Orleans, June 1994.

Chair and organizer: Fifth Annual Women in Science and Technology

Conference, sponsored by ORNL and ORISE, Oak Ridge, Tennessee, April 1994.

Cochair and coorganizer: Session on Should We—Could We Engineer the Earth's Climate?, annual meeting, AAAS, San Francisco, February 1994.

Member: Committee on Science, Engineering, and Public Policy, AAAS, 1990–96.

Participant: Sixth Annual Abilities Expo, sponsored by DOE-ORO, Energy Systems, and ORISE, Oak Ridge, Tennessee, October 1993; DOE Oak Ridge Graduate School Fair, sponsored by DOE and ORISE, Oak Ridge, Tennessee, November 1993; Science, Technology and Public Policy Seminar, sponsored by U.S. Office of Personnel Management, Oak Ridge, Tennessee, June 1994.

Other: Board of Directors and volunteer reader, Recording for the Blind, Oak Ridge, Tennessee.

SHRINER, D. S.

Member: Committee on Environment and Natural Resources, Subcommittee on Resource Use and Management, National Science and Technology Council, 1994–95; Subcommittee on Air Quality, Subcommittee on Global Change Research, and Subcommittee on Water Resources, Coastal and Marine Environments, CENR, National Science and Technology Council, 1994–95.

Participant: Summit on Sustainable Agriculture, sponsored by Remington Farms, Chestertown, Maryland, September 1994.

Ad Hoc Reviewer: Research program plan for USDA ARS.

SHUGART, L. R.

Chair: Session on Effects on DNA and Nuclear Metabolism, 15th Annual Meeting, European Society of Comparative

Physiology and Biochemistry, sponsored by University of Genova and Società Italiana di Biologia e Chimica, Genova, Italy, September 1994.

Chair and organizer: Napa Conference on Genetic and Molecular Ecotoxicology, sponsored by NIEHS, Yountsville, California, October 1993.

Participant: Invited expert, Workshop on Biomarkers and Wildlife Health Assessment, sponsored by Canadian Wildlife Service, Mount Tremblant, Quebec, November–December 1993; group of experts on Science Aspects of Marine Pollution, sponsored by United Nations Environmental Program, London, November 1993; invited speaker, Savannah River Conference on Quantitative Ecotoxicology, sponsored by Savannah River Ecology Laboratory, Aiken, South Carolina, June 1994.

Faculty: Adjunct Associate Professor, Oak Ridge Graduate School of Biomedical Sciences, The University of Tennessee.

Advisor: Chris Theodorakis, Ph.D. candidate, The University of Tennessee.

Editor: Founding Editor, *Ecotoxicology*, 1992–.

Ad Hoc Reviewer: *Environmental Toxicology and Chemistry*; *Ecotoxicology*; *Aquatic Toxicology*; *Environmental Health Perspectives*; proposals for NSF, The Canadian Science Council, several U.S. government agencies, and ORNL.

SIEGRIST, R. L.

Member: Publications Committee, ASCE; Groundwater Committee and International Committee Task Force, Water Environment Federation; DOE Planning Committee for In Situ Remediation Technology Development.

Participant: DOE Integrated Program for In Situ Remediation, Program Review, Houston, February 1994; Waste Management '94, sponsored by

DOE, Tucson, Arizona, March 1994; DOE Integrated Program for In Situ Remediation, Program Peer Review Meeting, Washington, D.C., May 1994; Waste Quality and Testing Symposium, sponsored by EPA, Washington, D.C., July 1994.

Faculty: Adjunct Associate Professor, Department of Civil and Environmental Engineering, The University of Tennessee.

Advisor: Oren F. Webb, postdoctoral fellow, The University of Tennessee; Paula Labieniec, Ph.D. candidate, Carnegie Mellon University.

Editor: Contributing Editor, *Journal of Environmental Engineering*, ASCE, September 1993–94.

