United States Environmental Protection Agency

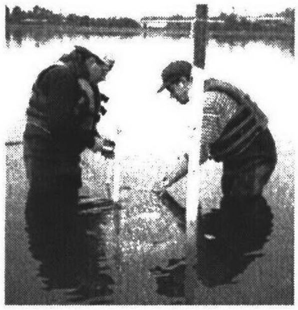
Office of Research and Development

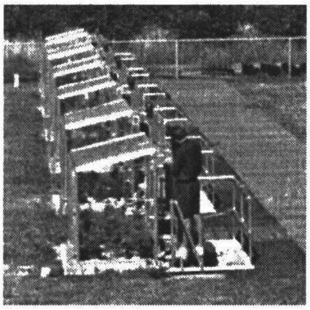
Western Ecology Division

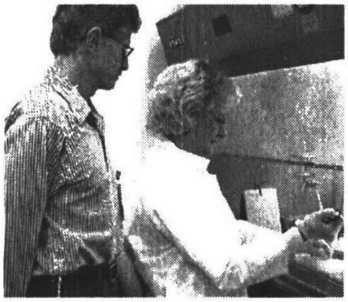
Office of Research and Development

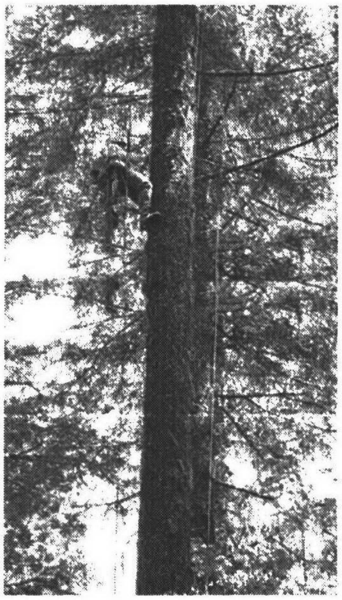
National Health and Environmental Effects Research Laboratory

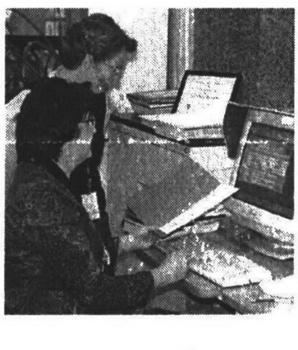
Corvallis and Newport, OR











Division Review August 27-29, 2001

Agenda

Divisional Peer Review
Western Ecology Division
National Health and Environmental Effects Research Laboratory
Office of Research and Development
August 26-29, 2001

August 26th

afternoon	Panel arrives	
7 30pm	Executive session and dinner with Dr Reiter	
August 27th	*USEPA Main Building, 200 SW 35th St, Corvallis, OR*	
8 30-8 45	Welcome and Introduction (Rm A&B, JSB)	Reiter/Veith
8 45-9 00	WED Overview	Fontaine
9 00-9 30	Introduction to WED's Research Program	Orme Zavaleta
9 30-1 30	Goal 8 1 Monitoring Research	Paulsen/Stoddard
	Lunch catered during poster review	
1 30-2 30	Research Background	
	Goal 1 Clean Air	Hogsett
	Goal 6 Global Change	Tingey
	Goal 8 2 Alternative Futures Modeling	Baker
2 30-4 30	Goal 4 Plant Effects-Pesticides	Beedlow/Rygiewicz
4 30-5 00	Tour of Corvallis Facility	
August 28th	*Main Building (Rm 190 Main Building)*	
8 30-11 30	Goal 8 2 Modeling research	Laurence
11 30-12 30	Lunch - Panel Executive Session (Rm 104)	
12 30	Depart for Hatfield Marine Science Center, Newport	
2 00-5 00	Goal 2 Coastal habitat - nutrients (A105)	Nelson/Power
5 00-5 30	Tour of Newport Facility	
6 00	Dinner in Newport and Return to Corvallis	
August 29th	*Main Building (Rm 190)*	
8 30-10 00	Goal 2 Freshwater Habitat	Laurence/Wigington
10 00-3 00	Lunch - Panel Executive Session (Rm 104)	
3 00-4 00	Exit discussion with NHEERL management	
4 00	Depart	

WED REVIEW
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INTRODUCTION

The U.S. Environmental Protection Agency (EPA) was established in 1970 in response to growing concerns over polluted air, unclean rivers, unsafe drinking water, endangered species, and careless waste disposal. EPA was given the responsibility for implementing a broad set of federal environmental laws, which have contributed in the intervening years to significant improvements in environmental quality. Currently, EPA has jurisdiction over more than a dozen statutes enacted to protect public health and the environment (e.g, the Safe Drinking Water Act and the Clean Air Act).

EPA is both a regulatory and a scientific agency; it is one of only a few federal organizations that operates in this capacity. The environmental laws that form the legal basis for the Agency's regulatory activities also authorize its research efforts. It is this research that provides the foundation for scientifically defensible environmental policies, programs, and regulations. EPA research is housed chiefly in the Office of Research and Development (ORD), which includes the National Health and Environmental Effects Research Laboratory (NHEERL).

EPA's Mission

Protect human health and safeguard the natural environment – air, water, land – upon which life depends.

EPA's OFFICE OF RESEARCH AND DEVELOPMENT (ORD)

ORD is the principal research arm of EPA. Its role is to integrate science into environmental decision-making. Unlike most of the rest of the Agency, ORD has no direct regulatory function; rather, its responsibility is to inform the regulatory process. Through the development of technical information and scientific tools, ORD's research strengthens EPA's science base, providing the Agency's Program Offices and Regional Offices with sound data for use in developing and implementing tenable environmental policies and regulations. Comprising five national Laboratories and Centers across the country, ORD's broad scope encompasses both human health and ecology.

ORD is organized around the principles of **risk assessment and risk management**. These principles not only help shape and prioritize ORD's research agenda, they also are an inherent part of its organizational structure. A diagram of risk assessment and its relationship to ORD's Labs and Centers is depicted in Figure 1 on the next page. The paradigm in Figure 1a applies to human health risk assessment, while the framework in Figure 1b, which conceptually mirrors the health paradigm, is used for ecological risk assessment. Simply put, risk assessment is the process of evaluating the nature, magnitude, and likelihood of an adverse effect following exposure to a stressor, such as pollution or habitat loss. For health risk assessment, the step-wise process involves hazard identification, dose-response assessment, exposure assessment, and risk characterization. Ecological risk assessment, on the other hand, involves problem formulation, exposure and effects analysis, and risk characterization. Once risk has been characterized, that information, together with factors such

Figure 1. Risk Assessment and ORD

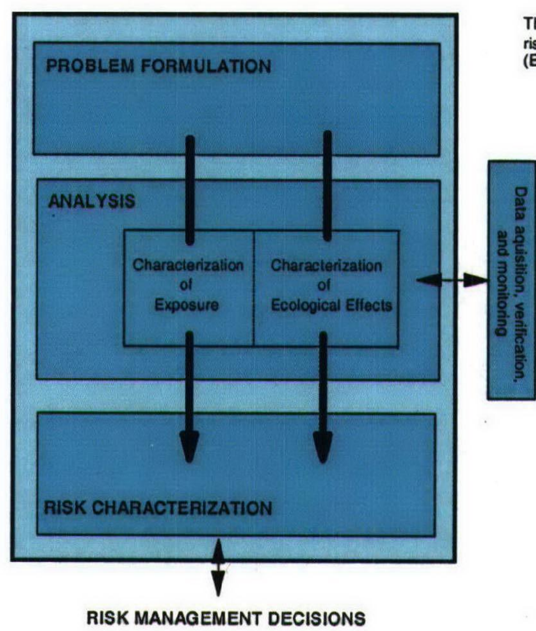
a. Health Paradigm

*Adapted from:

Risk Assessment in the Federal Government: Managing the Process. National Academy of Sciences. 1983.

Science and Judgement in Risk Assessment. National Research Council. 1994.

b. Ecology Framework



The US EPA ecological risk assessment framework (EPA, 1992)

c. Alignment of ORD Labs / Centers with Risk Paradigm

National Exposure Research Laboratory	National Health and Environmental Effects Research Laboratory	National Center for Environmental Assessment	National Risk Management Research Laboratory	National Center for Environmental Research
Research to measure, characterize, and assess exposures and to support compliance with environmental regulations and policies	**Research to identify hazards, formulate the problem, and characterize response**	Risk characterization and research on risk assessment methods	Research and technology transfer to prevent, mitigate, and control pollution	Extramural program - grants, fellowships, and national centers of excellence - to complement ORD's intramural program

as economic considerations, is used to make decisions on how to manage risk. Figure 1c shows how ORD's institutional structure is aligned to comport with the risk paradigm, with each of ORD's Labs and Centers focusing on a different aspect of risk assessment. NHEERL's singular focus is upon potential effects of environmental stressors. Our role is to help formulate environmental problems, identify the hazards, and characterize adverse effects.

ORD cannot address every problem in the environmental arena. It must be selective when deciding which problems to tackle. Some research is required by law; other research is initiated in response to specific environmental exigencies or opportunities. Thus, research in ORD can be broadly viewed from two perspectives: **scientific and programmatic**. This is an important distinction because it reflects the dual responsibility of ORD to advance environmental science frontiers while remaining responsive to the program needs and priorities of the Agency. ORD research must be scientifically relevant, but it also must be responsive to those in the Agency tasked with making regulatory and policy decisions.

The framework for organizing research within ORD (and NHEERL) is drawn from **EPA's Strategic Goals**, summarized in the box to the right. These Goals identify the overall environmental results, such as cleaner air, that EPA is working to attain. We use these goals to systematize the way in which we plan and prioritize our research, report our research findings and products, and budget our programs. EPA has 10 national environmental goals, the first eight of which involve research. Each goal is linked to key environmental statutes. For example, *Goal 2: Clean and Safe Water* is arrayed with the Clean Water Act and the Safe Drinking Water Act. Accordingly, research performed under a particular goal supports the regulatory actions mandated by the corresponding legislation.

EPA's Strategic Goals

1. Clean Air
2. Clean and Safe Water
3. Safe Food
4. Preventing Pollution and Reducing Risk in Communities
5. Better Waste Management
6. Reducing Global Risks
7. Expansion of American's Right to Know About their Environment
8. Sound Science
9. Greater Compliance with the Law
10. Effective Management

Goal 8, Sound Science, deserves some explanation due to its confusing nomenclature. This category is where our core research falls (similar to basic research, and described more fully on page 6). As opposed to problem-driven research, which addresses specific environmental problems, core research improves our fundamental understanding of complex environmental and human health issues. The information and tools gleaned from this research are the kind that can apply to a wide variety of environmental problems, including prospective environmental hazards. An example of "Sound Science" research is our study of the unique susceptibilities of infants and children to toxic substances, the results of which are far-reaching and can be used to address age-related scientific issues in many problem areas.

All research performed in ORD (and, therefore, in NHEERL) is driven by one of these strategic goals. For each of the goals, ORD's Labs and Centers have committed to reaching certain milestones and delivering specific products within a given time period, thus providing a mechanism for measuring tangible progress toward completion of long-term objectives. This explicit accountability grew out of the Government Performance and Results Act (GPRA) passed by Congress in 1993; consequently, these Agency goals are sometimes referred to as "GPRA Goals."

THE NATIONAL HEALTH AND ENVIRONMENTAL EFFECTS RESEARCH LABORATORY (NHEERL)

Organizational Structure. NHEERL is the largest research organization in ORD, employing over 700 federal employees at various facilities across the country. The current organizational structure is diagramed in Figure 2. Based in Research Triangle Park, NC, NHEERL has nine divisions that specialize in different facets of human health or ecology research. Our Health Divisions are centrally located in Research Triangle Park and Chapel Hill, NC. Our Ecology Divisions are based in Gulf Breeze, FL; Duluth, MN; Corvallis, OR; and Narragansett, RI, each location representing a significant regional ecosystem (Gulf of Mexico, Great Lakes, Pacific Coast, and Atlantic Seaboard, respectively). Table 1 on the next page lays out the research focus for each NHEERL division.

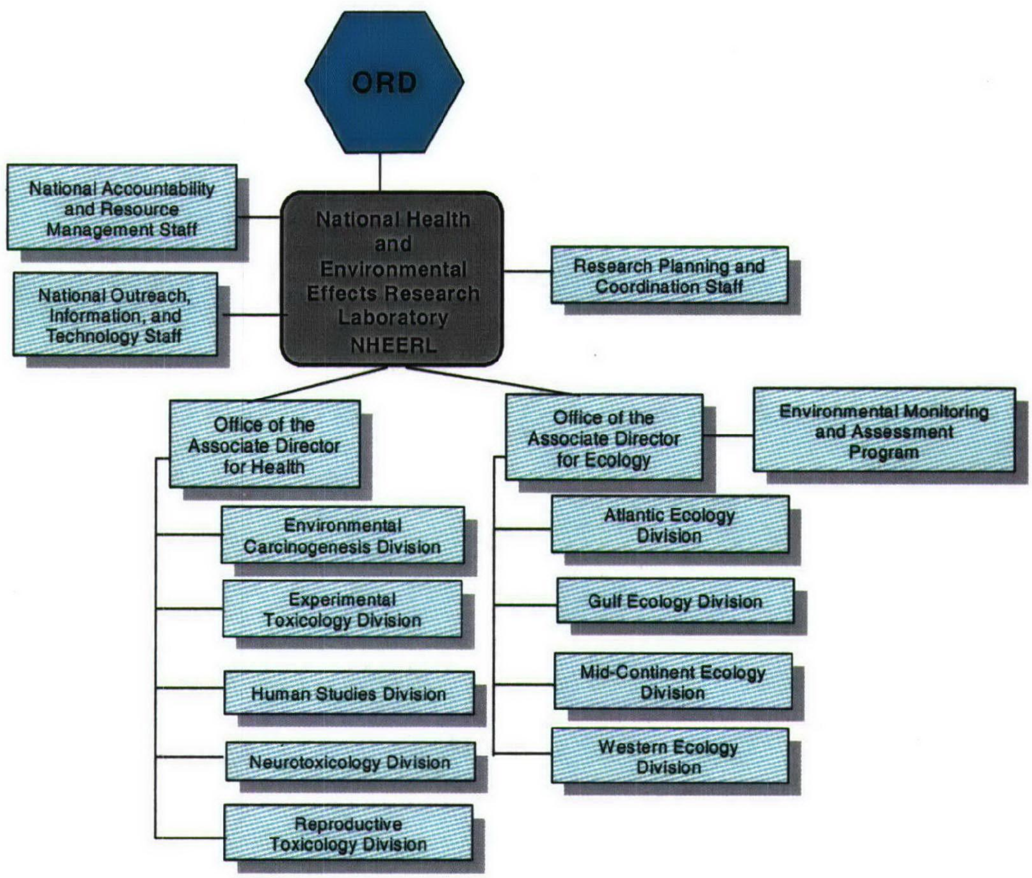


Figure 2. Organizational Structure of NHEERL and its Relationship to ORD

Table 1. Overview of NHEERL's Health and Ecology Divisions

DIVISION	LOCATION	RESEARCH FOCUS
Atlantic Ecology Division (AED)	Narragansett, RI	Studies the environmental effects of anthropogenic stressors on marine, coastal and estuarine water quality, with an emphasis on the coastal waters and watersheds of the Atlantic seaboard. Areas of research specialization include modeling cumulative effects of multiple stressors on coastal ecosystems, developing methods for assessing the ecological effects of contaminated marine sediments, analyzing the role of biogeochemical processes on effects, and conducting geographic-based ecological assessments for the Atlantic coast.
Environmental Carcinogenesis Division (ECD)	Research Triangle Park, NC	Performs research to assess potential carcinogenicity of environmental chemicals. The aim is to reduce uncertainty in cancer risk assessment models by developing mechanistic data underlying chemical carcinogenesis for agents of environmental concern (including mixtures). This approach is enhanced by developing and applying biomarkers of response for predicting cancer outcomes and by incorporating information gained from structure-activity and molecular modeling approaches.
Experimental Toxicology Division (ETD)	Research Triangle Park, NC	Performs research to determine the health effects of environmental pollutants and cause-and-effect relationships at pollutant concentrations that mimic those in the environment. Investigations center on the pulmonary and cardiovascular systems; the immune system; and susceptibility to infectious, allergic, and neoplastic disease. Focal point for pharmacokinetic studies to elucidate dose-response relationships for systems susceptible to pollutants.
Gulf Ecology Division (GED)	Gulf Breeze, FL	Assesses the ecological condition of estuaries, coastal wetlands, coral reefs, and other critical habitats of the Gulf of Mexico. Determines cause(s) of affected and declining systems; predicts future risk to populations, communities, and ecosystems from aquatic stressors; and supports the establishment of criteria to protect critical habitats.
Human Studies Division (HSD)	Chapel Hill, NC	Conducts an interdisciplinary program of clinical and epidemiologic research that provides critical data for health risk assessment. Clinical studies determine the pharmacokinetics, dosimetry, and effects of pollutants in controlled exposure studies of healthy and susceptible individuals. Epidemiologic studies evaluate the relationship between real-world exposures and observed health effects in populations of interest. The program focuses on the effects of pollutants in air and water on the pulmonary, cardiovascular, and neurobehavioral systems.
Mid-continent Ecology Division (MED)	Duluth, MN Grosse Ile, MI (field station)	Develops methods for predicting and assessing the effects of anthropogenic stressors on freshwater ecological resources, including the Great Lakes and Great Rivers. Conducts cause-and-effect research on the effects of nutrients, clean sediments, climate change, and toxic chemicals on lake, stream, and wetland ecosystems, as well as aquatic life and wildlife communities and populations. Wildlife and aquatic life toxicology research, conducted in collaboration with human health-based research performed in NHEERL's health divisions, establishes advanced animal and dose-response extrapolation models to support integrated risk assessments.
Neurotoxicology Division (NTD)	Research Triangle Park, NC	Performs research to provide the scientific and technological means to predict the neurotoxicity of environmental agents in humans. Human neurotoxic disease is modeled in laboratory animals, and data are collected in animals to make predictions about possible neurotoxic risk. Studies range from the molecular level to the whole organism and include neurobehavioral, neurochemical, neurophysiological, and neuroanatomical approaches. Major emphasis on the study of sensitive subpopulations and developmental neurotoxicity.
Reproductive Toxicology Division (RTD)	Research Triangle Park, NC	Performs research on the effects of environmental pollutants on reproduction and development. Develops biological indices for assessing germ cell maturation, embryonic development, and adult reproductive capacity and endocrine status, integrating information into biologically based dose-response models. Major research emphasis on assessing modes of action for endocrine disrupting chemicals and drinking water disinfection by-products in order to reduce uncertainties in the risk assessment of associated adverse reproductive outcomes.
Western Ecology Division (WED)	Corvallis, OR Newport, OR (field station)	Studies estuarine, terrestrial and watershed ecology with a focus on the Pacific Northwest region. Research emphasizes marine, coastal, and inland ecosystem functions and response to stress. Areas of specialization include ecological theory for spatial and temporal analysis of regional environmental data; developing methods for assessing regional-scale condition of ecological resources; and assessing the effects of changes in habitat and land use on terrestrial systems; and modeling of estuarine systems.

NHEERL's Mission. NHEERL is a problem-solving organization. We are EPA's focal point for research on the adverse effects of contaminants and environmental stressors on human health and ecosystem vitality. Our mission is to:

- perform high quality ***effects-based research*** to identify, understand and solve current and future environmental problems;
- provide ***leadership*** in addressing environmental issues; and
- provide ***scientific and technical assistance*** at the local, state, federal, and international level.