Ad Hoc Reviewer: *Journal of Environmental Engineering*; program documents for Integrated Program for In Situ Remediation, DOE-HQ; program documents for Integrated Demonstration for VOCs in an Acid Site, DOE-HQ; Energy Systems Environmental Restoration Division, Document Peer Review of ER project documents; proposals for DOE SBIR.

SIGAL, L. L.

Chair: Session on Tapping Human Resources for Sustainable Development, Global Strategies for Environmental Issues, 19th Annual Conference, NAEP, New Orleans, June 1994.

Participant: SNF EIS Advisory Group Meeting, sponsored by DOE, Idaho Falls, Idaho, January 1994; SNF Project Budget Review, sponsored by DOE, Idaho Falls, Idaho, February 1994; Site Visit for the Air Products/DOE Four Rivers Energy Modernization Project, Calvert City, Kentucky, March 1994; SNF EIS Technical Concurrence Meeting, sponsored by DOE, Idaho Falls, Idaho, April 1994; Science and Public Policy, 45th Annual Meeting, AIBS, Knoxville, Tennessee, August 1994.

Ad Hoc Reviewer: Mimetismo por Tettigoniidae (Orthoptera) en Poblacion de *Usnea duriuscula* Mot. (liquen) procedente de los Andes Venezolanos; *The Bryologist*.

SMITH, E. D.

Other: East Fork Poplar Creek Citizens' Working Group, Oak Ridge, Tennessee; Greenways Oak Ridge, Oak Ridge, Tennessee.

SMITH, J. G.

Ad Hoc Reviewer: *Ecotoxicology*.

SMUIN, D. R.

Participant: Sixth National Technology Information Exchange, sponsored by DOE, Kennewick, Washington, May 1994; Solving Problems at Abandoned Metal Mine Sites, sponsored by U.S. Forest Service and EPA, Butte, Montana, August 1994.

SOUTHWORTH, G. R.

Member: SETAC; ACS.

Ad Hoc Reviewer: *Canadian Journal of Fisheries and Aquatic Sciences; Water, Air, and Soil Pollution*.

Other: Environmental Quality Committee, Farragut, Tennessee.

STOSS, F. W.

Organizer: Session on Global Change Data, annual meeting, Special Libraries Association, Atlanta, June 1994; Poster session, National Action Plans for International Commitment: Evaluating Climate Change Actions, sponsored by Center for Environmental Information, Washington, D.C., November–December 1994.

Officer: President, Southern Appalachian Chapter, Special Libraries Association.

Member: Scientific and Technical Information Advisory Board, School of Information Sciences, The University of

Tennessee; Library Information Subgroup, Working Group for Data Management on Global Change; Advisory Panel, Program in Environmental Risk Communication, Center for Environmental Information; Environmental Task Force, American Libraries Association; Environmental, Safety, and Health Communicators Professional Interest Committee, Society for Technical Communication; Environment and Resource Management Division, Special Libraries Association.

Participant: Annual Technical Information Meeting, DOE OSTI, Oak Ridge, Tennessee, October 1993; Second Consortium for International Earth Sciences Information Network Users' Workshop: Sharing Data through the Information Cooperative, Atlanta, October 1993; moderator, Part I: Collectors, Disseminators, Producers, and Products—Vital Information for Today and Tomorrow, Global Change Data session, annual meeting, Special Libraries Association, Atlanta, June 1994; annual meeting, Air & Waste Management Association, Cincinnati, June 1994; Second Annual Meeting of Fish and Wildlife Managers, Mountain Lake, Virginia, August 1994.

Advisor: Nina Petrov, M.S. candidate, The University of Tennessee.

Editor: Column Editor, *ERMD Newsletter*, Special Libraries Association, 1983–; Editor, *ES&H News*, Society for Technical Communication, 1994–; Editorial Board, *Electronic Green Journal*, 1994–; Advisory Board, *Environment Abstracts*, 1990–.

Ad Hoc Reviewer: *Electronic Green Journal; ERMD Bulletin*.

STOW, S. H.

Officer: Secretary-Treasurer, Education Division, GSA, 1991–94.

Member: Chair, Commission on Hazardous Waste, International

Association of Hydrogeologists, 1992-; Executive Committee, Environmental Advisory Board, Committee on Accreditation of Geology Departments, and Strategic Planning Committee, American Geological Institute, 1992-; Geology and Public Policy Committee, GSA, 1994-.

Participant: Commission on Hazardous Waste, sponsored by International Association of Hydrogeologists, Krakow, Poland, October 1993; annual meeting, AGU, San Francisco, February 1994; meeting, AAAS, San Francisco, February 1994.

Faculty: Adjunct Professor, Department of Geological Sciences, The University of Tennessee.

Editor: Editorial Board, *Environmental Geology*, 1990-.

Ad Hoc Reviewer: Proposals for NSF.

Other: Environmental Quality Committee, Farragut, Tennessee.

STRONG-GUNDERSON, J. M.

Cochair and organizer: Session on Organic Contaminant Bioavailability, sponsored by American Society for Microbiology, Las Vegas, May 1994.

Cochair: Session on Physiology, Biochemistry, Toxicology and Molecular Biology, Entomological Society of America, Indianapolis, December 1993.

Member: AAAS; American Society of Microbiology; Entomological Society of America.

Participant: Site Visit for TCE In Situ Bioremediation, sponsored by DOE, Phoenix, Arizona, July 1993; Outreach to Industry, sponsored by DOE, Seattle, February 1994; In Situ Remediation Integrated Program Primary Investigator Meeting, sponsored by DOE OTD, Houston, February 1994; Field Demonstration Site Visit, sponsored by DOE, Kansas City, Missouri, April 1994; In Situ Remediation Integrated

Programs—Research Opportunity Review, sponsored by DOE, Morgantown, West Virginia, May 1994; Remediation Technology Development Forum, sponsored by DOE, Dover, Delaware, June 1994.

Advisor: Shannon Bowden and Udit Minocha, M.S. candidates, The University of Tennessee; Tiege Davidson, Graduate Student Research Program, ORAU; Andrew Beld, Student Research Program, ORISE; Susan Wheelis, Science and Engineering Research Semester Program, ORISE.

Ad Hoc Reviewer: *Cryobiology; Ecological Entomology; Journal of Microbiological Methods; Ecotoxicology; American Chemical Society; Environmental Science and Technology; Journal of Economic Entomology; Environmental Toxicology and Chemistry.*

Other: EnvironMENTAL Fair, Oak Ridge, Tennessee.

SUTER, G. W., II

Chair: Session on Ecological Risk Assessment, 20th Canadian Aquatic Toxicity Workshop, sponsored by Quebec Ministry of Environment, Quebec City, Quebec, October 1993.

Member: Publications Committee, SETAC, October 1992-95; Aquatic Life Criteria Committee, EPA, 1992-.

Participant: Superfund Ecotox Thresholds Workgroup Workshop, sponsored by EPA, Washington, D.C., January 1994; Ecological Risk Assessment Issue Paper Peer Review Workshop, Risk Assessment Forum, sponsored by EPA, Alexandria, Virginia, August 1994.

Advisor: Elizabeth M. Will, postdoctoral fellow, ORISE; James Mabrey, B.S. candidate, University of West Florida.

Editor: Editorial Board, *Environmental Toxicology and Chemistry*, 1993-94;

Editorial Board, *Human and Ecological Risk Assessment*, April 1994-.

Ad Hoc Reviewer: Environmental Management; proposals for Air Force Office of Scientific Research; Risk Assessment Improvement Act Draft, Technology, Environment, and Aviation Subcommittee, Science, Space, and Technology Committee, and U.S. House of Representatives; *Australasian Journal of Ecotoxicology*; book chapter, SETAC; report for EPA, EMAP; *Risk Analysis*; *Archives of Environmental Contamination and Toxicology*; *Environmental Science and Technology*.

TOLBERT, V. R.

Officer: Treasurer, North American Benthological Society, 1988-.

Member: Awards Committee, East Tennessee Chapter, AWIS, 1990-95; Chair, Audit Committee, Association of Southeastern Biologists, 1992-94.