These three elements, discussed separately below, interface squarely with the missions of EPA and ORD.

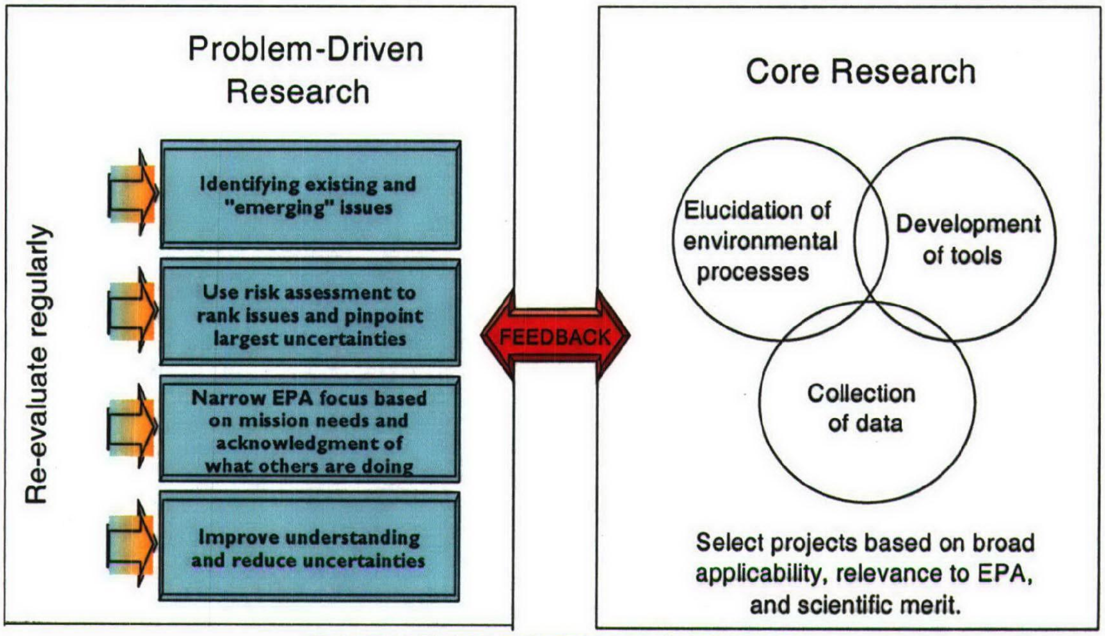
Research. Research provides EPA with the necessary information and technologies for detecting, abating, and avoiding environmental problems. NHEERL's approach to research, in accordance with ORD, is founded on principles of risk assessment. Our research is designed, within a risk assessment context, to answer scientific questions and reduce major uncertainties about the effects produced by pollutants and human activities on health and the environment. As shown in Figure 1, our research focuses on two components of the risk assessment paradigm: *problem identification / formulation* (does the contaminant or stressor cause the adverse effect?) and *dose-response / stressor-response analysis* (what are the relationships between the contaminant or stressor and the extent of injury, disease, or damage?).

> *Core and problem-driven research are similar, but not equivalent, to basic and applied research. Their complementary nature enhances NHEERL's ability to address diverse environmental issues. Scientists often pursue both types of research simultaneously, and cross-fertilization is encouraged*

Rather than characterize our research as basic or applied, we use the terms core and problem-driven. **Core research** (supporting EPA's Strategic Goal 8. Sound Science) seeks to produce a fundamental understanding of the key biological, chemical, and physical processes that underlie environmental systems, thus forging basic scientific capabilities that can be applied to a wide range of environmental problems. Core investigations address questions common to many EPA programs, and they provide the preparedness needed to confront unforeseen environmental problems. Examples of this type of research include NHEERL's multidisciplinary efforts to improve human health and ecological risk assessment (in which issues such as susceptibility and extrapolation of response are addressed) and the Environmental Monitoring and Assessment Program (designed to develop the science needed to describe the condition of our nation's ecological resources). **Problem-driven research** (supporting EPA Goals 1-7), on the other hand, focuses on specific environmental problems. Studies in these areas respond to explicit Agency needs and may be motivated by regulatory requirements or court-ordered deadlines. This type of research is exemplified by our Particulate Matter research program, in which the relationships between airborne particles and increases in morbidity and mortality are being studied to address critically important human health questions. Another example is our Aquatic Stressors Program, in which we are developing stressor-response models to advance our understanding of the basis for aquatic toxicity.

Figure 3. The Relationship between Problem-Driven and Core Research

(adapted from NRC, 1997)



FRAMEWORK FOR ENVIRONMENTAL RESEARCH

Of course, core and problem-driven research are not entirely separable. In fact, they are highly complementary and interactive, each informing the other (see Figure 3). An example from our program can illustrate this. As previously mentioned, one of the issues under our core research program is the unique susceptibilities of infants and children to toxic chemicals: how does age influence health effects? This is a fundamental question in toxicology, and the results of this research may be far-reaching, providing useful information to other studies. For instance, under Goal 2: Clean and Safe Water, we are studying the reproductive and developmental effects of disinfection by-products found in drinking water. Because this is an age-related susceptibility issue, the results from our core program readily feed into this program area, and vice versa. Thus, susceptibility research takes place in both areas (under Goal 8 and Goal 2), but the target question is different. In our core program (Goal 8: Sound Science), the question relates to the rudimentary principles of age-related differences; in Goal 2 (Clean and Safe Water), the question is how disinfection by-products impact an organism during its developmental stages. This blend of core and problem-driven research yields a robust research portfolio that couples a stable core effort with research focused on the mission needs of the Agency.

NHEERL's current core and problem-driven research topics are listed in Table 2 on the next page. (All of NHEERL's core research falls under Goal 8: Sound Science.) Relative emphasis in each of these topics may change as ORD priorities shift, as new data surfaces, as court-ordered deadlines are met, or as budgets grow and shrink. However, substantial efforts are made by NHEERL to build and maintain research programs that are both relevant to the scientific problem and responsive to Agency needs. The objective is to create an integrated and coherent program, not a collection of disconnected projects. There are three principal types of research product:

- *test methods* for detecting and characterizing hazard (e.g., new bioassays or ecological indicators);
- *predictive models* for understanding and predicting relationships between stressors and response (e.g., biologically based dose-response models or computer models that predict the effects of climate change); and
- *data* designed to fill information gaps and address limitations associated with risk assessment (e.g., toxicity test results).

Table 2. NHEERL's Core and Problem-Driven Research Programs

CORE	PROBLEM-DRIVEN	
Goal 8: Sound Science ▸ Human Health Risk Assessment • Harmonizing Cancer/Noncancer Risk Assmt. • Cumulative/Aggregate Risk • Susceptibility ▸ Research to Improve Ecosystems Risk Assessment ▸ EMAP ▸ Endocrine Disruptors	**Goal 1: Clean Air** ▸ Particulate Matter ▸ Air Toxics **Goal 2: Clean, Safe Water** ▸ Drinking Water ▸ Aquatic Stressors **Goal 3: Safe Food** ▸ Effects of Pesticides	**Goal 4: Reducing Risk in Communities** ▸ Human Health Effects and Susceptible Subpopulations ▸ Ecosystem Effects **Goal 6: Global Risks** ▸ Global Climate Change **Goal 7: Right-to-Know** ▸ Chemical Information Databases

Leadership. NHEERL provides vital leadership in the environmental research arena, and its scientists are proactive in the scientific community at many levels. Within the Agency, we help shape the research agenda by contributing to research planning and coordination exercises, and we participate in the development of ORD Research Plans and Strategies. Our scientists represent the Agency on workshops and task forces addressing major risk assessment, public health, and environmental issues. Outside EPA, we influence the direction and priorities of environmental research worldwide. We steer collaborative research efforts at the national and international level, we are members of international planning committees and research review panels, we serve on advisory boards of other major agencies and organizations, and we serve as adjunct faculty members at major universities across the nation.

Scientific and Technical Assistance. As part of our mission, NHEERL responds to diverse requests for scientific advice and technical consultation, both within and outside EPA. We provide technical support to the Agency by advising EPA Program Offices and Regional Offices on scientific matters, by participating on Agency workgroups, and by helping develop testing and risk assessment guidelines. We bring our expertise to bear at the national and international level by organizing scientific workgroups and symposia, and by serving in professional and scientific societies and on publication boards. We provide guidance to local, state, tribal, and international governments and other federal agencies, informing them on issues of environmental importance and enabling them to implement more effective environmental programs. We work to establish partnerships with the corporate, public, private, and educational sectors and assist them in setting and achieving environmental goals. We provide technical training and developmental opportunities for the senior scientist as well as the post doctoral candidate and the student. By sharing our skills and knowledge, we enhance the ability of other organizations to protect public health and the environment, and we serve as an important catalyst for scientific and technological progress.

PRIMER ON RESEARCH PLANNING AND RESOURCE ALLOCATION WITHIN NHEERL

Certain functions and operations within NHEERL are expressly governed by federal law. For example, explicit limitations and constraints are placed upon the way in which we obligate research funds. In other cases, NHEERL sets its own policies and procedures. The information below is designed to present the ways in which NHEERL operates with respect to two important responsibilities: research planning and resource allocation.

Research Planning. EPA's research agenda is determined by means of a research planning process involving every organizational level within the Agency. Long-term guidance for research direction is provided by several sources, the most important being **Strategic Plans**. These Plans focus on both organizational issues and research topics, and they help set the course for research direction. EPA's Strategic Plan is broad in scope, articulating EPA's mission and its 10 national environmental goals ("GPRA Goals") and offering a framework for planning and resource allocation. ORD's Strategic Plan and NHEERL's complementary Organizational Strategy, on the other hand, are specific to each organization's own research role within the Agency, though they naturally adhere to the principles and long-term objectives contained in EPA's Strategic Plan.

High Priority Research Areas

- Particulate Matter
- Drinking Water
- Water Quality
- Global Change
- Ecological Risk
- Human Health Risk
- Endocrine Disruptors
- Pollution Prevention and New Technologies

ORD's first Strategic Plan, published in 1996, was pivotal to the research planning process. It instituted a new system for determining research priorities. The system, founded on a risk-based approach to decision-making, uses the risk paradigm to shape the research agenda. Using this risk-based process, ORD identified – and later updated – research areas of potentially greatest risk to human health and the environment (see box to right). The selection of these high-priority research topics was conducted in partnership with ORD's many stakeholders, including the external scientific community (EPA's Science Advisory Board, the National Research Council, other government agencies, and the private sector) and the Agency's Program and Regional Offices and scientific staff.

Once identified, these high-priority areas became the strategic targets for ORD research. For each of these topics (plus several other high-profile areas), ORD has developed or is in the process of developing Research Strategies and Plans. **Research Strategies** frame the scientific questions associated with the environmental issue and delineate research needs. (If effects-based research is needed, NHEERL becomes involved and identifies the areas where it has the expertise and technical capability to reduce scientific uncertainty.) **Research Plans**, in contrast, are more detailed, outlining the research approaches to be applied to the problems. Issue-specific ORD **Multi-Year Plans** integrate research across ORD and relate research to the Strategic Goals of the Agency; they are developed in the context of existing Research Strategies and Plans with input from all of ORD's Labs and Centers. Finally, NHEERL is developing multi-year **Implementation Plans** that bring the planning process to the operational level. They are being developed by a steering committee made up of two representatives from each Division as well as representatives from appropriate EPA Offices. NHEERL and its staff play a lead role in developing all of the above-described documents. ORD's research strategies and plans are available on the Internet at http.//www.epa gov/ORD/WebPubs/final.

This description of our long-range planning process and the accompanying documents that serve as blueprints for research is meant to illustrate the interconnectedness of EPA's environmental goals, ORD's research priorities, and the course set by NHEERL to address these priorities. This process establishes research direction for a 5- to 10-year period. We are held accountable for meeting the commitments made under this exercise, and certain measures are put into place to gauge our progress. Table 3 shows more clearly how NHEERL's research is aligned with, and linked to, ORD priorities and EPA goals.

Annual research planning also takes place within the Agency as part of the federally mandated planning and budgeting process. Annual planning in ORD is driven in part by the multi-year commitments laid out in the process described above. Specific research needs are identified based on input from the Program and Regional Offices and ORD's scientific staff, and these needs are then prioritized by Agency-wide teams (called Research Coordination Teams). Special attention is paid to research required to fulfill a legislative mandate, court order, or Agency GPRA commitment; priority setting also takes into consideration scientific feasibility, the status of ongoing research, budgetary constraints, and ORD's ability to make a contribution relative to other research institutions that may be working in the same area. The objective is to focus on environmental problems that pose the greatest risks to people and the environment (using criteria such as severity, permanence, scale), on uncertainties in risk assessment that can be effectively reduced, and on areas that clearly help the Agency fulfill its regulatory mandates. These research needs become the priorities for ORD and, in turn, for NHEERL.

While the problems NHEERL is tasked to solve are defined by the above process, the research agenda for solving these problems is determined by NHEERL and its staff (see the Implementation Plans description above). NHEERL structures a coherent research program around the problem areas, with the various divisions playing specified roles. Divisions are held accountable for implementing research activities within the program and for addressing the priorities established through the ORD planning process. Divisional scientists identify the critical paths for research to resolve the key scientific questions and are often the first to raise new questions and recommend new methods for problem-solving. Their suggestions and ideas are fed back into the planning process by several means, the most common being discussions with the appropriate NHEERL Associate Director and Assistant Laboratory Director (ALD) and through the steering committee process. (It is the ALDs who, as members of the ORD Research Coordination Teams, are at the interface of ORD and NHEERL planning.) Figure 4 is a simplified diagram of the inter-relationships that exist in research planning.

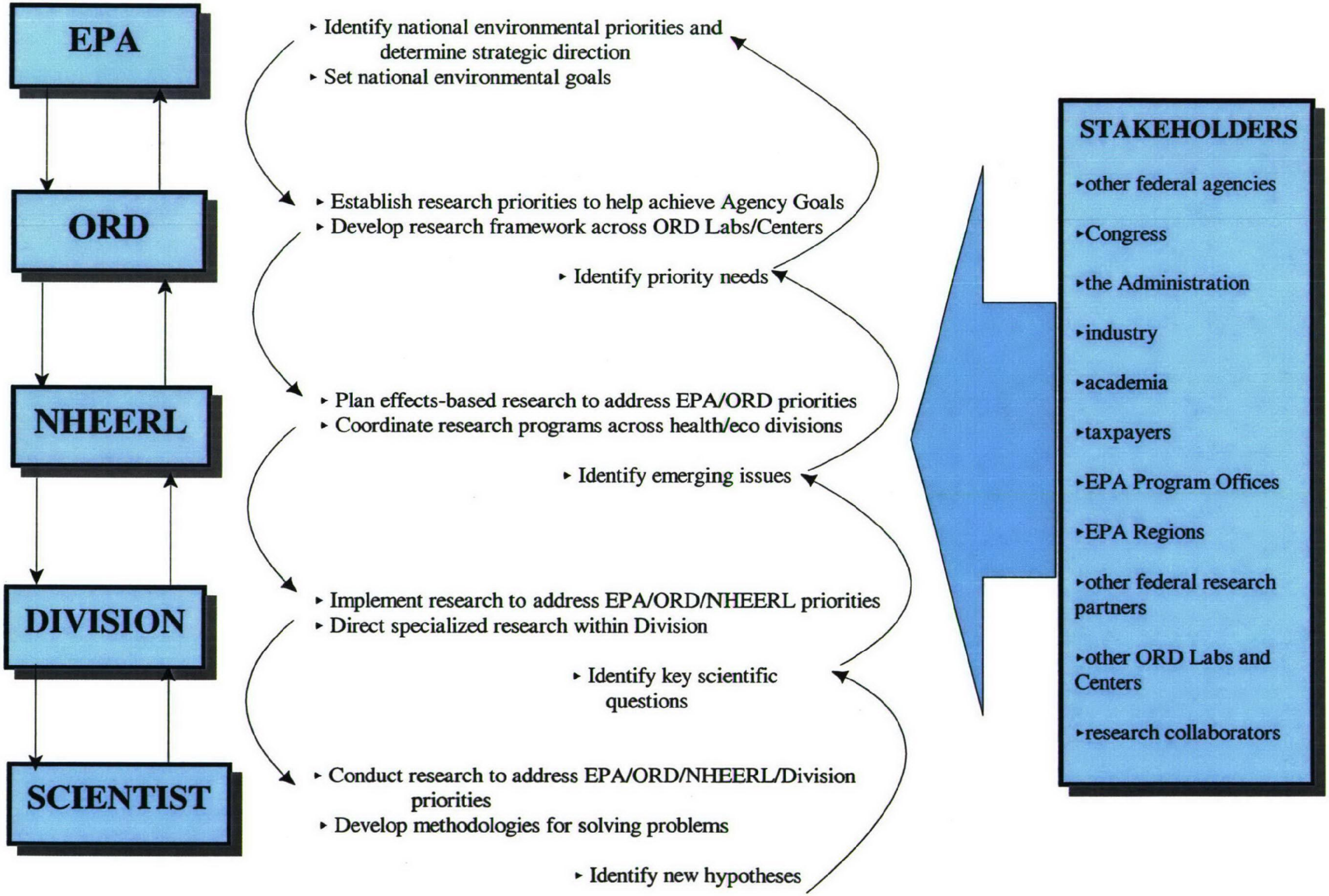
TABLE 3. Alignment of NHEERL's Research with ORD's Research Priorities and EPA's Strategic Goals

- EPA Goal 8 — SOUND SCIENCE
- EPA Goal 7 — RIGHT-TO-KNOW
- EPA Goal 6 — REDUCING GLOBAL RISKS
- EPA Goal 5 — BETTER WASTE MANAGEMENT
- EPA Goal 4 — SAFE COMMUNITIES
- EPA Goal 3 — SAFE FOOD
- EPA Goal 2 — CLEAN AND SAFE WATER
- EPA Goal 1 — CLEAN AIR

ORD RESEARCH PRIORITY	NHEERL RESEARCH TOPIC	1	2	3	4	5	6	7	8
Particulate Matter*	Particulate Matter	●							○
Air Toxics	Air Toxics	●							○
Drinking Water*	Drinking Water		●						○
Water Quality*	Aquatic Stressors		●		○	○			○
Safe Food	Effects of Pesticides			●	○				○
Safe Communities	Health/Ecosystem Effects				●				○
Contaminated Sites	Contaminated Sites		○			●			○
Global Change*	Global Climate Change						●		○
Right-to-Know	Chemical Info. Databases							●	○
Ecosystem Assessment*	Ecosystems Research		○		○	○	○		
Human Health Risk Assmt*	Human Health Research	○	○	○	○		○		
Endocrine Disruptors*	Emerging Risks (EDCs)		○	○	○	○		○	

*ORD's highest research priorities
Directly contributes to meeting Strategic Goal
○ Supports achievement of Strategic Goal

Figure 4. Research Planning



Resource Allocation. Each year, EPA develops a budget that defines the funding required to accomplish its goals and objectives. EPA provides its funding targets to ORD, and ORD provides a funding target to NHEERL. When approved by the President and Congress, the enacted budget serves as the blueprint for all Agency activities. NHEERL research planning is done assuming a flat overall budget from year to year. However, when fluctuations occur, resource allocation is adjusted accordingly. Although the funding priority of a research area within NHEERL may shift over time as research is completed or as new problems emerge, NHEERL's overall resources have remained more or less fixed in the recent past. This means that if expenditures (and research) are allowed to grow in one area, spending (and research) in another area must shrink. It should also be noted that a limit on NHEERL FTEs is imposed by EPA, and each Division is required to operate with an FTE ceiling.

In addition to salaries and benefits, travel, and operating expenses (e.g., equipment, equipment maintenance, supplies, training, etc.) NHEERL's resources include those required to sustain our in-house research capabilities (generally referred to as "research support" or "infrastructure") and those that augment or leverage our in-house efforts (referred to as "above infrastructure"). Above-infrastructure resources become available to the Laboratory through the ORD planning process as the result of initiatives for research in certain high-priority areas. In certain cases, an internal competition is held within the Laboratory for these funds, which are then awarded to Divisions whose research proposals are meritorious based on reviews for scientific excellence and programmatic responsiveness. These above-infrastructure resources may be used to provide funding for:

- support contracts (used, for example, for technical support, analytical services, information technology, and animal care);
- competitive cooperative agreements (used, for example, to train post-doctoral candidates); and
- interagency agreements (used to fund collaborative research across federal agencies).

The management of certain support services, such as computer support and animal procurement and care, is location-based: such services are centrally managed in Research Triangle Park for our health divisions, while the ecology divisions manage these activities themselves due to their geographically separate locations. However, most other resources are managed by the Divisions.

It is important to realize that there are explicit limitations – mandated by law – on spending and obligating funds. The law states that spending (by <u>any</u> agency) cannot exceed the amount appropriated by Congress. This means that NHEERL cannot apply for grants from other agencies or institutions, and we cannot increase our technical support staff through the use of external resources. However, NHEERL scientists are encouraged to collaborate both within the Agency (within Divisions, across Divisions, across Laboratories) and outside of EPA. In these cases, external resources may become available. Examples include Interagency Agreements, which foster research across federal agencies, and Cooperative Research and Development Agreements, which allow us to work with industry partners on issues of mutual interest.

It should be stated that NHEERL does <u>not</u> have its own extramural grants program. EPA research grants are handled by the National Center for Environmental Research in ORD and are not administered by NHEERL.

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Overview of the Western Ecology Division

The Western Ecology Division (WED) is one of nine divisions of the National Health and Environmental Effects Research Laboratory (NHEERL) As one of four divisions that focus on ecological research in NHEERL, WED scientists study the effects of anthropogenic stressors in estuarine , freshwater, and terrestrial ecosystems The division is a dynamic research organization with the staff capability to adapt to the changing needs of the Agency WED is currently undergoing a number of changes with respect to organizational structure, scientific leadership and the types of research problems we are addressing for the Agency The following summarizes background information about the division, our research scientists, and the changes that have occurred or are taking place since the last divisional peer review held in January, 1997 (See panel report and WED response in Appendix A)

I. Background: Evolution of WED

In 1961, amendments to the Federal Water Pollution Control Act authorized the establishment of seven laboratories in specified regions of the United States Oregon State University was selected as the site for one of these, the Pacific Northwest Water Laboratory The University had strong ecological research programs in areas of interest associated with the proposed laboratory, and cooperation was extensive from the start Temporary offices were opened in 1963, the main laboratory building was completed in 1966 The facility initially was part of the U S Public Health Service

The facility was transferred to the Federal Water Pollution Control Administration within the Department of Interior in 1967, and its mission shifted from regional technical support to conducting and managing national research in water pollution control The facility took the lead in research on lake eutrophication, coastal pollution, water quality criteria, gas supersaturation, thermal pollution, sediment criteria, and waste treatment for pulp, paper, and food processing industries

The facility became part of the newly formed Environmental Protection Agency in 1970 and, soon thereafter, was named one of four national research centers A nationwide network of nine laboratories and six field stations reported to the Corvallis Center The Center's activities rapidly expanded far beyond the original mandate of research on causes and effects of water pollution In 1972, EPA scientists studying air pollution effects on vegetation were transferred from an EPA laboratory in North Carolina to Corvallis This marked the entrance of the Corvallis facility into the emerging field of air pollution and ecological research

A reorganization in 1975 altered EPA's research centers by having individual research laboratories report directly to Washington, D C The revamped Corvallis laboratory was named the Environmental Research Laboratory-Corvallis, and its responsibilities were broadened to include diverse programs in freshwater, marine, and terrestrial environment research

EPA and its predecessor agencies have stationed marine scientists at the Hatfield Marine Science Center in Newport, Oregon, since 1965 A 40,000 square foot EPA marine laboratory was completed at Newport in October 1990 A realignment brought the Corvallis facility under the new National Health and Environmental Effects Research Laboratory in spring 1995, at which time the Corvallis and Newport labs were merged to form the Western Ecology Division

WED's Mission

Defined in 1995, WED's mission is 1) to provide EPA with national scientific leadership for terrestrial and regional-scale ecology, and 2) to develop the scientific basis for assessing the condition and response of ecological resources of the western United States and the Pacific Coast

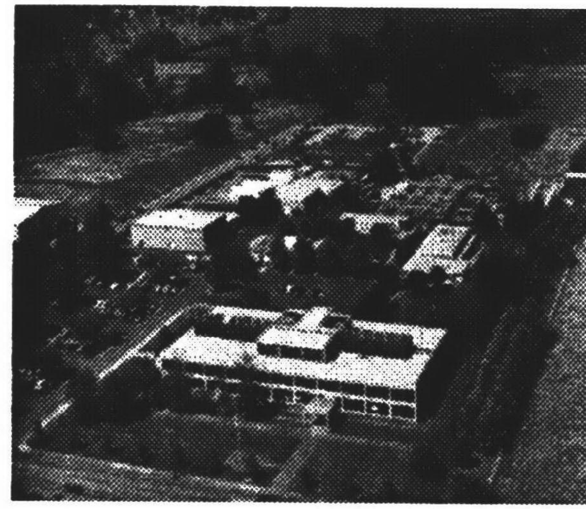
The Division addresses scientific issues of major importance in formulating public policies, programs, and regulations to protect and manage ecological resources WED scientists conduct research in a range of scientific disciplines, usually working in multi-disciplinary teams In addition to their work at the Division's facilities and field sites, they collaborate with leading scientists at research institutions throughout the world

The research addresses the ecological processes that determine the response of biological resources to environmental change and to land and resource use Priority is given to those ecological systems at greatest risk, with emphasis on the scientific uncertainties that most seriously impede ecological risk assessment

WED's research approach comprises two aspects 1) developing an understanding of the structure and function of ecological systems, and 2) conducting holistic analyses of ecological phenomena at the ecosystem, landscape, and regional scales Key scientific disciplines include terrestrial biology, aquatic biology, marine biology, ecology, geography, statistics, microbiology, soil science, plant science, biogeochemistry, plant physiology, landscape ecology, and oceanography

The Division seeks to advance scientific understanding through 1) experiments conducted in the laboratory and in specialized exposure chambers, 2) field studies, 3) modeling, and 4) analysis of large-scale environmental and ecological data sets

Since 1995, WED's mission continues to evolve With the implementation of the organizational structure discussed below, the above mission statement will be revised to reflect WED's current research directions that are described in the remainder of this notebook



WED's Research Facilities

WED's research facilities are located at Corvallis and Newport, Oregon. The main research complex is located on 14 acres in Corvallis, surrounded by the Oregon State University campus. It includes a variety of laboratories, plant and animal research facilities, a library, a computer center, and office buildings. The Willamette Research Station (WRS) comprises laboratories and field research facilities on a 10-acre site adjacent to the Willamette River in Corvallis, approximately 4 miles south of the main lab. The Pacific Coastal Ecology Branch (PCEB) carries out research in laboratory facilities at the Hatfield Marine Science Center, the marine campus of Oregon State University. The Center is located on Yaquina Bay on the Pacific Ocean at Newport, 55 miles west of Corvallis.

A terrestrial ecology laboratory within the Corvallis complex includes a number of greenhouse and field research modules. These units provide the capability for research on: 1) effects of gaseous air pollution, 2) effects of heavy metals, 3) effects of toxic substances, and 4) plant propagation and growth assessments.

Also located at the main complex, a field exposure facility includes 21 large open-top exposure chambers, a nursery site, an automated irrigation system, an experimental rhizotron site, and a control center containing automated pollutant delivery-control and data-acquisition/management systems. This field site provides a unique setting for research that addresses environmental issues such as tropospheric ozone effects on conifers, deciduous trees, and crops.

To complement the plant exposure facilities described above, WED constructed a highly sophisticated Terrestrial Ecophysiology Research Area (TERA) completed in 1994. The facility consists of a large polyhouse to shelter the data acquisition and control computers, and a field of sunlit plant growth chambers Ambient temperature, dew point and CO_2 concentration in each outdoor enclosure are carefully controlled by programmable microprocessors This facility has played an important role in research aimed at understanding the long-term effects of global climate change

The PCEB is housed in a state-of-the-art laboratory building on a 3 2 acre site at the Hatfield Marine Science Center of Oregon State University in Newport, Oregon The facility is located on the shore of Yaquina Bay in an ideal physical setting for research on marine and estuarine ecosystems The main laboratory building contains approximately 42,000 sq ft, with 7,250 sq ft of office space in the office wing, and 23,560 sq ft in the laboratory wing Wet laboratories equipped with flow-through seawater systems are available for a wide variety of experiments Unique, specialized treatment facilities on site allow experiments to be safely conducted on important regional and national environmental issues, including tests involving exotic species and chronic exposures of marine organisms to pollutants A new mesocosm facility with capability for temperature and salinity control is being constructed at the site in order to support the Branch research program on estuarine stressor effects Adjacent facilities on the Hatfield Marine Science Center campus include research laboratories operated by Oregon State University, Oregon Department of Fish and Wildlife, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, and the U S Fish and Wildlife Service This concentration of marine research organizations provides an unparalleled opportunity for collaborative research on national environmental problems, and EPA scientists interact with their colleagues to further scientific achievement in a variety of ways

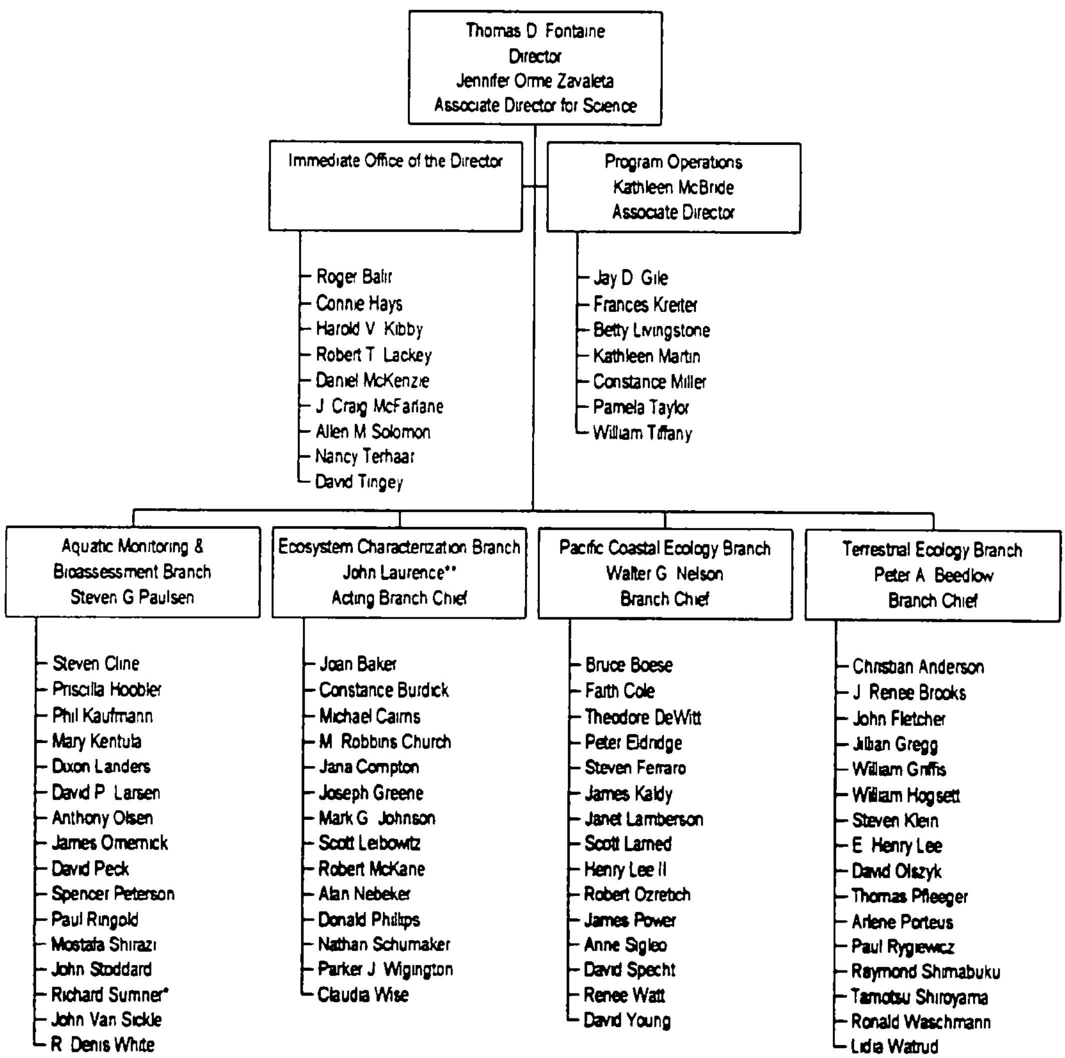
WED operates a fully integrated local area network covering its Corvallis (35th Street Campus and the Willamette Research Station) and Newport facilities, supporting both NT and UNIX workstations, large Geographic Information Systems, digitization hardware, and over 300 PCs These systems permit precise analysis of spatially distributed landscape data (e g , vegetation, soils) The Agency and Oregon State University supercomputers are also available to Division scientists via a high-speed communication network

II. WED's Organizational Framework

WED is a versatile organization with a staff that has shown a remarkable capability to adapt to the changing needs of the Agency Each of these changes bring with it opportunities for further growth in the division The following discusses changes with respect to WED's new organizational structure and scientific leadership Changes in WED's research program are discussed in Section III WED's Research Program, that follows

Organizational structure

In April 1995, WED was established with a 3 branch structure, two in Corvallis and one in Newport In addition, an administrative staff was maintained in Corvallis to provide support for the Division as a whole In the time since NHEERL and WED were established, it has become clear that a different organizational structure could improve the Division's efficiency and ability to address the Agency's research needs A new organization consisting of four branches has recently been created to improve the alignment of WED's research with specific Agency research needs and to improve the ability of supervisors to provide scientific leadership, guidance, and mentoring necessary to maintain an outstanding workforce The new structure is shown in Figure 1 and reflects our areas of research emphasis



* OW Employee, ** IPA from Boyce Thompson Institute, Cornell University

The following describes the mission of the new branches

AQUATIC MONITORING AND BIOASSESSMENT BRANCH

The Aquatic Monitoring and Bioassessment Branch provides the scientific leadership to develop monitoring tools for assessing the status and trends in condition of freshwater ecosystems (including streams, rivers, lakes, wetlands, and riparian areas) Important aspects of this research include environmental statistics, design of monitoring networks at different scales, development of biocriteria, and determining reference conditions for freshwater aquatic resources

ECOSYSTEM CHARACTERIZATION BRANCH

The role of the Ecosystem Characterization Branch is to determine the effects of natural and anthropogenic stress on the structure and function of ecosystems Research includes characterizing the relationship between ecological processes and ecosystem condition, particularly at watershed and landscape scales In addition, research will address the effect of landscape patterns on habitat quality and other life support functions for wildlife and other aquatic dependent populations, especially those which may be rare or endangered

TERRESTRIAL ECOLOGY BRANCH

The focus of the Terrestrial Ecology Branch is to determine the effects of natural and anthropogenic stressors on terrestrial plants and plant communities Branch responsibilities are to resolve key scientific questions on the response of the plant-soil system to anthropogenic stressors such as air pollution and chemical pest control agents Research will evaluate the impact of both single and multiple stressors Experimental work is conducted in greenhouses, open-top chambers, mesocosms, and field plots to develop stressor response models characterizing the direct and indirect effects of pollutants on these systems

PACIFIC COASTAL ECOLOGY BRANCH

The Pacific Coastal Ecology Branch is responsible for determining the effects of natural and anthropogenic stressors on ecological resources of Pacific Coast estuaries at multiple and temporal scales This Branch resolves key scientific questions on coastal ecosystems ranging from individual estuaries and coastal watersheds to broader near-coastal issues linking marine, estuarine and watershed (both freshwater and terrestrial) components Key stressors include nutrients, sedimentation, pollution, and nuisance exotic species Research includes determining the ecological function values of estuarine habitats, factors controlling the distribution and effects of watershed alterations, and nutrient inputs

The Branch provides the administrative home for WED employees Within each branch are 1 to 2 research teams that address specific Agency problems The Branch Chief provides the scientific leadership guiding each research team (described under WED Research Program, below), while a team leader serves as the overall coordinator for the research team and oversees the day to day management of the research Research Teams consist of principal investigators, and in some cases, research support scientists, technicians, and affiliates The teams are envisioned to have a life span of 3-5 years depending on the nature of the research problem being addressed

Scientific Leadership

Changes have also occurred with respect to scientific leadership at the division and branch level Since the previous divisional peer review in 1997, WED's Director, Dr Thomas Murphy, retired after heading the research laboratory in Corvallis for 18 years During the two years this position has been vacant, Drs Peter Beedlow (May 1999 to December 1999) and Harold Kibby (December 1999 to August 2001) served in acting capacities In August, 2001, Dr Thomas Fontaine joined WED as the new Director Dr Fontaine recently served as Director, Environmental Monitoring and Assessment Division, South Florida Water Management District and brings with him experience in scientific leadership and management that will complement and advance the research directions for the division

The reorganization of the division has also brought about changes in other leadership positions within the division Jennifer Orme Zavaleta joined WED as the Associate Director for Science adding a risk assessment and Agency program perspective to the division, Dr Robert Lackey was named as a Special Assistant to the Director focusing on the development of a research program addressing salmon restoration issues for NHEERL, and Dr Roger Blair was named as the Technical Director of the Western - Environmental Monitoring and Assessment Program (EMAP) WED also has two other scientific leadership positions in the division Dr Allen Solomon holds a Science and Technology (ST) position as a Senior Research Global Ecologist and Dr David Tingey was appointed to an ST position in plant physiology

The new four branch structure has also provided some new leadership opportunities at the branch chief level Dr Steve Paulsen serves as chief of the newly created Aquatic Monitoring and Bioassessment Branch Dr Walt Nelson continues to serve as the Chief of the Pacific Coastal Ecology Branch and Dr Peter Beedlow continues as Chief of the Terrestrial Ecology Branch The Branch Chief position for the newly created fourth Branch, Ecosystem Characterization, is vacant Dr John Laurence who is on an Interagency Personnel Appointment from Boyce Thompson Institute, Cornell University to EPA is currently acting

III. WED Research Program

Since 1997, the Agency problems and research priorities have changed resulting in a shift in WED's research program As a further consideration, ORD's research program must now be aligned with the 1993 Government Performance and Results Act (GPRA) objectives for the Agency (see Introduction) Many of WED's research projects have predated GPRA and thus, may be responsive to more than one objective Changes in research that have occurred since the 1997 peer review have affected all aspects of WED's research program Some of these include