TORAN, L. E.

Member: Groundwater Committee, AGU, 1994-96.

Participant: DOE ER Review of Large Computational Projects, sponsored by OPA, Bethesda, Maryland, July 1994.

Faculty: Adjunct Faculty, Department of Geological Sciences, The University of Tennessee.

Advisor: Paige Stafford, M.S. candidate, The University of Tennessee.

Ad Hoc Reviewer: Water Resources Research; proposals for DOE EPSCOR and NSF.

TRABALKA, J. R.

Member: Scientific Committee 64-9 on Effects of Radiation on Aquatic Organisms, National Council on Radiation Protection and Measurements, 1987-.

Participant: Workshop on the Alberta Experience in Stakeholder Partnerships in

Hazardous Waste Treatment and Disposal, sponsored by DOE-ORO, Oak Ridge, Tennessee, May 1994.

Advisor: Lien Nguyen, M.S. candidate, The University of Tennessee.

Ad Hoc Reviewer: Separation Science and Technology.

TSCHAPLINSKI, T. J.

Editor: Editorial Review Board, *Tree Physiology*, 1994-96.

Ad Hoc Reviewer: Environmental and Experimental Botany; Ecotoxicology; Tree Physiology; Physiologia Plantarum; competitive grants proposal for USDA.

TURNER, R. R.

Chair: Session on Industrial Sources II, International Conference on Mercury as a Global Pollutant, sponsored by EPRI, Whistler, British Columbia, Canada, July 1994.

Chair and organizer: Session on Characterization and Treatment of Mercury in Environmental Media, Emerging Technologies in Hazardous Waste Management, sponsored by ACS, Atlanta, September 1994.

Participant: Expert Panel on Mercury Atmospheric Processes, sponsored by EPRI and EPA, Tampa, Florida, March 1994.

Faculty: Adjunct Faculty, Graduate Program in Environmental Toxicology, and Research Assistant Professor, College of Liberal Arts, Center of Excellence-Biology Consortium, The University of Tennessee.

Advisor: Mark O. Barnett, Ph.D. candidate, University of North Carolina at Chapel Hill; Kevin R. Henke, Ph.D. candidate, University of North Dakota; William P. Hamilton, M.S. candidate, The University of Tennessee.

Ad Hoc Reviewer: Water, Air, and Soil Pollution; Environment International; Environmental Toxicology and Chemistry;

proposals for EPA, Michigan Department of Natural Resources, and Louisiana State Board of Regents.

TURNER, R. S.

Chair and organizer: ORNL DAAC User Working Group Meetings, Oak Ridge, Tennessee, March 1994, and Airlie, Virginia, August 1994; Integrated Assessment Key Policy Issues Workshop, sponsored by DOE, Washington, D.C., June 1994.

Cochair and coorganizer: Integrated Assessment Workshop, sponsored by NAPAP, Oak Ridge, Tennessee, November 1993.

Member: ORNL DAAC User Working Group, 1993.

Participant: First ISLSCP Field Experiment Workshop, sponsored by NASA, Manhattan, Kansas, October 1993; BOREAS Workshop, sponsored by NASA, Coalfont, West Virginia, October 1993; Water Resources Colloquium, sponsored by Joint Institute for Energy and Environment, Knoxville, Tennessee, January 1994; Mid-Atlantic Integrated Assessment Symposium, sponsored by EPA, Hershey, Pennsylvania, February 1994; DAAC Science and Operations Focus Team, sponsored by NASA, Landover, Maryland, March 1994, and College Park, Maryland, June 1994; ORNL Global Change Symposium, sponsored by DOE, ORNL, and NIGEC, Oak Ridge, Tennessee, March 1994; Industrial Ecology Symposium, sponsored by National Academy of Engineering, Woods Hole, Massachusetts, June, 1994; EOSDIS Core System Design Review, sponsored by NASA, Greenbelt, Maryland, June 1994; Southeast Environmental Assessment Workshop, sponsored by EPA and SAMAB, Atlanta, July 1994; BOREAS Modelers' Meeting and Site Visits, sponsored by NASA, Prince Albert, Saskatchewan, and Thompson, Manitoba,

Canada, July 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994; Long-Term Ecological Research Sites Data Managers Meeting, sponsored by NSF, Seattle, September 1994; Integrated Assessment Planning Workshop, sponsored by DOE and ORNL, University of Puerto Rico, Mayagüez, September 1994; Tracking and Analysis Framework Workshop, sponsored by NAPAP, Washington, D.C., September 1994.