- the Environmental Monitoring and Assessment Program (EMAP), has shifted the regional emphasis from the Mid-Atlantic to the Western US,
- coastal research has shifted from contaminated sediments to the effects of nutrient loadings on estuarine habitats,
- process and modeling research is shifting from a focus on air pollutants (i e, ozone) and the effects of global climate change on forested ecosystems to the effects of pesticides on non-target plant communities,
- a new focus on the relationship between terrestrial and freshwater habitats and wildlife populations across different levels of biological organization

These types changes are usually identified during the ORD and NHEERL research planning processes The following describes how the research planning process in ORD and NHEERL guide WED's research program

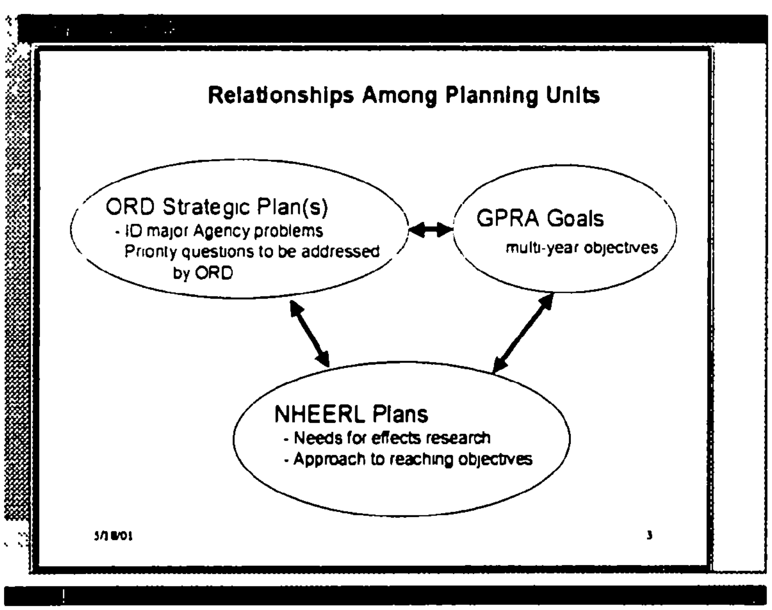
Research Planning

As noted in the Introduction, ORD research planning is a hierarchical process that is aligned with the GPRA objectives for the agency Congress enacted GPRA in response to concerns with government performance and declining budgets EPA established 10 strategic goals as part of the strategic planning under GPRA WED conducts research in support of Goal's 2, 4, and 8 (Table 1) The strategic goals lay out the framework for annual planning For Goal 2, the Agency objective is to conserve and enhance the Nation's waters ORD's research focus is on aquatic stressors The objective for Goal 4 is the safe handling and use of commercial chemicals and microorganisms with ORD's research targeted to improve community based eco-health, measurements, methods, and models Goal 8 addresses research for ecosystem assessment and restoration ORD's research program covers four areas ecological monitoring, ecological process and modeling, ecological assessment, and ecosystem restoration WED contributes to this research in the areas of monitoring and process and modeling

Table 1 Alignment of WED's Research with GPRA Goals

Goal	Agency Problem	ORD Research Focus	WED's Research Focus
2	Clean Water	Aquatic Stressors	▸ Nutrients ▸ Coastal Habitats ▸ Fresh Water Habitats
4	Safe Communities	Ecosystem Protection	▸ Nontarget Plant Communities ▸ Habitat-Wildlife Populations
8	Sound Science	Ecosystem Assessment and Restoration ▸ monitoring ▸ process and modeling	▸ Monitoring Design ▸ Biocriteria & Bioassessments ▸Coastal Monitoring ▸ Ecological Risk Assessment

Relationship Between Research Planning Process and WED's Research Program



NHEERL has developed a research and implementation planning process that links the broader strategic research directions identified from the ORD Planning effort with NHEERL's research The goal of NHEERL's process is to improve the responsiveness and relevancy of the laboratory's research program in addressing Agency problems as well as to foster cross-divisional collaboration within the laboratory (Figure 1)

Figure 1

The Agency problems identified by the ORD Strategic Plans are evaluated to determine how

NHEERL's mission relates to the problem and identifies scientific uncertainties NHEERL can address

NHEERL's planning effort involves research scientists and managers from each division where appropriate The product of NHEERL's planning effort is an implementation plan that highlights key uncertainties and the approach NHEERL will take to address these uncertainties over the a five year time frame Included are specific goals and measures for evaluating progress Where feasible, the approaches involve cross divisional collaboration to maximize resources and expertise in solving the problem This process was initiated in 1999 to focus NHEERL's research program in Goal 2 Aquatic Stressors and Goal 8 3 Endocrine Disruptors It is now being expanded to include NHEERL's research supporting Goal 1 Air Toxics, Goal 2 Safe Drinking Water, Goal 4 Safe Communities, and Goal 8 2 Human Health Risk Assessment Research

WED's research is an integral component of NHEERL's research and implementation for Goal 2 Aquatic Stressors, and will be for the other plans as they are developed From the ORD and NHEERL level plans, WED has developed the following research program (Table 2)

Table 2 Alignment of WED Research Projects within New Branches with GPRA

Branch	**Goal 2**	**Goal 8**	**Goal 4**
Aquatic Monitoring and Bioassessment		EMAP/Biocriteria	
Ecosystem Characterization	Fresh Water Habitats	Terrestrial Habitats	
Pacific Coastal Ecology	Coastal Habitats	Coastal EMAP	
Terrestrial Ecology			Plant Effects-Pesticides

WED's Goal specific research projects are organized in this notebook by past research accomplishments and current research Under past research accomplishments, three research projects are described that are completed or nearing completion These projects were initiated several years ago in response to needs by EPA's Office of Air Quality Planning and Standards in developing standards for ozone, regional issues concerning the effects of global climate change, and implementation of the Northwest Forest Plan Since 1997, funding for these projects has been eliminated from the ORD research planning process and redirected to other high priority needs Although established before GPRA objectives were identified, these research areas correspond to Goals 1 Clean Air, 6 Global Change Research and 8 1 1 2 Ecological processes and modeling with relevance to Goals 2 and 6 as well The capabilities developed from these projects will be applied to the new research projects on freshwater and terrestrial habitats that are being developed These and projects on monitoring, coastal habitats and pesticide effects on nontarget plants are described under Current Research

IV. Resources

WED receives an annual allocation of both financial resources and FTEs (full time equivalents) Financial resources are categorized as operating expenses, travel, and research and development that includes "research support" or "above research support " Research support covers the research projects within the division These resources are used to fund technical support and other contracts or cooperatives that provide support to WED's research projects The above research support resources are targeted for a specific area of research such as Western EMAP or TIME/LTM research (see Goal 8 1 Monitoring research description) These funds are used to support EPA Regional, State and Tribal partners in this program

Resources-Budgetary

The annual budget covers allocations for such things as research support, operating expenses, repairs and improvements, and travel expenses Operating expense includes items such as the facilities support contract, utilities, landscaping, telephones, maintenance and supplies Research support covers computer support, library support, and contract technical support to the approved projects within the branches Repair and improvement funds and travel funds are allocated separately

Special initiatives, such as the EMAP Western Pilot or TIME/LTM, are allocated over and above the research support funds, and are only available for expenditure against the project for which they are allocated

Through fiscal year (FY) 02, which runs from October 1 to September 30, ORD allocates resources to the Laboratories by GPRA Goal In FY03, ORD will apply a comprehensive formula for the allocation of resources similar to that described for NHEERL below

In FY01 NHEERL began distributing resources for research support using a comprehensive formula that entails an analysis of federal and contract technical support to PI's, analytical services, information technology needs, facilities, safety and health, and general support The largest single element of research support funding for WED covers the technical support contract Operating expenses are allocated by an NHEERL methodology which is based on

FTEs, with some adjustment for historical expenditures. Travel is allocated by a formula which accounts for FTEs, grade level, and geographic distance.

Over the past few years, funding for WED programs has declined, and we project a further decline in FY02, as seen in Figure 2. Declines in WED's budget have primarily been due a redirection of research during the ORD planning process and a recent redistribution of funds within NHEERL.

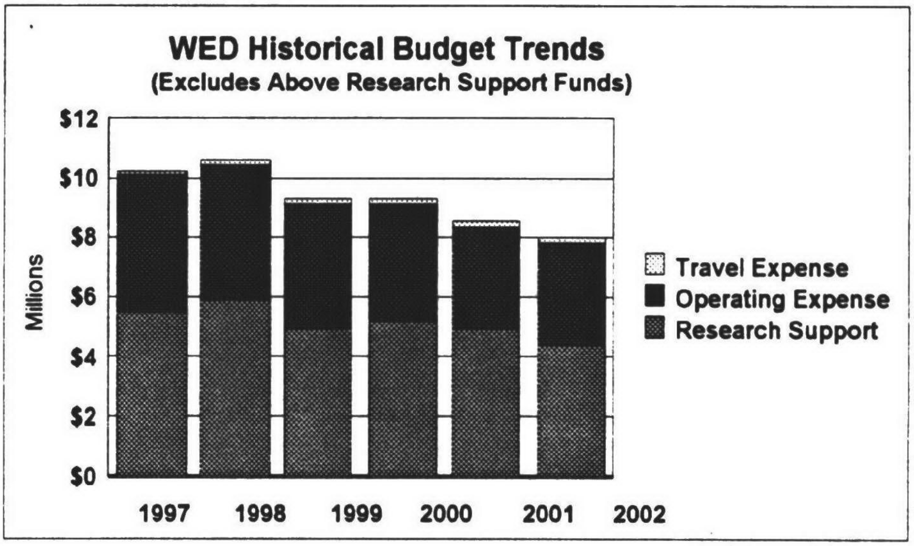
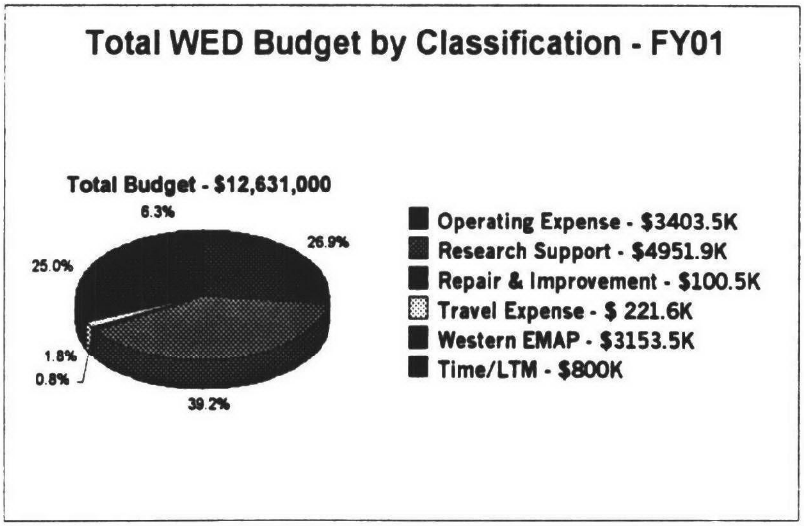


Figure 2. WED Fu
nding Trends

Figure 3. illustrates how this allocation of funds is distributed between types of expenditures.



WED Funding Process

Once funds have been allocated to WED, the senior division management distributes the funds to the research projects. Criteria for this allocation include the priority of the Agency research problem being addressed by WED's research project, the costs associated with federal Principal Investigators (PIs) and contract technical support as well as general support, travel and operating expenses. These allocations are by GPRA goal, objective and subobjective. Figure 4 illustrates WED's FY01 total budget allocation from NHEERL by GPRA goal area, including the above research support allocation for Western EMAP.

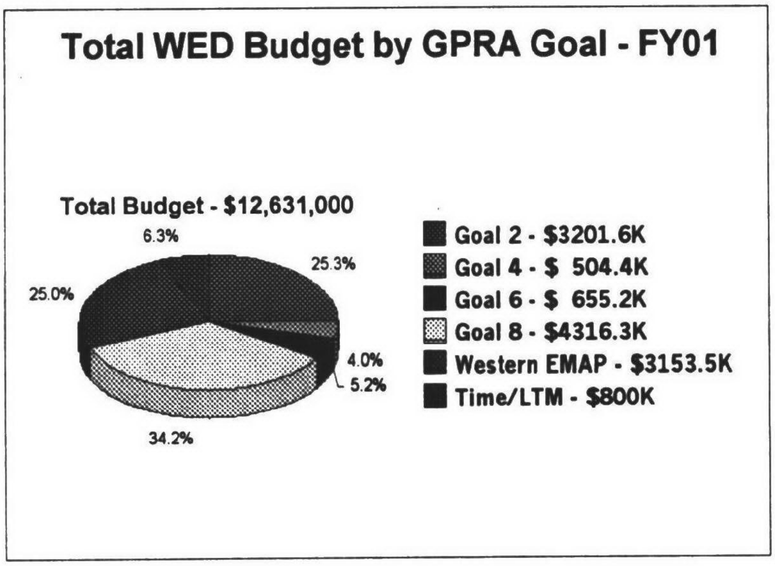


Figure 4.

Resources - FTE (Full Time Equivalency)

WED currently has a multidisciplinary workforce of 81 Federal personnel on board and an FTE ceiling of 78.3. Thus, we are over ceiling by approximately three FTE's. The federal workforce includes Principal Investigators, support research scientists, and administrative staff. In addition to this workforce there are 11 student volunteers, 14 guest workers, 10 cooperators, 4 National Research Council Post doctoral fellows, 5 non federal research associates, and 10 predoctoral trainees at the division.

WED also uses contract support for technical assistance. WED has the greatest amount of contract support within NHEERL. This is the result of past EPA policies promoting the use of contractors to assist EPA's workforce. The use of contractors in WED is gradually decreasing and is limited to technical assistance, with PI responsibilities being largely assumed by the Federal workforce. Presently, the contract workforce includes74 employees with Dynamac Corp; 9 with NAPCA Senior Environmental Employee program (administered by NAPCA); and 1 with QST that provide technical support, 31 employees with Computer Sciences Corporation for automated data processing, 3 with Native American Technology and 10 with NAPCA providing administrative assistance, and 4 employees with Associated Cleaning Services, 4 with Service Master, and 14 with TEI for facilities maintenance.

Federal employee's personnel compensation and benefits are paid from a pool of funds within NHEERL and are not allocated to WED in the budget process. What NHEERL allocates instead is an FTE ceiling. Figure 5 shows the distribution of our FY01 ceiling of 78.3 FTE's.

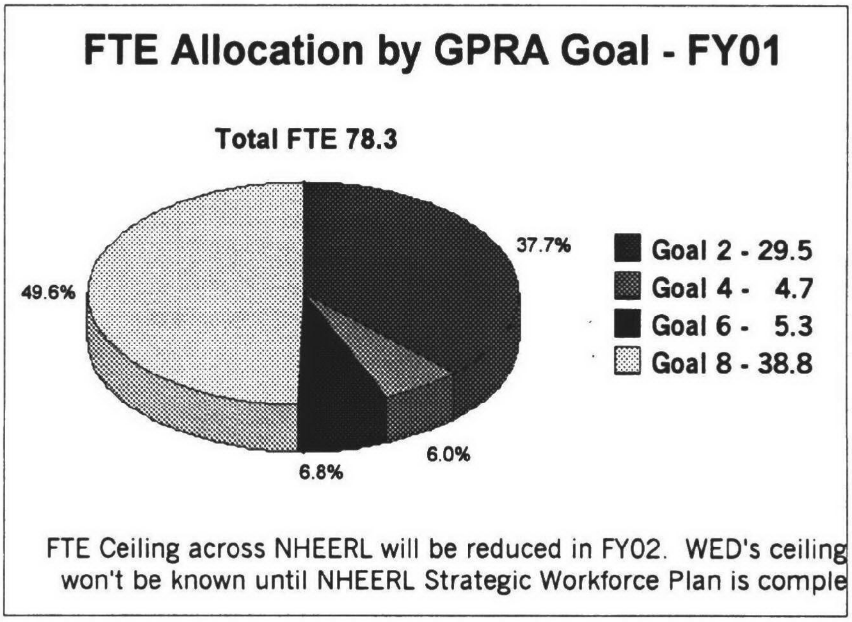


Figure 5.

WED has been very successful in attracting and retaining a well educated, productive and versatile workforce. The division has been successful in recognizing employees through awards and promotions as well as offering career development opportunities. Our location next to the Oregon State University campus along with several other federal agencies provide a rich research environment further making WED a desirable place to work. As such, WED's workforce is fairly stable, with little turnover. That may soon change since many of our employees are eligible or approaching eligibility for retirement. Of the 81 currently on board, 14 are now eligible to retire with a total of 28 eligible by 2005. Those eligible include research scientists, technicians and administrative personnel. WED is in the process of developing a long term strategic hiring plan with the goal of replacing critical functions as they occur, acquiring new scientific expertise (EPA

Post Doc or permanent FTE) to support priority research, and Federalizing the workforce. Figures 6-9 provide some additional background information concerning our workforce.

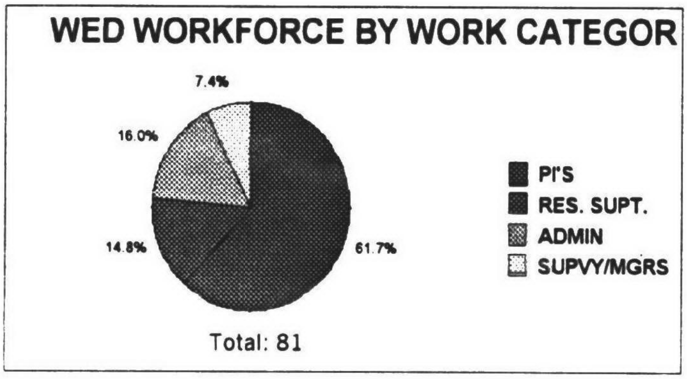


Figure 6.

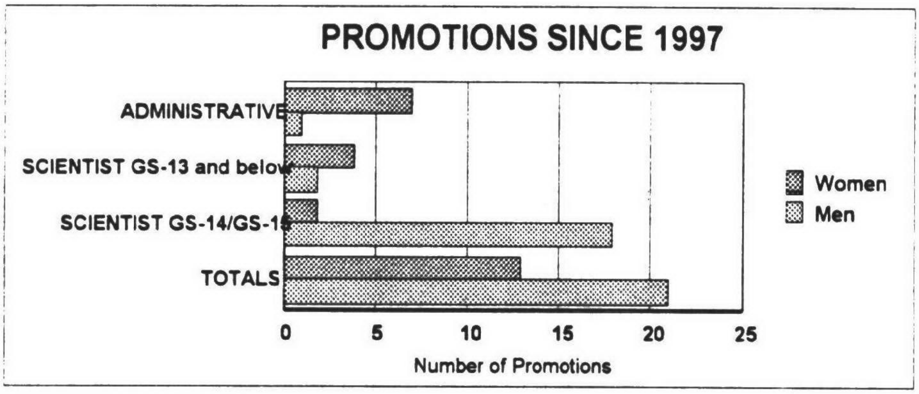


Figure 7.

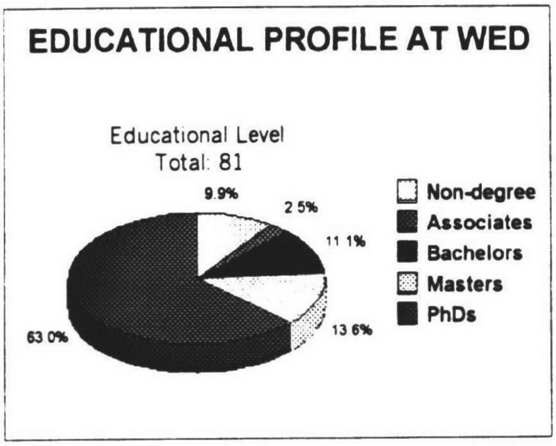


Figure 8.

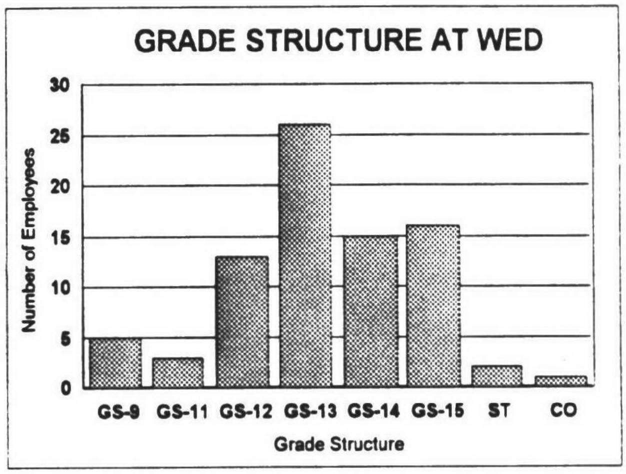


Figure 9.

Scientifically, the WED staff are well recognized among the EPA, national and international scientific communities. WED scientific staff have received numerous awards from EPA for outstanding scientific contributions to the organization as well as by awards received from scientific societies (see Addendum IV.A). WED scientific staff are regular participants at international meetings (Addendum IV.B), participate as members and officers in scientific societies (Addendum IV.C), and contribute to the scientific community at large serving as reviewers or on the editorial board of a large number of scientific journals (Addendum IV.D). In addition, many of WED's scientific staff hold adjunct or courtesy appointments at several universities (Addendum IV.E). A brief biosketch for each of our scientific staff can be found in Appendix B. A listing of WED publications since 1997 organized by goal is included in Appendix C.

V. Addendum

IV.A. WED Awards

EPA Awards

EPA Bronze Medal for Outstanding Contributions to Ecological Monitoring and Assessment
EPA Bronze Medal in Recognition of the EMAP Western Pilot Implementation
EPA Bronze Medal for Outstanding Achievement of the Wetlands Research Team for its Contributions to the Agency's Wetlands Protection Strategy and to the Science of Wetlands Ecology
EPA Bronze Medal for Assistance in Developing Standard Chronic Sediment Toxicity Test Methods
EPA Bronze Medal for Superior Technical Assistance to the Regions and Program Offices in the Area of Invasive Species
EPA Bronze Medal for Helping to Establish the Regional Science Council in Region 9 (San Francisco) and the National Regional Science Council
EPA Bronze Medal for Outstanding Work Involved in a Broad-based EPA Effort to Evaluate Tropospheric Ozone Control Policy in Light of Recent Research Findings
EPA Bronze Medal for Preparation of Air Quality Criteria Document for Photochemical Oxidants
EPA Bronze Medal for Designing, Executing, and Completing the National Crop Loss Assessment Research Program to determine the Biological Effects of Ozone on Major Crops Throughout the Nation
EPA Bronze Medal for Efforts in Environmental Compliance
EPA Scientific and Technological Achievement Award
1997 - Level I (1), Level II (1), Honorable Mention (3)
1998 - Level II (1), Level III (1), Honorable Mention (2)
1999 - Level II (1), Level III (1), Honorable Mention (1)

IV.A. WED Awards

Science Society Awards

American Society for Photogrammetry and Remote Sensing-ESRI Award for Best Scientific Paper in Geographic Information Systems
American Water Resources Association Award for Outstanding Achievement as Conference Program Planning Committee Chair
Distinguished Statistical Ecologist Award (International Association for Ecology)
Twentieth Century Distinguished Service Award in Statistics and Ecology (Ninth Lukacs Symposium)
Soil Science Society of America Journal Editors Citation for Excellence in Manuscript Review

Other Awards

Fulbright Scholarship
Honorarium Award, Innovative Science in Salmon Restoration
Honor Alumnus, College of Natural Resources, Colorado State University
U S Public Health Service Commendation Medal and Meritorious Service Medal

IV.B. International Meetings Attended by WED Scientists

1997

US-Dutch International Symposium, Air Pollution in the 21st Century, The Netherlands
5th International Symposium on the Biosafety Results of Field Test of Genetically Modified Plants and Microorganisms", Braunschweig, Germany
25th Annual Aquatic Toxicity Workshop, Quebec City, Quebec, Canada

1998

VII International Congress of Ecology, Florence Italy
International Conference on Tropical Forests and Climate Change Status, Issues and Challenges, Manila, Philippines
International Conference on Assessing Ecological Integrity of Running Waters, Vienna, Austria
46th Annual Meeting, North American Benthological Society, Charlottetown, PEI, Canada
Colorado River Delta Workshop, Mexico
XXVII Congress of the International Limnological Society, Dublin, Ireland
Annual Meeting of Statistical Society of Canada, Sherbrooke, Ontario
North American Symposium, Toward a Unified Framework for Inventory and Monitoring Forest Ecosystem Resources, Guadalajara, Mexico
European Union and British Environment Agency Conference on Bridging the Gap, London, England
International Geosphere-Biosphere Science Meeting, Barcelona, Spain
Workshop on Dispute Resolution (Effects of Air Pollution on Vegetation), Taipei, Taiwan
International Symposium on Tropospheric Ozone in East Asia and Its Potential Impact on Vegetation, Tokyo, Japan
Second International Conference on Micorrhizae, Uppsala, Sweden
Applications of Stable Isotope Techniques to Ecological Studies Meeting, Saskatoon, Saskatchewan, Canada
International Council for the Exploration of the Sea Symposium - Marine Benthos Dynamics Environmental and Fisheries Impacts, Crete, Greece
14th Task Force of the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes, Zakopane, Poland

IV.B. International Meetings Attended by WED Scientists

1999

Research Colloquium, Univ of Northern British Columbia, Prince George, British Columbia
International Environmetrics Conference, Athens, Greece
International Symposium on Landscape Futures, Armidale, NSW, Australia
Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland
Terrestrial Observations Panel on Climate (TOPC), Birmingham, UK
Environmental Impacts of Atmospheric Reactive Substances, Identification of Exposure Hazards First International Symposium on Atmospheric Reactive Substances (ARS), Bayreuth, Germany
European Cooperation in Science and Technology (COST), Ljubljana, Slovenia
Second International Symposium, Dynamics of Physiological Processes in Woody Roots, Nancy France
International Symposium on Oxidants, Acidic Species and Forest Decline in East Asia, Nagoya, Japan
International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes, Oslo, Norway
Sixth Canadian Continuous-Flow Isotope Ratio Mass Spectrometry Workshop, Victoria, British Columbia, Canada
Endocrine Disruption in Invertebrates Workshop (SETAC), Noordwijkerhout, The Netherlands
International Conference on Tropical Forests and Climate Change Status, Issues, and Challenges, Manila, Philippines
Workshop on Trace Element Sampling and Analytical Procedures, Seoul, Korea
Research Collaboration on Global Climate issues, Ibarki, Japan
IMAGE 2 Integrated Assessment Model Advisory Board meeting, Bilthoven, The Netherlands
International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes, Milan, Italy
26th Annual Canadian Aquatic Toxicity Workshop, Edmonton, Alberta, Canada

IV.C. WED Membership in Professional Societies

American Association for the Advancement of Science
American Chemical Society
American Fisheries Society*
American Geophysical Union*
American Institute of Biological Sciences
American Institute of Fishery Research Biologists
American Phytopathological Society
American Quaternary Association
American Society of Agronomy
American Society of Mechanical Engineers
American Society for Microbiology
American Society of Photogrammetry and Remote Sensing
American Society of Plant Biology
American Society of Plant Physiologists
American Society of Limnology and Oceanography
American Statistical Association*
American Water Resources Association*
Association Internationale Pour L'Etude Des Argiles
Association of State Wetland Managers
Association of American Geographers
Biological Society of Washington
British Ecology Society
Clay Minerals Society
Crustacean Society
Ecological Society of America*
Estuarine and Coastal Sciences Association
Estuarine Research Federation
Geochemical Society
International Association for Ecology
International Association for Landscape Ecology
International Association for Vegetation Science
International Environmetrics Society*
International Limnological Society
International Society of Plant Pathology
International Soil Science Society
International Statistics Institute
International Tree Ring Society

IV.C. WED Membership in Professional

Japan Water Environment Society*
National Association of Marine Laboratories
North American Benthological Society
North American Lake Management Society*
Northern Association of Marine Invertebrate Taxonomists
Pacific Estuarine Research Society
Pacific Fishery Biologists
Rocky Mountain Biological Laboratory
Sigma Xi Research Society
Society of Environmental Toxicology and Chemistry
Society of Ecological Restoration
Society of Toxicology
Society of Wetland Scientists*
Soil Ecology Society
Soil Science Society of America
Southern California Association of Marine Invertebrate Taxonomists
Western Association of Marine Laboratories
Western Society of Naturalists

* Indicates WED scientists have leadership roles in these societies

IV.D. Journals for which WED Scientists are Members of Editorial Boards and/or Manuscript Reviewers

Agriculture
Agriculture Ecosystems and Environment
Agronomy Journal
American Journal of Botany
American Midland Naturalist
Annales Geophysicae
Annales des Sciences Forestiéres
Annals of Forest Science
Archives of Environmental Contamination and Toxicology
Arctic
Arctic and Alpine Research
Atmospheric Environment
Australasian Journal of Ecotoxicology

BioScience
Biogeochemistry
Biotropic
Bulletin of Environmental Contamination and Toxicology
Bulletin of Marine Science, Chemistry and Ecology
Bulletin of the Torrey Botanical Club

Canadian Journal of Botany
Canadian Journal of Fisheries and Aquatic Sciences
Canadian Journal of Forest Research
Caribbean Journal of Science
Climatic Change
Clinical Chemistry
Conservation Biology

Ecological Applications
Ecology
Ecology and Ecological Monographs
Ecoscience
Ecosystems and Environment
Ecotoxicology

IV.D. Journals (cont'd)

Environmental and Ecological Statistics
Environmental and Experimental Botany
Environmental Management
Environmental Monitoring and Assessment
Environmental Pollution
Environmental Science and Policy
Environmental Science and Technology
Environmental Toxicology and Chemistry
Environmetrics
Estuaries
Estuarine and Coastal Shelf Science

Fisheries
Fishery Bulletin
Forest Science
Freshwater Biology

Geochimica et Cosmochimica Acta
Global Biogeochemical Cycles
Global Change Biology
Global Ecology and Biogeography Letters

Health and Ecological Risk Assessment
Human and Ecological Risk Assessment

International Journal of Environmental Analytical Chemistry
International Journal of Geographical Information Systems
International Journal of Remote Sensing
International Union for Forestry Research Organizations
Iranian Journal of Science and Technology
Israel Journal of Science

Japanese Journal of Agricultural Meteorology
Journal of the Air and Waste Management Association
Journal of American Water Resources Association
Journal of Aquatic Ecosystem Stress and Recovery
Journal of Biogeography
Journal of Coastal Research

IV.D. Journals (cont'd)

Journal of Computing and Graphical Studies
Journal of Environmental Quality
Journal of Environmental Engineering
Journal of Environmental Science
Journal of Experimental Marine Biology and Ecology
Journal of Forestry
Journal of Herpetology
Journal of Hydrology
Journal of Hydrologic Engineering
Journal of Irrigation and Drainage Engineering
Journal of Phycology
Journal of Phytopathology
Journal of the International Limnological Society
Journal of the North American Benthological Society
Journal of Soil and Water Conservation
Journal of Sustainable Forestry
Journal of Tropical Forest Science
Journal of Vegetation Science

Lakes and Reservoirs Journal
Landscape Ecology
Limnology and Oceanography

Marine Biology
Marine Ecology Progress Series
Marine Environmental Research
Marine and Freshwater Research
Marine Pollution Bulletin
Microbial Ecology
Mitigation and Adaptation Strategies for Global Change
Molecular Ecology
Mycology
Mycorrhiza

Nature
Netherlands Journal of Sea Research
New Phytologist
Northwest Science

IV.D. Journals (cont'd)

Oecologia
Ophelia

Photochemistry and Photobiology
Physiologia Plantarum
Phytopathology
Plant Cell and Environment
Plant Disease
Plant Ecology
Plant Physiology
Plant and Soil
Proceedings of the National Academy of Sciences

Sarsia
Science
Soil Science Society of America Journal
Southwestern Naturalist
Structure and Function

Texas Journal of Science
The Quarterly Review of Biology
The Science of the Total Environment
Transactions of the American Fisheries Society
Transactions of the American Geophysical Union
Tree Physiology
Trees

Vegetation

Water, Air, and Soil Pollution
Water Resources Research
Wetlands

IV.E. U.S. EPA NHEERL WESTERN ECOLOGY DIVISION COURTESY/ADJUNCT PROFESSOR APPOINTMENTS

NAME	BRANCH	INSTITUTION	DEPARTMENT
Andersen, Chris	TPEB	OSU	Forest Science
Blair, Roger	IO	OSU	Forest Science
Boese, Bruce	PCEB	OSU	Environmental & Molecular Toxicology
Brooks, J Renee	TPEB	OSU University of South Florida	Forest Science Biology
Church, Robbins	REB	OSU	Geosciences
Compton Jana E	TPEB	OSU University of Rhode Island	Forest Science Natural Resources Science
DeWitt, Theodore H	PCEB	OSU OSU	Oceanic & Atmospheric Science Environmental & Molecular Toxicology
Gregg Jillian W	TPEB	OSU	Forest Sciences
Johnson Mark G	TPEB	OSU	Crop & Soil Science
Kaufmann Philip R	REB	OSU	Fisheries & Wildlife
Kentula, Mary	REB	OSU	Botany/Plant Pathology
Lackey Robert	IO	OSU	Fisheries/Wildlife Political Science
Landers, Dixon	REB	OSU	Fisheries/Wildlife
McFarlane, Craig	IO	OSU	Horticulture

NAME	BRANCH	INSTITUTION	DEPARTMENT
Olszyk, David	TPEB	OSU University of Portland	Crop and Soil Science Biology
Peterson, Spence	REB	University of Washington	Civil and Environmental Engineering
Power, Jim	PCEB	OSU LSU	Fisheries/Wildlife Oceanography & Coastal Systems
Rygiewicz, Paul	TPEB	OSU	Forest Science
Schumaker, Nathan	REB	OSU	Fisheries/Wildlife
Shirazi, Mostafa	REB	OSU	Mechanical Engineering
Sigleo, Anne	PCEB	OSU	Oceanic & Atmospheric Sciences
Solomon, Al	IO	U of O, OSU	Geography Forest Science
Tingey, David	IO	OSU	Botany/Plant Pathology
Van Sickle, John	REB	OSU	Statistics
Watrud, Lidia	TPEB	OSU	Botany/Plant Pathology
Wigington, Parker	REB	OSU	Forest Engineering
Young, David	PCEB	OSU	Oceanography and Atmospheric Sciences

TROPOSPHERIC OZONE RESEARCH

GOAL 1: CLEAN AIR This research supports the GPRA Objective to meet national clean air standards for sulfur dioxide, carbon monoxide, nitrogen dioxide, lead, ozone and particulate matter throughout the country by 2018 contained within the Agency's Clean Air Goal The first Subobjective under this Objective is to protect and improve air quality so that by 2012, air throughout the country meets the national standards for ozone ORD supports the ozone and other national ambient air quality standards (NAAQS) standards by providing methods, models, data and assessment criteria on the health and welfare risks associated with particulate matter, and other NAAQS alone and in combination, focusing on the exposures, mechanisms of injury, and components which affect public health and welfare

AGENCY PROBLEM:

The research program addressed the needs of EPA, and in particular, the Office of Air and the Office Air Quality Planning and Standards in establishing a secondary National Ambient Air Quality Standard for tropospheric ozone (oxidants) that protects public welfare (which includes vegetation, crops, forests, soils and ecosystems) from adverse effects In the CAA amendment of 1990, the administrator is directed to conduct cost-benefit analyses for the standards to protect forests and forested ecosystems from adverse effect This research program was designed to provide necessary scientific information to develop a rationale for standard setting for protection of ecological resources and in particular forests

SCIENCE QUESTIONS:

The program addressed the following questions (1) What is the nature of the effect of tropospheric ozone on crop species and forest tree species? (2) What is the extent and magnitude of the effect on crops and forests? and (3) What is a biologically meaningful index of ozone exposure for use as a secondary NAAQS protective of ecological resources?