Advisor: Brenda Rashleigh, Ph.D. candidate, The University of Tennessee; Jennifer Swanson, M.S. candidate, Duke University.

Ad Hoc Reviewer: Proposals for EPA and NASA; reports for NSF, DOE Program on Ecological Research, and state of Maryland.

TUSKAN, G. A.

Participant: CPBR Review Meeting, Chicago, November 1993; Poplar Genetic Transformation Cooperative Meeting, sponsored by Oregon State University, Corvallis, February 1994; North Central Populus Research Consortium, sponsored by BFDP, St. Paul, March 1994; Biofuels Division Review Meeting, sponsored by DOE, Golden, Colorado, May 1994.

Faculty: Adjunct Professor, Department of Horticulture and Forestry, North Dakota State University.

Advisor: Theresa Hartley, B.S. candidate, University of the South; Migdila Plaza, B.S. candidate, Universidad Interamericana; Stephanie Russ, B.S. candidate, Wesleyan College.

Ad Hoc Reviewer: *Canadian Journal of Forest Research*; *Environmental and Experimental Botany*; *Tree Physiology*; *U.S. Park Service*; proposals for USDA Plant Genome and Plant Response to the Environment programs.

VAN WINKLE, W.

Chair and organizer: Workshop for COMPMECH Staff, sponsored by EPRI, Dauphin Island, Alabama, March 1994.

Coorganizer: Workshop on the COMPMECH Percid Project, sponsored by EPRI, Syracuse, New York, July 1994.

Member: Technical Advisory Committee, South Atlantic Bight Recruitment Experiment, National Marine Fisheries Service, 1990–; Advisor, Study to Quantify Impacts of Increased Navigation Traffic on the Upper Mississippi River, Army Corps of Engineers, 1993–.

Participant: Individual-Based Approaches to Modeling Life Histories, sponsored by Marine Sciences Research Center, State University of New York at Stony Brook, February 1994; Working Meeting for the COMPMECH Trout Project, sponsored by EPRI, San Ramon, California, March 1994; Annual Larval Fish Conference, sponsored by AFS, St. Andrews, New Brunswick, Canada, June 1994; annual meeting, AFS, Halifax, Nova Scotia, Canada, August 1994.

Faculty: Adjunct Professor, Graduate Program in Ecology, The University of Tennessee.

Advisor: Jeff Tyler and Ed Rutherford, postdoctoral fellows, ORISE and ORAU.

Editor: Coeditor, *COMPMECH News*, EPRI, 1988–.

Ad Hoc Reviewer: *Transactions of the American Fisheries Society*.

VOORHEES, L. D.

Participant: First ISLSCP Field Experiment Workshop, sponsored by NASA, Manhattan, Kansas, October 1993; BOREAS Workshop, sponsored by NASA, Berkeley Springs, West Virginia, October 1993; Earth Observing System Data and Information System Core System Review, sponsored by NASA, Landover, Maryland, December 1993;

DAAC Managers Meeting, sponsored by NASA, Landover, Maryland, December 1993, and Greenbelt, Maryland, March 1994; ORNL DAAC User Working Group Meeting, Oak Ridge, Tennessee, March 1994, and Airlie, Virginia, August 1994; Science Operations Focus Team Meeting, sponsored by NASA, Greenbelt, Maryland, March 1994; Data Center Directors Meeting, sponsored by NRC Committee on Geophysical and Environmental Data, Greenbelt, Maryland, July 1994.

WATKINS, D. R.