APPROACH

WED's research addressed the unique experimental design requirements of risk assessment and setting a NAAQS, including (1) quantification of the biological response of tree species to changing ozone concentrations (exposure-response functions), (2) understanding, and quantifying if possible, the uncertainty in the exposure-response, including the interaction of multiple environmental factors with ozone exposure (e g drought, insect/pathogen infestations), genetics, and the role of age and size in trees, (3) the role of exposure dynamics, both temporal and seasonal, in determining a biologically-relevant exposure index for use as an air quality indicator in the NAAQS development process, (4) develop, apply, and validate process-based models that (a) incorporate the mechanistic effect of changing ozone air quality on tree growth (seedling, sapling and mature trees) alone and in combination with natural stresses, and (b) incorporate the output from the growth models into stand models to investigate long-term effects on forest community, and (5) develop means to characterize risk spatially and temporally for use in demonstrating the extent and magnitude of ozone impact on ecological resources The data needed to be of sufficient quality (e g , precise, accurate, policy-relevant) and scope (e g , range of scenarios, species, forest types, and time frames) to support a defense of the standards developed

In meeting these objectives, the program had to contend with two important issues of scale First, the breadth of interest was national in scale There is a wide range of forest tree species and forest ecosystems within the U S , and an estimation of the extent and magnitude of the effect of ozone was needed without the ability to test every species and forest type Second was the biological scale, or level of complexity, at which the study was conducted It is important to know the forest or ecosystem response, but the size and complexity of working with stands and ecosystems make quantitative assessments at this level impossible with our current knowledge and budgets Since the tree is the basic individual component of the forested ecosystem, this program chose to focus at the whole-tree level of biological complexity as an achievable first step The concerns of scale were addressed by conducting both 'extensive' and 'intensive' studies The "extensive" studies developed exposure-response functions for each of 13 species which addressed the need to have national coverage of species and forests At the same time "intensive studies" of 2 species (pine and aspen) focused on 1) process-model parameterization, and 2) the mechanistic basis of ozone effects, environmental interactions, the role of age and size, and the role of exposure dynamics The mechanistic allowed extension of the information in a defensible manner beyond the empirical data base for predicting the long-term effect on tree productivity

The simulation of ozone effects over time and different environments was critical to the cost-benefit assessments required in the Office of Air We developed a spatial integration of empirical response functions (seedlings) or model simulations (mature trees and stands) with climate, species extent, relevant environmental factors, and estimated ozone exposure using a Geographical Information System (GIS) This GIS-linked assessment tool was developed as an interactive means to predict potential magnitude and extent of impact of ozone on forest resources with changing changing climate and ozone, and changing control strategies for regulation of VOCs and NOx With improvement of the model components, the tool was used as a means to examine the interaction of multiple climate and environmental factors (e g ppt and N availability) in ozone response across the extent of the species, and was eventually linked to a stand-level model for predictions in species composition The approach is further discussed regarding future applications and development in Goal 8 descriptions in this booklet

TIMELINE:

Support of Goal 1 has encompassed both crop and forest research From 1978-1988 the research focused on crops From 1988-1999, the program focused on forests The program ended in 1999 Publications will continue from this program for at least the next 5 years

PRODUCTS

Major findings

- Effects of ozone on tree seedlings and mature trees occur at ambient concentrations in a number of areas in the U S , including Class 1 areas (National Parks)
- Impact of tropospheric ozone on tree seedlings is primarily on carbon and nitrogen acquisition and allocation in the tree, and this effect is species-dependent and modified by the temporal dynamics of exposure, and the environmental and climatic conditions at the time of exposure
- Episodic ozone events over a season are more damaging to plants than continuous daily exposure
- Competition impairs a plant's ability to withstand ozone impact
- Drought alters plant uptake of ozone and thus alters response to ozone
- The effect of ozone on nitrogen cycling in coniferous and deciduous species is significant and potentially a significant factor in retention of N in upland forests within watersheds
- The impact of ozone is cumulative over a season or multiple seasons The impact of very high peak hourly concentrations is not as important as the season-long total exposure and the time of year of the exposure relative to the tree's acquisition and storage of resources
- Parameterized TREGRO for 12 species of trees in the U S representing 5 different forest types for use in assessing current and future impact of ozone
- The issues of scale, i e seedling to mature trees, chamber to field, revealed more questions and uncertainty in quantification of effects
- The primary effects of ozone are most evident in root growth and the effects are carried over to the following growing season The effect on below-ground processes may in fact be the most important impact of ozone and has yet to be fully understood and quantified

How we helped the Agency

- Provided the scientific basis for need of a secondary NAAQS protective of forest resources and that the NAAQS should be at least a 1 yr Seasonal, cumulative concentration –weighted index, and not the current 1 hr peak concentration
- Provided an estimation of the current (1988-1995) potential extent and magnitude of the impact of ozone on forest resources in the U S

- Provided technical leadership to ORD/NCEA in preparation of the Oxidant and NOx Criteria Documents, critically reviewing the literature and authoring chapters
- Provided consultation and interpretation of relevant science for the Office of Air/OAQPS in preparation of the Staff Paper recommending proposed alterations in the secondary NAAQS for ozone based on biologically-meaningful indices of exposure
- Provided information to CASAC (Clean Air Science Advisory Board) regarding the uncertainty in estimating effects of ozone on forest resources resulting from issues of scale at which the experiments are conducted The CASAC highlighted this lack of information as critical to setting regulatory policy

RESOURCES:

The program fluctuated from $2 8 million/year to 1 2 million/year from 1978-1997 The program was reduced to $400K in 1998 and finally zero in 1999 Historically, 12-15 FTE were assigned to the program each year Resources were redirected during the FY99 research planning process to other high priority research within Goal 1

LINKAGES TO OTHER GOALS AND PLANNED PROJECTS:

This work provides input in 3 areas of current and future research at WED (1) Understanding basic ecophysiological processes in plants with emphasis on linking the above and belowground processes with changing size/age and complexity, (2) Parameterization and testing of individual process-based tree growth model (e g TREGRO) and identification of critical processes in scaling from seedlings to trees for model simulation, and (3) Utilization of GIS as a tool in spatial and temporal distribution of stressor effects across landscapes All of these experiences contribute to planned research in scaling the impact of stressors on vegetation into changes in habitat quality for wildlife Examples include

- Experience developed in plant exposure-response with ozone will contribute to approaches for studies on non-target plant studies for pesticide effects research in Goal 4
- Ecophysiological studies with ozone have linked critical physiological processes with growth responses and demonstrated the close interactions with climate, community structure, carbon, nutrient and water cycling above- and belowground These studies with above and belowground systems will contribute to work planned in Goals 2,4, & 8
- Experience from this program has led to scaling stress response from seedlings to mature individuals, individuals to stands, and stands to landscapes and watersheds These studies will contribute to the planned research in Goal 8
- Contributed to development of parameter sets for TREGRO and ZELIG, models that will play crucial roles in determining impact on wildlife habitat described in Goal 8

- Understanding of shifts in vegetation composition within communities of sensitive and non-sensitive species will contribute to the community modeling for determination of vegetative structure that will be used to model wildlife habitat alteration in Goal 8 and 4
- GIS-linked assessment tool developed in this program is being used and will be expanded in scaling studies planned in Goal 8 for predicting habitat changes using GEM and the hierarchical model for determining uncertainty

Abstracts - Goal 1

Blue wild-rye grass competition increases the effect of ozone on pine seedlings

Christian P Anderson, William E Hogsett, Milton Plocher , Kent Rodecap, and E Henry Lee

Individual ponderosa pine (Pinus ponderosa Dougl ex Laws) seedlings were grown in mesocosms with three levels of blue wild-rye grass (Elymus glaucus Buckl) at densities equivalent to 0, 32, or 88 plants m-2) to determine if the presence of a natural competitor altered ponderosa pine seedling response to ozone After three years of ozone exposure, grass presence significantly reduced total pine mass by nearly 50%, while ozone alone had no significant effect on pine growth The combination of ozone and grass further reduced needle, stem and branch dry weights significantly below that induced by grass competition alone Root-shoot ratios increased with the combination of grass and ozone Grass competition significantly reduced soluble sugar concentrations in all pine tissue components examined Starch concentrations were highly variable but non-significant among treatments Ozone significantly reduced soluble sugar concentrations in fine roots and stems In the absence of grass, ozone-treated seedlings tended to have higher tissue N concentrations than controls In the presence of grass, N concentration increased without ozone and decreased with ozone, resulting in a significant interaction between these two stresses in one and two year old foliage C/N ratios in foliage decreased in response to grass due to increased N concentration (no change in C) An opposite response was observed in ozone treated plots due to decreased N concentrations Ozone-exposed seedlings appear to either be unable to take up or alternatively to retain as much nitrogen when growing in the presence of grass The results suggest that ponderosa pine seedlings are more susceptible to ozone when growing with other plant species
Characterizing Risk to Forest Tree Species of Tropospheric Ozone

WE Hogsett, J A Laurence, J.A Weber, E H Lee, A. Herstrom, and C.P. Andersen

The extent and magnitude of the effects of tropospheric ozone on forest tree species is dependent on the variation in ozone exposure and in the environmental and climate factors influencing response to ozone across the species' range A Geographical Information System (GIS) was used to integrate certain spatial and temporal data, including output from a process-based single tree growth model (TREGRO) simulating growth over 3 years The GIS aggregates factors considered important in ozone effects on trees, including (1) estimated ozone exposures over forested regions, (2) species' distribution, density and total above-ground biomass, (3) exposure-response functions describing ozone effects on individual species' growth, and (4) spatially distributed climate, environmental, and exposure influences on species' response to ozone The exposure-response functions are generated from output from TREGRO parameterized for each species as a 30 year old individual The potential range of the species' response to ozone is obtained using 3 climate sites for each species across its range Possible environmental interactions influencing the species's response to ozone were represented by using site-specific ozone exposure and water or nitrogen availability scenarios in the model The model-simulated growth response is integrated in the GIS with Forest Inventory Data (FIA) to generate estimations of productivity as a function of ozone and water or nitrogen availability across a range of climate sites within the species' distribution When compared with earlier emperically-derived and spatially-distributed exposure response functions of tree seedlings, the simulated 30 yr-old trees were apparently less sensitive to ozone, but demonstrated clear interaction in response to altered precipiation or nitrogen availablity with ozone The interactive nature of GIS provides a tool to explore consequences of the range of climate conditions across a species' distribution, forest management practices, changing ozone precursors, regulatory control strategies, and other factors influencing the spatial distribution of ozone over time as more information becomes available

Elevated CO_2 and Temperature Alter the Response of *Pinus ponderosa* to Ozone: A Simulation Analysis

David T Tingey, John Laurence, James A Weber, Joseph Greene, William E Hogsett, Sandra Brown and E Henry Lee

We investigated the potential impact of projected future temperature and CO_2 concentrations in combination with tropospheric O_3 on the annual biomass increment of *Pinus ponderosa* Doug ex Laws TREGRO, a process-based whole-tree growth model in which trees experienced a seasonal drought, was used to study the interactions of CO_2, temperature and O_3 on tree growth along a latitudinal gradient in California, Oregon, and Washington, USA The annual biomass increment increased proportional to CO_2 concentration, however, the magnitude varied among sites Increasing air temperature (+1 3 °C) increased growth at most sites Elevated CO_2 increased the temperature optimum for growth at four sites and decreased it at two sites The annual biomass increment decreased with increasing O_3 exposure The differences in O_3 effects among sites were primarily controlled by differences in precipitation Although increasing CO_2 can reduce the O_3 impact, it does not eliminate the impact of O_3 Elevated CO_2 would enhance tree growth more if O_3 exposures were reduced, especially in the more polluted sites The greatest benefit for tree growth would come from reducing O_3 exposures in the most polluted sites, but, we must also consider locations that have high inherent O_3 sensitivity because of their mesic conditions Limiting the increase of O_3 levels in those areas will also increase tree growth

GLOBAL CLIMATE CHANGE RESEARCH

GOAL 6: REDUCING GLOBAL AND TRANSBOUNDARY ENVIRONMENTAL RISKS. This research supports the GPRA Objective of reducing US greenhouse gas emissions to levels consistent with international commitments agreed upon under the Framework Convention on Climate Change Within this objective, this research specifically supports sub-objective 2 3 which calls for ORD to assess ecological and human health vulnerability to climate-induced stressors at the regional scale, and assess adaptation strategies All climate-induced changes are assessed in the context of multiple stressors, that is, climate change will be viewed as one of many stressors, including non-climate-related stressors For example, the synergistic effects of climate change and tropospheric ozone exposure were assessed

AGENCY PROBLEM

ORD provides research and assessment support to the US Global Change Research Program One of the four focus areas for assessment is ecosystems, and has included forested ecosystems for both effects and mitigation activities To accomplish these assessment, EPA needs quantification of ecosystem processes and change with climate, as well as tools to conduct future scenario assessments

SCIENCE QUESTION

The research at WED addressed the question of what are the qualitative and quantitative effects of elevated CO_2, temperature and ozone on biogeochemical processes in forests and the associated ecosystem

APPROACH:

WED conducted investigations in both controlled environments and across a transect in the Pacific Northwest, including coastal and cascade Douglas-fir/Hemlock forests and western juniper forests

Two separate experiments in controlled environments to quantify effects on processes were conducted to address the question One experiment evaluated the effects of elevated CO_2 and temperature on a Douglas-fir ecosystem to answer the following Agency questions

- What are the effects of elevated CO_2 and climate change on the growth and productivity of forest trees?
- Will elevated CO_2 and climate change alter the carbon sequestration potential of forest trees?
- What is the magnitude of elevated CO_2 and climate change impacts on forest trees and will the impacts be widely distributed?

The second experiment evaluated the effects of elevated CO_2 and O_3 on a Ponderosa pine ecosystem to answer the following Agency questions

- What are the effects elevated CO_2 on C and N cycling and the productivity of Ponderosa pine?
- Will elevated O_3 decreased on C and N cycling and the productivity of Ponderosa pine?
- Will elevated CO_2 eliminate the negative effects of O_3 on C and N cycling rates and plant productivity?

In both studies, we used a combination of experimental and modeling studies to determine the effects on ecosystem processes (plant and soil) The experimental studies used sun-lit controlled-environment chambers in which the climatic and edaphic factors were monitored and controlled so that long-term (multi-year) experiments could be conducted The goal of the studies was to measure the C and N inputs, pools, fluxes, and losses from the model ecosystems to develop C and N budgets The controlled studies also provided data for model parameterization, development of specific model inputs and permitted the testing of model hypotheses The experiments were planned to support the application of whole plant (TREGRO) and biogeochemical models (Marine Biological Laboratory-General Ecosystem Model or GEM) The models provided a consistent analytical framework and provided a conceptual basis for (1) integrating diverse measures into a self-consistent framework, (2) relating stressors to probable effects, and (3) making meaningful extrapolations across scales of time, space, and biological organization

TIMELINE:

This work began in 1990 and has continued through 2000 Resources supporting Global Change research within NHEERL have been redirected as part of the ORD Research Planning process to other priority research areas The products of this work, however, will continue to be published for at least the next 5 years

PRODUCTS

Major Findings

- Elevated temperature decreased winter chilling and reduced tree growth

- Reduced winter chilling made the needles less cold tolerant (which could result in winter injury from sudden drops in temperature), reduced bud break, and inhibited stem and branch elongation

- High temperatures in the summer caused abnormal bud morphology and inhibited a second flush of growth

- Elevated CO_2 had no effect on frost tolerance, while elevated temperature decreased frost tolerance

- Elevated temperature increased leaf nitrogen and photosynthetic rates during the winter but the increases assimilation was off set by the adverse effects of elevated temperature, resulting in no net significant difference in seedling biomass due to elevated temperature

- Elevated CO_2 did not alter plant growth or C allocation It was inferred that the lack of CO_2 response was the consequence of low soil N, which is typical of large areas of PNW forests

- Subsequent modeling studies confirmed that low soil N limited the response of Douglas-fir to elevated CO_2 In addition, Douglas-fir may be less responsive to elevated CO2 than other tree species, possibly due down-regulation of photosynthesis with elevated CO2, especially at low soil N

- Elevated CO_2 lower foliar N and increased sugar concentrations and also increased the water use efficiency of the seedlings

- Elevated CO_2 increased the photosynthetic rates of Ponderosa pine and the growth of Ponderosa pine was increased even though soil N was low

- Soil respiration increased as root biomass increased, and increased with elevated CO_2

- Elevated O_3 decreased both the shoot and root growth of Ponderosa pine
- Parameterized TREGRO model for Douglas-fir so it can be used to extrapolate the results from controlled chamber studies

- Collected the necessary biological, edaphic and climatalogical data necessary to parameterize and test the GEM biogeochemistry model

How we helped the Agency

- Provided biological data to support the Agency Climate Change Assessment activities

- Provided a parameterized plant simulation model for use in climate change assessments

- Provided a parameterized biogeochemical model for use in climate change assessments

RESOURCES:

The budget for this activity has fluctuated from a high of 5 million/year to approximately 500K, and FTE has gone from 15 in 1990 to 6 in FY01 In 2002, there will be 1 FTE and no financial resources for this activity

LINKAGES TO OTHER GOALS & FUTURE PROJECTS:

This work provides input in two areas for current and future research programs at WED (1) Understanding of basic ecosystem processes and biogeochemistry of terrestrial systems and (2) Parameterization and testing of the biogeochemical model GEM Both contribute to an analytical framework for analyzing the data from the global change and interacting stress studies, and GEM provides important linkages to other WED projects in support of Goal 2 and 8

1 GEM supports the terrestrial scaling activities pursued in Goal 8 by providing tool for integrating data on C and N pools and fluxes and also for providing input to the hierarchical model

2 GEM will be used to provide stressor exposure-response relations and provide important ecosystem mechanisms and processes as input to the habitat model development pursued in Goal 8

3 GEM will be applied to the Salmon River study to analyze and project the fluxes of C and N through the watershed as pursued in Goal 2

Abstracts for Goal 6

Effects of Carbon Dioxide and Increased Temperature on Forested Ecosystems

M G Johnson, D M Olszyk, P T Rygiewicz, D.T Tingey, D L Phillips, R. Shimabuku, R.S Waschmann, L Watrud, and C. Wise

Rising atmospheric CO_2 and other greenhouse gases may lead to altered climates, that may dramatically affect the structure and function of forests Motivated by the uncertainties associated with these potential effects, the Western Ecology Division developed a dynamic research facility that mimics natural environmental variation in long-term exposure experiments Understanding above – and belowground physical and biological processes is crucial for evaluating ecosystem response to climate change and developing models to make projections of these effects at various scales To investigate the potential effects climate change on northwest forests we conducted a four-year study on Douglas-fir seedlings growing in a reconstructed native forest in our outdoor, sun-lit, controlled environment chambers (Terracosms) The treatments were CO_2 (ambient CO_2 and ambient CO_2 + 200 µmol/mol) and temperature (ambient and ambient + 4°C) We made periodic measures of tree growth, photosynthesis and morphology To make non-destructive *in situ* measurements throughout the study we instrumented each soil compartment with thermistors for measuring soil temperature, TDR (time-domain-reflectometry) probes for measuring soil moisture, tension lysimeters for collecting soil solutions, gas wells for sampling soil air, and minirhizotron tubes for observing roots processes We measured soil CO_2 efflux and cored the soil two times a year to obtain root and soil samples We followed a wet winter and dry summer moisture regimen, typical of northwest forests Soil temperature followed air temperature and captured natural daily and seasonal variations There were 8 primary tasks in this project each with specific objectives and hypotheses 1) Shoot carbon and water fluxes, 2) Shoot growth and phenology, 3) System nutrients, 4) System water, 5) Litter layer, 6) Root growth and phenology, 7) Soil biology, and 8) Soil organic matter Data are being used in a physiological process-based tree growth model (TREGRO) to assess effects of climate change on trees The results of this research provide needed information on the effects of climate change

Effects of Carbon Dioxide and Tropospheric Ozone on Forested Ecosystems

Dave Olszyk, Renee Brooks, Jillian Gregg, Mark Johnson, Bob McKane, Don Phillips, Dave Tingey, and Lidia Watrud

The combined effects of two important atmospheric pollutants, CO_2 and tropospheric O_3, on C and N cycling in forested ecosystems were studied in a multi-year experiment using a ponderosa pine (Pinus ponderosa Laws)system The experiment was conducted from April, 1998 through March, 2001, in outdoor, sun-lit chambers where linked atmosphere/plant/litter/and soil ecological processes could be studied in detail The CO_2 treatments were ambient and elevated (ambient + 280 ppm) O_3 treatments were elevated (SUM06 = 10 ppm $\sum$ hr in 1998 and 1999, and 26 ppm

$\sum$ hr in 2000), and a low control level (SUM 06 <0 1 ppm $\sum$ hr) Significant individual and interactive effects occurred with elevated CO_2 and elevated O_3 affecting many of the components of the system For example, elevated CO_2 increased photosynthesis, soil respiration and overall shoot productivity as indicated by stem diameter Elevated O_3 tended to reduce the stimulatory effect of elevated CO_2 on stem diameter, especially early in the study, but may increase the stimulatory effect of elevated CO_2 on root biomass, suggesting CO_2 x O_3 interactions on plant growth Thus, the combined effects of future elevations in CO_2 and O_3 on ecosytems can not be estimated solely by adding the responses from the individual stresses The data from this experiment will be used to parameterize models (the single-tree TREGRO model, and ecosystem C and N cycling General Ecosystem Model)on tree and ecosystem scales in order to better understand and predict the impacts of CO_2 and tropospheric O_3 at larger biological and ecological scales

Assessment of climate change on fine roots of Douglas-fir

Mark G Johnson, Donald L Phillips, David T Tingey, and Paul T. Rygiewicz

We used periodic root observations, collected over 4 years with a minirhizotron camera system, to investigate the effects of elevated CO_2 and temperature on the production and turnover of Douglas-fir fine roots ($\leq$ 2 mm diameter) in a climate-controlled mesocosm facility Specific root length (m/g), obtained from roots collected in soil cores, was used to convert root length data obtained with minirhizotrons to biomass density (g/m^2) More than 138,000 root images were collected and used in this analysis Elevated temperature resulted in higher standing crop root biomass in year 1 For ambient CO_2, elevated temperature caused higher root production and biomass in year 2, and higher turnover in years 2 and 3 There were no significant CO_2 effects on standing crop biomass, production, or turnover, in line with the general lack of CO_2 effects on aboveground growth in this experiment However, elevated CO_2 appears to alter fine root distribution by increasing the amount of fine roots deeper in the soil Limitations of nitrogen availability likely limited the response of Douglas-fir to elevated CO_2 in this experiment

PACIFIC NORTHWEST (PNW) RESEARCH PROGRAM
WILLAMETTE BASIN ALTERNATIVE FUTURES ANALYSIS

GOAL: The PNW Research Program was initiated prior to GPRA and development of ORD's current research structure The research is relevant, however, to GPRA Goals 2 Clean Water, 6 Global Change, and 8 Sound Science - Modeling

AGENCY PROBLEM:

The PNW Research Program (Baker et al 1995, 1997) was funded as part of EPA's follow-up to the President's Northwest Forest Plan (NFP) The Agency committed to 5 years of "ecological risk assessment research" specifically in support of community-based decision making, under the interagency Community Assistance Memorandum of Understanding To complement research conducted by other agencies, EPA focused on basin-scale analyses (as defined in the NFP's 4-scale hierarchy of decision-making) in areas with multiple land uses and multiple ownerships The research program involved 34 investigators at 10 different institutions, called collectively the Pacific Northwest Ecosystem Research Consortium (http //www orsst edu/dept/pnw-erc) The PNW program was externally peer reviewed in 1995, 1996, and 1997, and received positive comments and strong support in each review, including the following quote from the 1997 review

> *"The research consortium involving USEPA, three major universities, and several federal agencies organized through the Corvallis Laboratory is the most significant opportunity to advance ecosystem risk assessment at the watershed to regional scale This research team is in the position to couple GIS maps with ecological processes which will provide a scientific basis for formulating public policy."*

Community-based environmental protection involves working collaboratively with State, tribal, and local governments, community groups, private landowners, and other interested parties to develop integrated management strategies tailored to the problems and conditions in a given geographic area It represents an alternative to EPA's classical one-size-fits-all regulatory approach to environmental protection The emphasis is on places, rather than specific stressors, and on comprehensive management strategies not constrained by the specific legislative mandates of EPA or any other individual organization EPA's Ecosystem Protection Workgroup identified two primary roles for the Agency within this collaborative process (1) facilitator and integrator – across different agencies, public and private lands, and different ecosystem types and (2) technical support and scientific information The PNW Research Program contributed to the latter

Large-scale landscape change resulting from human use of land and water represents one of the most profound threats to ecosystem sustainability and biodiversity (National Research Council 1993, Vitousek 1994, Dale et al 2000, Naiman and Turner 2000, Postel 2000) Today's policy choices and individual actions regarding land and water use will shape landscapes for many years to come Thus, understanding the likely consequences of these policies and actions is fundamental to informed decision making While the effect of any individual action or policy may be relatively small, it must be viewed within the broader perspective of the combined effects of multiple decisions made across different land and water uses (forestry, agricultural, urban), ownerships (private, state, federal), and political jurisdictions (city, county, state) The goal of the PNW Research Program was to evaluate and communicate the combined effects of land and water use policies over relatively large geographic areas in a manner that effectively informs the community-based decision-making process

SCIENCE QUESTIONS:

The central, integrating effort within the PNW Research Program was the Willamette Basin Alternative Futures Analysis, a multidisciplinary, multi-investigator evaluation of past and possible future landscape changes in the basin, and associated environmental effects We addressed four basic questions

1 How have people altered the land, water, and biotic resources of the Willamette Basin over the past 150 years since pre-EuroAmerican settlement?

2 How might human activities alter the basin's landscape over the next 50 years, considering a range of plausible management and policy options?

3 What are the expected environmental consequences of these long-term landscape changes?

4 What types of management actions, in what geographic areas or types of ecosystems, are likely to have the greatest effect?

APPROACH:

Study Area Selection: The States of Washington and Oregon were asked to identify priority areas, within the geographic scope of the NFP, for the proposed research Washington selected Willapa Bay and watershed in SW Washington Oregon selected the Willamette River Basin Because of funding reductions, work in Willapa Watershed had to be terminated in 1998/1999 Thus, this write-up describes only research within the Willamette Basin

The Willamette Basin (30,000 km^2) encompasses 12% of the State of Oregon, but is home to 68% of Oregon's population and accounts for 31% of the timber harvested and 45% of the market value of agricultural production in the State The basin contains the richest native fish fauna in the Oregon as well as several species listed under the Endangered Species Act The number of people in the basin is expected to double in the next 50 years, placing tremendous demands on limited land and water resources, and creating major challenges for land and water use planning and management Recognizing the need for an integrated strategy for development, conservation, and restoration, Governor Kitzhaber initiated several basin-wide planning efforts, including the Willamette Valley Livability Forum (http //www wvlf org) and Willamette Restoration Initiative (http ///www oregonwri org) The Forum consists of basin citizens plus representatives of business and industry, non-profit organizations, educational institutions, and local, state, federal, and tribal governments Its charge is to create and promote a shared vision for the basin's future The Willamette Restoration Initiative (WRI) was established in 1998 as the Willamette component of the Oregon Plan for Salmon and Watersheds Its charge is to develop "a basin-wide strategy to protect and restore fish and wildlife habitat, increase populations of declining species, enhance water quality, and properly manage floodplain areas – all within the context of human habitation and continuing basin growth" (WRI 2001) The Forum served as the primary client for the PNW Research Program, although program products have also been heavily used by the Willamette Restoration Initiative

Trajectories of Landscape Change: The current landscape (circa 1990) was characterized at 30-m pixel resolution into 64 different land use/land cover classes using a combination of thematic mapper (TM) imagery and ancillary data sources, such as tax assessor parcel data, 1990 U S Census data, OR Department of Transportation digital layers, and USGS topographic quadrangle maps Seasonal changes evident from comparing five TM scenes taken between March and August 1992 helped to distinguish different types of agricultural land use

Land cover prior to EuroAmerican settlement was derived from historical reconstructions completed previously by The Nature Conservancy, U S Forest Service, and Oregon State University, based on General Land Office surveys in the valley 1851-1865 and somewhat later surveys of forest resources in upland portions of the basin Historical records were also used to quantify and map changes in Willamette River channel structure from 1850 to 1995

Using these maps of the historical and current landscape as background information, we then worked with stakeholders to design three alternative future landscapes (scenarios) for the basin The stakeholders defined explicit written assumptions regarding urban development, rural development, agriculture, forestry, surface water withdrawals, and dam management Consortium scientists then translated those assumptions into basin-wide maps of land use/land cover at 10-year intervals from 2000 to 2050, using spatially explicit algorithms and models of land transformations Draft maps were reviewed by the stakeholder group, and adjustments made as needed to better reflect stakeholder visions, in an interactive process until closure was reached The landscape scenarios were also reviewed twice by the full Forum

The Plan Trend 2050 scenario assumes that current policies and plans will be implemented exactly as written and current trends continue The Development 2050 scenario assumes current policies are relaxed and greater reliance on market-oriented approaches to land and water use The Conservation 2050 scenario places greater priority on ecosystem protection and restoration, although still reflecting a plausible balance between ecological, social, and economic considerations as defined by the stakeholders

The scenario development process is, itself, a tool for enhancing stakeholder understanding and communication A fundamental assumption of the approach is that the usefulness of the product increases if citizens decide what alternatives are most plausible Articulating an explicit "story" (set of assumptions) about how the future may unfold forces strongly held, but vaguely defined viewpoints into written specificity Significant and conflicting sets of values as to what the future *should be* are each given a fair test against what is possible, enabling progress on complex and partially understood problems to be made in spite of incomplete information and widely divergent opinions

We then evaluated the likely effects of these long-term landscape changes, from 1850 to 1990 to 2050, on four selected endpoints of concern

1 Willamette River – projected changes in river channel structure and streamside vegetation, and the implications of these changes for fish communities

2 Water Availability – projected changes in the demands for water for irrigation, municipal and industrial supplies, fish protection, and other uses, and the degree to which these demands can be satisfied by the finite water supply in the basin

3 Ecological Condition of Streams – projected changes in the habitat and biological communities (fish and benthic invertebrates) in all 2nd to 4th order streams in the basin

4 Terrestrial Wildlife – projected changes in the amount of habitat for amphibians, reptiles, birds, and mammals in the basin, and the abundance and distribution of selected wildlife species

The Willamette Basin Alternative Futures Analysis involved scientists at WED/EPA, EPA's National Center for Environmental Economics, Oregon State University (OSU), University of Oregon (UO), U S Forest Service, and ECONorthwest (a private consulting firm) The lead investigators were Joan Baker (WED), Dave Hulse (UO), and Stan Gregory (OSU) In addition to providing overall project coordination, WED's primary role was in evaluating the ecological effects of landscape change The contributions of individual WED scientists are described in the attached abstracts

TIMELINE:

The Willamette Alternative Futures Analysis was a 5-year effort 1997-2001 The project is essentially complete, except for publication of the final products WED plans no further work on the alternative futures approach nor research to support community-based decision-making Some of the methods developed as part of this project will, however, be adapted and expanded for other purposes, in other WED projects

PRODUCTS AND ACCOMPLISHMENTS:

Research on the effects of multiple stressors across large geographic areas, and to develop improved approaches for ecological risk assessment, are regularly identified as high priority research needs in external reviews of EPA's science (e g , SAB 1998, 2000, Noonan 1999) as well as in EPA's own internal research planning efforts (e g , EPA 1996) The PNW Program has successfully and creatively demonstrated one such approach to addressing these needs

All analyses are complete and final publications are in preparation Results from the alternative futures analysis will be submitted in fall 2001 as an Invited Feature in *Ecological Applications* An overview of the entire Willamette Basin study, designed for an informed layperson audience, will be published in book format by OSU Press (*Willamette River Basin Atlas. Trajectories of Landscape and Ecological Change*, Hulse et al, in review) Other publications completed and in preparation are cited in the attached abstracts and listed in the Citations Addendum Results from individual components of the project have been presented at national and scientific conferences dealing with the various disciplinary fields (landscape ecology, river ecology, hydrology, wildlife, fisheries, environmental statistics, etc) – many as invited presentations Several post-doctoral and Ph D students were supported by and contributed to this research

An important goal of the project was to inform community-based decision making in the Willamette Basin While we have no way to judge to what degree our results have or will influence the ultimate decisions, we do have evidence that they're being actively used as part of the debate Our results have been presented twice to the Willamette Valley Livability Forum (at their invitation), including a presentation and interactive poster session at a recent (4/26/01) basin-wide conference organized by the Forum, titled *Willamette Valley: Choices for the Future* We were one of three studies highlighted in a recent 6-page tabloid insert published in all newspapers in the basin in early April 2001 (*The Willamette Chronicle The Future is in Our Hands*) The other two studies, evaluating transportation futures and infrastructure costs of development, both used data and scenarios developed by the Consortium for the Alternative Futures Analysis The Conservation 2050 scenario, and associated ecological opportunities map, was used by the Willamette Restoration Initiative as a central organizing theme in its recently published *Restoring A River of Life: The Willamette Restoration Strategy* The Oregon Department of Environmental Quality has expressed interest in using both Consortium data layers and the future scenarios as part of their Total Maximum Daily Load analyses in the basin Efforts are underway to demonstrate how watershed councils can use the Conservation 2050 scenario and evaluation results to guide the design and prioritization of restoration and protection efforts

In a broader arena, several presentations on the alternative futures approach, as an organizing structure for scientific evaluations in support of community-based decision making, have been made to EPA's Office of Water and Regions With guidance from WED, EPA Region 5 funded an alternative futures analysis for the Fox River Watershed, Illinois

RESOURCES:

The Willamette Alternative Futures Analysis, and associated studies, involved 7 WED research scientists, 11 extramural senior researchers, two postdocs, several graduate students, and numerous support staff The total funding was approximately $9 5M

Effects on Wildlife Habitat Suitability and Biodiversity

Denis White, Patti Haggerty, Joan Baker, and Paul Adamus

Denis White (WED) led evaluation of the effects of the landscape scenarios on habitat suitability and biodiversity for amphibians, reptiles, birds, and mammals (White et al , in review) Wildlife experts assigned each of the 279 species in the basin to one or more of 34 habitat types (cross-referenced to the 64 standard land use/land cover classes), using a suitability rating of 0 to 10 that represented the relative preference of the species for breeding or feeding (separate evaluations) in that habitat These initial ratings were then modified by one or more of 50 adjacency rules that adjusted ratings up or down to reflect the importance of nearby features, such as water or houses, on habitat suitability Each species was also constrained within a specified geographic range, reflecting climatic or other physiographic limits to its distribution Habitat suitability outside this range was set to zero The final habitat suitability scores, for each species and each 30-m pixel, were then summed to assess changes over time (1850 to 2050) and among the future scenarios in the total amount of habitat (weighted by its suitability) for groups of species (e g , all amphibians, all species with conservation ranks of S1, S2, or S3) and the likely influence of these habitat changes on patterns of species richness in the basin

Effects on Wildlife Abundance and Distributions

Nathan Schumaker and Ted Ernst

Effects of the landscape scenarios on wildlife abundance and distribution were evaluated using a model developed for the project called PATCH (a Program to Assist in Tracking Critical Habitat, Schumaker 1998) PATCH simulates a wildlife population by following each individual's growth and survival, reproductive output, and movement These rates and behaviors are influenced by the quality, quantity, and patterns of habitat found in a landscape PATCH was designed for territorial, terrestrial species, and the data required to run it include estimates of habitat suitability, territory size, survival and reproductive rates, and movement ability Estimates of habitat suitability were derived from White et al (previous abstract) An extensive literature search was conducted to obtain the remaining parameter values PATCH was applied for 17 wildlife species for which complete data were available Model outputs include projections of where, and at what densities, wildlife species are likely to occur, for each scenario Results for the Willamette Basin will be presented in Schumaker et al (in prep) PATCH has also been applied in several other settings (Carroll et al 2001, Wilhere and Schumaker 2001, Rustigian et al , in review)

Effects on Stream Habitat and Biota

John Van Sickle, Joan Baker, Alan Herlihy, Stan Gregory, Peter Bayley, and Judy Li

Stream response variables included stream habitat area and volume, cutthroat trout habitat suitability and abundance, native fish richness, the fish Index of Biotic Integrity, EPT richness, and an index of benthic invertebrate composition developed specifically for Willamette Valley streams Empirical models were developed to predict each variable as a function of physiographic, land use/land cover, and streamflow driving variables, with the latter two sets of variables subject to change in the historical and future landscape scenarios Several different "areas of influence" and alternative approaches for expressing land use effects on streams were explored Models were developed and evaluated using sample data collected between 1993 and 1999 from about 150 streams in the basin The models were then applied to all 2nd to 4th order streams in the basin (4045 stream reaches, 6500 km) for each landscape scenario preEuroAmerican settlement, circa 1990, and three alternative futures Model uncertainties were incorporated into the final basin-wide projections using Monte Carlo simulation

Influence of Riparian Areas on Stream Condition in Agricultural Landscapes
Jim Wigington, Tom Moser, Steve Griffith, and John Van Sickle

Early on in the PNW Research Program, it became evident that relatively little was known about stream conditions and processes in agricultural landscapes in the Willamette Basin Most prior work dealt with upland, forested systems, to assess effects of timber harvest practices Thus, Jim Wigington (WED) led a field-based effort designed to expand both the database and understanding of streams in agricultural landscapes, in particular the influence of riparian buffers on stream condition Both intensive and extensive field studies were conducted Three stream sites were intensively monitored to assess hydrologic flowpaths, nutrient transformations, and sediment transport as water moved from agricultural fields, through riparian areas, and into streams (Griffith et al 1997) For the extensive evaluation, 23 streams in predominately agricultural landscapes were randomly selected along a gradient of woody riparian buffer vegetation Each stream was sampled for water chemistry, physical habitat, fish, and benthic invertebrates Land use/land cover was characterized in the entire upstream watershed as well as within riparian bands of varying width using color infrared aerial photographs with extensive groundtruthing Statistical analyses were used to quantify relationships between stream condition and various riparian area attributes (Schuft et al 1999, Moser et al 2000) These data, together with streams sampled by WED scientists involved in the Environmental Monitoring and Assessment Program (EMAP), provided the majority of stream samples used to generate the empirical stream models for the Alternative Futures Analysis (Van Sickle et al , previous abstract)

Ecological Functions of Off-Channel Habitats in the Willamette River

Dixon Landers, Steve Cline, Sam Fernald, Chip Andrus, Marilyn Erway, Hank Lavigne, Jim Wigington, and Bruce Dykaar

The Willamette River has lost 25% of its active channel habitat area and over 50% of its off-channel habitat over the last 150 years (Gregory et al 1998, in prep), due to direct channel manipulation and flow modifications The Development 2050 landscape scenario assumes that recent trends of channel simplification will continue The Conservation 2050 scenario assumes recovery of some channel complexity, consistent with current proposals for the Willamette Restoration Initiative and the Corps of Engineers' Willamette River Floodplain Restoration Project Little data existed, however, to confirm that increased habitat complexity would benefit the river ecosystem To fill this knowledge gap, Dixon Landers (WED) led a field-based study to evaluate the ecological significance of off-channel habitats in the river Sampling efforts focused on alcoves, connected to the river only at the downstream end during summer, because these areas provide habitat quite distinct from the main river and flowing side channels All alcoves were mapped along a 70-km river length A statistically representative set of 16 alcoves were sampled for water chemistry, streamside and aquatic vegetation, and fish communities (Landers et al , in prep , Andrus and Landers, in review, Cline and McAllister, in prep , also Dykaar and Wigington 2000) Fish communities were characterized in alcoves and nearby main river channels during both night and day in the summer, as well as during winter Radiotracking further documented use of off-channel habitats by adult suckers, in relation to fish bioenergetics (LaVigne et al , in review) Changes in river channel structure can also affect the amount of hyporheic flow through the porous gravel bars created by river channel meandering Dye tracer studies, detailed monitoring of river, alcove, and well water at 6 sites, coupled with solute transport modeling indicated that at summer low flow a volume of water equal to about 70% of the total river flow enters the hyporheic zone daily (Fernald et al 2000, 2001) Historically, when the river was more complex, hyporheic flows may have been 400% of current levels Water quality monitoring demonstrated significant decreases in water temperature and changes in nutrients during hyporheic flows through gravel bars

ADDENDUM

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Willamette Restoration Initiative 2001 Restoring a River of Life The Willamette Restoration Strategy Willamette Restoration Initiative, Salem, OR

AQUATIC STRESSORS RESEARCH

GOAL 2.2.3: CLEAN/SAFE WATER; CONSERVE AND ENHANCE NATION'S WATERS; ASSESS AQUATIC STRESSORS Development of methods, models and other tools to improve identification, effects, exposure, and assessment of aquatic stressors This research supports the GPRA Objective of both restoring and protecting watersheds by improving the assessment and management tools available to decision makers In addition, this research complements that conducted under GPRA Sub-objective 8 1 Ecosystem protection