Participant: Sixth National TIE Workshop, sponsored by DOE ER, Kennewick, Washington, May 1994; Waste Management '94, sponsored by DOE, Tucson, Arizona, February–March 1994.

WATTS, J. A.

Chair: Session on Floodplains Mitigation (Moderator), annual meeting, AWRA, Nashville, Tennessee, April 1994.

Chair and organizer: Session on High School Programs, Women in Science and Technology Conference, sponsored by DOE, Oak Ridge, Tennessee, April 1994.

Officer: Vice-President of Membership, American Association of University Women, 1993–95; Secretary, Board of Directors, WATtec, 1994–95.

Member: AWRA; Education Committee Chair, AWIS.

Participant: SAMAB Education Committee Meeting, Asheville, North Carolina, November 1993; EPSCOR Review Panel Member, sponsored by DOE, Baton Rouge, Louisiana, February 1994.

Other: Poster Session, Oak Ridge High School Career Day, Oak Ridge, Tennessee; Cochair, SHADES

conferences, Knoxville, Tennessee, October 1993 and March 1994; WATtec, Science in Action Program, Oak Ridge and Knoxville, Tennessee.

WEBB, J. W.

Ad Hoc Reviewer: The Environmental Professional; Environment International.

WEST, O. R.

Participant: Tenth Annual Waste Testing and Quality Assurance Symposium, sponsored by EPA, Washington, D.C., July 1994; Emerging Technologies in Hazardous Waste Management VI, sponsored by ACS, Atlanta, September 1994.

Advisor: Steven W. Schmunk, M.S. candidate, Michigan Technological University.

Ad Hoc Reviewer: Separation Science and Technology; proposals for DOE; *Environmental Science and Technology.*

WHITE, D. C.

Chair and organizer: Analytical and Environmental Aspects of Chemicals, Southeastern Regional ACS Meeting, Johnson City, Tennessee, October 1993; Non-Polluting, Antifouling Marine Coatings Conference, sponsored by Office of Naval Research, Cashiers, North Carolina, May 1994.

Member: Scientific Advisory Panel, American Water Works Research, 1992–; Scientific Advisory Panel, NSF, Center for Microbial Ecology, Michigan State University, 1992–; Chair, Proctor and Gamble Award, American Society of Microbiology, January 1993–; Awards Committee, East Tennessee Branch, ACS, January 1993–; Scientific Advisory Panel, NSF, Center for Biofilm Engineering, Montana State University, January 1993–; Scientific Advisory Panel, National Water Research Institute, January 1993–.

Participant: Participant in the Retirement Festschrift of Dr. Larry Pomeroy, sponsored by University of Georgia, Athens, October 1993; Bioluminescence Symposium, sponsored by Office of Naval Research, Maui, Hawaii, November 1993; Non-Polluting, Antifouling Marine Coatings Conference, sponsored by Office of Naval Research, Monterey, California, November 1993; annual meeting, SETAC, Houston, November 1993; Microbial Origin Investigator Organizational Meeting, sponsored by DOE Subsurface Science Program, Annapolis, Maryland, December 1993; Fifth International Symposium on Supercritical Fluid Chromatography and Extraction, sponsored by Supercritical Fluid Society, Baltimore, January 1994; Second International Conference on Ground Water Ecology, sponsored by EPA, Atlanta, March 1994; Society for General Microbiology 128th Meeting, Cambridge, United Kingdom, March 1994; DOE Deep Subsurface Peer Review, Annapolis, Maryland, April 1994; annual meeting, American Society for Microbiology, Las Vegas, May 1994; American Industrial Hygiene Conference and Exposition, sponsored by American Industrial Hygiene Society, Anaheim, California, May 1994; Molecular Interactions at Marine Interfaces, sponsored by Office of Naval Research, Buffalo, New York, June 1994; BMFT-GBF Workshop on Molecular Microbiology and Biosafety, Wolfenbuttel, Germany, June 1994; Office of Health and Environment, Subsurface Science Program, sponsored by DOE, La Jolla, California, June 1994; annual meeting, ESA, Knoxville, Tennessee, August 1994; IGBP-GCTE Workshop, Leuvenberg, Switzerland, August 1994; Analytical Methods for Surface Analysis, sponsored by Office of Naval Research, Annapolis, Maryland, September 1994; NASA

Environmental Sensors Workshop, Houston, September 1994; National Water Research Institute Research Advisory Meeting, Chicago, September 1994.

Faculty: Distinguished Scientist, Professor, Graduate Program in Ecology, and Executive Director, Center for Environmental Biotechnology, The University of Tennessee.

Advisor: David Nivens, Anders Sonesson, Peter Angell, Ken Malachowsky, Sue Pfiffner, and Juinn-Shoung Lou, postdoctoral fellows, The University of Tennessee; Ward H. Johnston, Kim Keejun, and Denise Decker, Ph.D. candidates, The University of Tennessee; Gavin Black, Ph.D. candidate, University of South Carolina; Lisa Kohring, J. Ken Greer, Jr., and Janice Carpenter, M.S. candidates, The University of Tennessee; Thomas Ogle, Amy Spann, Julia Stair, and Jenny Foote, B.S. candidates, The University of Tennessee.

Editor: Founder and Editor-in-Chief, *Journal of Microbiological Methods*, 1989–; Editorial Board, *Wiley Microbiology Science*, 1992–.

Ad Hoc Reviewer: Grants for NSF; *Biological Mass Spectrometry*; *Applied Experimental Microbiology*; *Journal of Theoretical Biology*; *Archives of Microbiology and Biotechnology*; *Journal of Bacteriology*; *Journal of Bioremediation*; *Biotechnology and Bioengineering*; *Canadian Journal of Microbiology*; *Journal of Science and Engineering Corrosion*; *FEMS Microbiology*; *Applied Microbiology and Biotechnology*; *International Journal of Systemic Bacteriology*; *Current Microbiology*.

WHITE, T. W.

Participant: National Women in Science Poster Session, sponsored by

ORNL, Oak Ridge, Tennessee, March 1994; Meeting, SAS User's Group International, sponsored by SAS Institute, Inc., Dallas, April 1994.

WITH, K. A.

Ad Hoc Reviewer: *Animal Behaviour*, *The Auk*, *The Condor*, *Journal of Field Ornithology*.

WRIGHT, L. L.

Officer: Secretary, Sigma Xi, 1990–94.

Member: Membership Chair, East Tennessee Chapter, AWIS.

Participant: National Soy Diesel Board Quarterly Meeting, St. Louis, January 1994; SOLTECH 94, sponsored by DOE Biomass Power Program, Ponte Verda Beach, Florida, February–March 1994; Country Studies Kick-off, sponsored by Lawrence Berkeley Laboratory, Washington, D.C., March 1994; Partnership for Progress in Agricultural Technology, sponsored by DOE and USDA, Washington, D.C., April 1994; Program Review of Alkali Deposition Work by Tom Miles, sponsored by DOE Biomass Power Program, Livermore, California, April 1994; Iowa Conference on Integrated Biomass Energy Systems, sponsored by DOE Biomass Power Program, Des Moines, Iowa, April 1994; Utilities for Biomass Energy Commercialization, Washington, D.C., June 1994; DOE Quarterly Review, sponsored by DOE Biofuels System's Division, Washington, D.C., September 1994.

WULLSCHLEGER, S. D.

Chair: Session on Integration of Plant Responses in Air Pollution Research, 26th Annual Air Pollution Workshop, Cornell University, Ithaca, New York, March 1994.

Participant: Joint USDA/DOE Meeting on Agriculture, Beltsville, Maryland, April 1994; Joint TVA/EPRI

ROVE Review, Knoxville, Tennessee,
April 1994.

Editor: Editorial Review Board, *Tree
Physiology*, 1992-94.

Ad Hoc Reviewer: *Tree Physiology*; *New
Phytologist*; *Journal of Experimental Botany*;
Agronomy Journal; *Physiologia Plantarum*.

ZONDLO, T. F.

Member: National Groundwater
Association.

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