AGENCY PROBLEM

The Clean Water Act provides a legislative mandate to EPA to maintain and restore the biological and chemical integrity of the Nation's waters Preservation of these aquatic resources requires the development of scientifically based ecological criteria protective of designated uses A failure to meet designated use caused by one or more stressors results in a Section 303d listing under the Clean Water Act, requiring that states establish total maximum daily loadings (TMDLs) to ameliorate the problem While there have been major advances in methods to evaluate the effects of point-source discharges to aquatic systems, significant uncertainties remain with respect to defining system responses to stressors such as excess nutrients, sediments and habitat alteration An improvement of the ability to model stressor-response relationships is critical to the establishment of ecological criteria protective of aquatic resources

Thriving populations of fish, shellfish, and wildlife are valued by the public, not only for commercial, recreational, and aesthetic reasons, but also as tangible surrogates of the overall condition of the environment Habitats essential to the well being of these valued species are rapidly being affected by many anthropogenic activities (e g land-use changes, hydrologic modification, climate change, altered biological diversity, introduction of nonnative species) Habitat alteration has been identified as a major causes of endangerment for species within the United States (Carroll *et al* 1996) Habitat alteration is a common cause for the failure of aquatic systems to meet designated uses as required by the Clean Water Act (CWA) Addressing failures to attain designated uses increasingly requires an integrated approach perhaps best provided by habitat-based criteria As required by the Endangered Species Act, EPA is increasingly being asked to participate in interagency species protection and restoration efforts where habitat issues play a key role Integrated rather than piece-meal approaches to environmental protection require that the importance of habitat on various spatial scales be quantified Because one of EPA's core ecological regulatory authorities is the CWA, the species endpoints for which habitat alteration is of greatest concern are aquatic species, particularly fish, shellfish and aquatic dependent wildlife

WED research to improve stressor-response models addresses two elements of GPRA Goal 2 ("Clean/Safe Water") 2-016 Develop stressor-response models for habitat alteration and biocriteria-effects, and 2-017 Develop stressor-response models for nutrients, eutrophication, and harmful algal blooms The principal clients for this research include the EPA Office of Water, the EPA Regional Offices, and state, tribal, and local governments

NHEERL is currently developing a framework to guide ecological effects research on aquatic stressors The ultimate goal of this Aquatic Stressors Framework is to guide the research needed to develop scientifically valid approaches for protecting and restoring the ecological integrity of aquatic ecosystems from the impacts of multiple aquatic stressors The immediate focus is to develop and improve assessment methodologies, diagnostic capabilities, and ecological criteria to guide management options for (1) protection and restoration and (2) remediation efforts to meet designated uses

The context for Aquatic Stressors research is the common management goal of protecting aquatic systems to prevent degradation of habitat, loss of ecosystem function, and reduced biodiversity To this end, environmental managers must be able to (1) assess the condition of an aquatic resource and determine the degree of impairment, (2) diagnose the causes of impairment, (3) forecast the effects of changes in stressor levels, and (4) develop and implement remediation and maintenance strategies The Aquatic Stressors Framework provides a process to develop the tools needed to meet the goal of effective management and protection of aquatic resources, particularly fish, shellfish and aquatic dependent wildlife species

Aquatic stressor research at WED is concentrated in two ecosystem types, estuaries and freshwater streams

SCIENCE QUESTIONS: - **Estuaries**:
Excessive nutrient loading has been identified as one of the principal anthropogenic stressors on coastal ecosystems Excessive nutrients may derive from point sources, but are increasingly a consequence of human activities in the surrounding watershed The elevated nutrient levels may alter the estuarine food web in many ways, causing the estuarine ecosystem to diverge from its designated use Submerged aquatic vegetation (SAV) is one important estuarine habitat, both as a primary producer and a source of food and shelter for other organisms SAV is known to respond negatively to augmented nutrient levels, and loss or alteration of SAV habitat may have important effects on other estuarine species SAV is also a potentially important indicator of integrated estuarine water quality and condition Other habitats defined by species which are strong ecological interactors, such as burrowing shrimp, have similar importance to the estuarine system both in terms of nutrient dynamics and direct influence on other species

Important scientific questions being addressed by WED in order to improve protective criteria are

1 How do excessive nutrients affect the food web structure of Pacific Northwest estuaries? How can such impacts best be modeled?

2 How do important estuarine habitats (SAV, burrowing shrimp) respond to stressors such as nutrients, sediments, and other forms of disturbance? How does habitat alteration affect species dependant on these habitats?

APPROACH: - <u>Estuaries</u>:
A principal goal of the estuarine eutrophication research is the development of an estuarine food-web model which can be used to study how the food web changes under different scenarios of nutrient loading Carbon is the principal descriptor of the biomass fluxes in the model, while nitrogen fluxes are also used in a supplementary role The eutrophication model will be developed using the inverse modeling approach Such an inverse model will yield a description of the food web where the sum of the squares of the carbon and nitrogen trophic flows among model compartments has been minimized, and this solution is considered the best representation of the food web under a given set of conditions The inverse modeling approach is used because it incorporates constraints when describing the system, such as requiring all of the flows to be positive or that assimilation efficiencies are less than a specified percentage

The development of the nutrients-food web model is supported by an extensive set of empirical observations in Yaquina Bay being collected by a team of WED investigators A wide variety of estuarine biota have been collected and analyzed for their stable isotopic ratios to assist in delineating trophic pathways in the model Physical measurements include continuous recordings of conductivity, temperature, salinity, and turbidity at various locations in the estuary using moored CTD's These data series are supplemented by more spatially extensive measurements of light and temperature recordings collected using inexpensive sensors In situ nitrate concentration monitors have been deployed at the Hatfield Marine Science Center dock and at an upriver freshwater location Sensor data are verified with extensive water "grab" samples that are routinely collected and sent to an outside laboratory for analysis Nutrient fluxes across the sediment-water interface using "peepers" and benthic chambers have been measured Outside experts will provide data to parameterize the inherent optical properties of the estuary water column for the model

It is understood that such data intensive efforts cannot practically be applied to every estuary Hence, an additional objective of the model development is to evaluate minimum data requirements, so that it can be efficiently applied to other estuaries

A principal objective of the SAV research is development of a numerical model for predicting changes in the biomass of the above- and below-ground components of *Zostera marina* standing stock under varying conditions of nutrient and sediment loading The seagrass model is coupled to a sediment diagenesis model developed to allow prediction of changes in seagrass biomass resulting from changes in deposition of organic matter to the sediments Current research includes description of SAV distribution and abundance in the Yaquina Bay estuary, including measurements of shoot abundance, above- and below-ground biomass, and estimates of gross and net primary production Population processes controlling burrowing shrimp are studied because these organisms occupy extensive areas of the tidal flats and may compete with seagrass for space The estuarine nutrients and eutrophication research links to the seagrass component by providing measurements of light availability, sediment geochemical characteristics, and sediment flux rates of nitrate and ammonium to support the SAV stress-response model

A second objective of SAV research is development of an ecosystem services model to evaluate effects of habitat alteration on the estuarine ecosystem Habitat surveys of multiple estuaries over multiple years are being used to verify the model To support the Goal 8 effort to use SAV distribution as an indicator of estuarine condition, research is characterizing the processes that determine SAV survival, particularly at the upper, intertidal margin of the seagrass beds

TIMELINE: - Estuaries:
The estuarine habitat project received initial peer review and initiated research in the spring of 1999 The project has now collected field data over three years The development of the Aquatic Stressors Framework will result in some redirection of research effort in the years 2002-2005 to better meet specific objectives of the Framework Many of the project research products (described below) have had substantial effort directed towards them, and initial products will appear over the time period 2002-2003

PRODUCTS: - Estuaries:
The intended products of the nutrients-food web research component are

1 Characterization of the Yaquina Bay estuary as the model estuary for a data-intensive application of the eutrophication model
2 Reduction and error analysis of the above model to evaluate minimum data requirements and model robustness for application to other estuaries
3 A user-friendly software application, associated documentation, and guidance to allow individuals from management or regulatory entities to enter realistic values for the model parameters so that they can prepare scenarios of nutrient pollution and abatement on an exploratory basis

The food web model product is a designated outcome of the NHEERL Aquatic Stressors Framework nutrients research section

The intended products of the SAV - habitat research component are

1 A review of potential limiting factors for SAV growth and survival
2 Development of an ecosystem services response model for SAV habitat in the PNW
3 Development of a seagrass (*Zostera marina*) stress-response model for PNW estuaries
4 Documentation of SAV extent and condition as a tool to assess status of PNW estuaries with respect to nutrient and other stressors (Also involves Goal 8 research)

The SAV review and SAV stress response model are designated outcomes of the NHEERL Aquatic Stressors Framework nutrients research section The SAV ecosystems services response model is a designated outcome of the NHEERL Aquatic Stressors Framework habitat alteration research section

The SAV - habitat research links the Goal 2 research areas of Nutrients and Habitat, and also is related to Goal 8 estuarine research SAV is an important endpoint for assessment of eutrophication impacts in estuaries (Goal 2 - Nutrients) As primary nursery and feeding grounds for many fish and invertebrates, alteration of SAV habitat will impact other estuarine species, potentially including some salmonids (Goal 2 - Habitats) Goal 8 research will develop the means to use SAV distribution as an indicator of estuarine condition

RESOURCES: - <u>Estuaries</u>:
The Estuarine Habitat project research is supported by an approximately 10 FTE equivalent effort Research funding consists of approximately $0 7M per year of research support funds from WED There is no above research support for this research area

SCIENCE QUESTIONS: - <u>Freshwater Streams</u>:
NHEERL has initiated a nationwide research program to quantitatively link alterations in key habitats to fish, shellfish, and wildlife endpoints because habitat alteration is such an important, pervasive stressor on valued aquatic resources The research involves all four ecological divisions of NHEERL and spans the coastal resources of the East, West, Gulf states, and the Upper Midwest The purpose of the research described in this plan is to provide the scientific basis to implement regulations and policies to protect fish, shellfish, and wildlife populations and the ecosystems upon which they depend An important component of this research focusing on the wild Pacific Salmon and other native fish of the Pacific Northwest This research is currently in the development stage, with implementation to begin in FY2002 Herein, we provide an overview of the approach being proposed for the study Additional information will be provided at the time of the peer review

Objectives

1 To evaluate and to quantify the influence of human activities at the landscape and watershed scales on native fish habitat and wild Pacific Salmon and native fish populations

2 To evaluate how habitat spatial structure and connectivity of habitat in stream networks and estuaries influence wild Pacific salmon and native fish populations

APPROACH: - **Freshwater Streams:**
Populations of salmon and other native fish species have been in sharp decline across the Pacific Northwest for the last century Salmon catch peaked in Willapa Bay, Washington by 1902, and on the Oregon Coast by 1911 (Durning, 1996) Although many aspects of aquatic habitat - fish population relationships have been studied, such as the relationship of woody debris to success of salmon populations, many critical knowledge gaps must be filled in order to provide a firm scientific basis for protection and restoration of salmon populations Relatively little attention has been focused on the relationships between landscape structure and fish assemblages, and landscape structure and aquatic habitat In the report, *From the Edge: Science to Support Restoration of Pacific Salmon*, the Committee on Environment and Natural Resources (CENR) indicated that habitat for salmonids and all native aquatic species, and hence their populations, are strongly influenced by watershed conditions at a landscape scale The accelerated growth of the human population in the Pacific Northwest insures that severe pressure on landscape use patterns will continue in the foreseeable future Thus, it is critical to develop modeling and decision support tools that incorporate land use change relative to habitat impacts on the extensive spatial scale Since habitats are also temporally dynamic, it is critical that these tools are able to incorporate temporal changes as well

Our research will focus on populations of wild Pacific salmon and native fish Many of the anadromous salmonid populations in the Pacific Northwest have declined to the point where populations are now listed under the Endangered Species Act Landscape change, water pollution, introduced predators, fishing, hydropower development, disadvantageous ocean conditions, and other factors have lead to the extinction or decline of many stocks (Bauer and Ralph 1999, CENR 2000)

Upland and Riparian Effects on In-stream and Coastal Wetland Condition We will use an integrated modeling/field study approach An existing model developed by National Marine Fisheries Service (NMFS) simulates coho salmon population dynamics based on in-stream habitat condition For this model in-stream habitat condition was determined through simple stream reach classification that does not reflect watershed land use – land cover conditions If, however, we are to be able to examine how upland management affects fish dynamics, then it is necessary to understand how in-stream habitat condition is influenced by the surrounding uplands and riparian areas Shading by riparian trees, woody debris supply, non-point source introduction of sediments and nutrients, and land slides are all examples of important upland processes that can affect in-stream habitat condition and which could be influenced by upland management actions Such information would also allow us to predict habitat condition — based on upland characteristics — at locations which have not been sampled Besides affecting habitat condition, upland factors can also influence fish mobility For example, warm water temperatures or landslides could reduce or completely prevent fish movement between stream reaches Another important upland/riparian issue associated with the restoration of Pacific salmon is the possible need for nutrient additions (*i e* , raw or processed salmon carcasses, and commercially produced organic or inorganic fertilizers) to headwaters (*e g* , watersheds, lakes, or streams) to compensate for the loss of marine derived nutrients previously supplied by healthy salmon populations

Determining the ecological effects of surrounding upland areas on in-stream condition is therefore a critical component of our research

Technical approaches to examining upland effects on in-stream condition could include field studies, empirical modeling and process modeling Empirical modeling approaches would develop correlations between upland independent variables and in-stream response variables Upland variables could be derived from GIS data sets, and could be used to represent the watershed as a whole or the riparian zone in particular Data for explanatory and response variables could be obtained through field sampling, other research projects (*e g* , EMAP) or agencies, or through the literature Process models would relate upland factors to in-stream condition based on specific processes Examples include a model that predicts in-stream suspended sediment concentration based on soil characteristics, slope, upstream load, *etc* , or a physical model that calculates water temperature based on shading by trees Other modeling approaches are also available We envision linking such models with a salmon population model to examine the influence of land use changes on salmon and fish populations

<u>Effects of Network Structure and Connectivity on Fish Movement</u> Because fish are mobile, they are not limited to nor exclusively influenced by the habitat quality of a single stream reach Rather, they move between reaches and may require different habitat conditions during different life stages The spatial distribution of habitat condition and the ability of fish to move between reaches are therefore important considerations For example, salmonids returning from the ocean attempt to reach the same stream reach in which they were spawned Any obstruction in the stream network, which forces them to expend more energy to return, could affect spawning success If a barrier completely prevented them from returning to a particular home reach, then the ability of strays to recolonize new habitat would depend on the spatial distribution of habitat near the home reach and the occurrence of other obstructions to movement Thus any effort aimed at examining watershed management effects on fish populations needs to consider the effect of the watershed on the spatial structure of the network (*e g* , the distribution of habitat condition) and on the level of connectivity between stream reaches

Our approach to examining the effects of network structure and connectivity will be to build a spatially explicit network data structure that includes habitat quality and connectivity attributes and which can be linked to specific biological response models Such a network structure could be used in a number of ways For example, it might be desirable to conduct simulations of several specific drainage networks, and to compare results between basins with high habitat quality and low habitat quality Alternatively, it might be desirable to examine the effect of certain watershed characteristics (*e g* , slope, catchment area, stream density) on fish dynamics by systematically varying those characteristics using synthetic landscapes

<u>Biological Response of Fish to Habitat and Stream Network</u> EPA has responsibilities under the Clean Water Act to restore and maintain the biological integrity of the Nation's waters Therefore, it is desirable to understand how activities aimed at managing salmon would affect other fish species, in particular, native fish To address these needs, field research and modeling

efforts will be developed to examine how management actions would affect dynamics of various fish groups This may include modeling at different levels of organization First, we would use species-level models to examine the biological response of particular species to watershed and network structure Models would be run separately for salmon and possibly a few other species that are representative of different life history strategies This will allow us to examine how salmon and fish with different habitat needs respond to a common set of management actions Secondly, the biological response modeling could also include exploratory assemblage-level modeling In this case the dynamic behavior being tracked is overall species richness, rather than abundance of a particular species This allows us to examine community-level response to management actions

The abstracts that follow further describe the above areas of research In addition, there is an abstract that discusses salmon restoration issues This is a focus for WED that complements this research project

TIMELINE: -Freshwater Streams:
In response to the development of the NHEERL Aquatic Stressors Framework, the freshwater habitat project began planning discussions in late 2000 and has continued these discussions in parallel with the finalization of the Aquatic Stressors Framework A detailed research implementation plan for freshwater streams research will be developed and peer reviewed upon the release of the Aquatic Stressors Framework in the fall of 2001

PRODUCTS: - Freshwater Streams
The intended products of the freshwater stream project are currently pending, awaiting the direction provided by the final release of the Aquatic Stressors Framework All research elements described above are components of the Landscape Scale Habitat Research element of the Aquatic Stressors Framework

RESOURCES: - Freshwater Streams:
The Freshwater Habitat project research is supported by an approximately 10 5 FTE equivalent effort Research funding consists currently of approximately $0 4M per year of research support funds from WED This funding level represents a transitional funding level during project development There is no above research support for this research area

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I Nutrient Effects - Food Webs

Food web stress response models

Peter Eldridge, Jim Kaldy, Scott Larned, Robert Ozretich, Anne Sigleo, and David Specht

Addition of excess nutrients into estuarine ecosystems typically results in major alterations in the cycling of carbon and nutrients through the components of the food web We are developing an estuarine food web model that will allow managers to identify critical food web flows where small changes in a component can cascade through the ecosystem and result in eutrophication, extinction of important habitats, or changes in ecosystem trophic structure To fully encompass population, community, and ecosystem processes, the model uses natural abundance of carbon (^{13}C) and nitrogen (^{15}N) stable isotopes to examine the relationships between organisms, habitats, and the estuary ecosystem The model also incorporates other available data concerning organism biomass production and transport within and external to the estuary The result is a full description of carbon and nitrogen material flows in estuaries Separate models of estuaries subjected to various types and levels of multiple stressors can be used to determine the mechanistic links between stressors and effects within estuaries

The model can also be used to calculate metrics that define overall ecosystem state These metrics (similar to diversity and commonness), are quite sensitive to changes in ecosystem condition An example metric is an index of ecosystem trophic efficiency that quantifies how carbon and nutrients supplied to the estuary are passed thought the food web to the higher trophic levels The more nutrients and carbon that move into higher trophic levels, the higher the nutrient carrying capacity of the estuary Finally, the food web model can be used to evaluate the dependencies of charismatic and recreational species on other components of the food web and how these dependencies would be altered by changes in nutrient loading This knowledge will provide managers with a early warning system to detect alterations in an ecosystem that if unrecognized could lead to reductions or extinction of important species

Biogeochemistry and nutrient cycling in burrowing shrimp and seagrass habitats

Ted DeWitt, Tony D'Andrea (NRC Postdoctoral Research Associate), and Scott Larned

In order to support development of estuarine food web stress response models for the Pacific Northwest, it is essential to define the effects of critical ecosystem components on nutrient cycling Burrowing thalassinid shrimp (*Neotrypaea californiensis, Upogebia pugettensis*) and seagrasses (*Zostera marina, Z japonica*) are the dominant ecosystem engineering species in the region, and may have important influences on geochemical processes and nutrient fluxes between the sediments and the water column Research is quantifying these processes in order to model the ecosystem-scale effects of loss or addition of these habitats on nutrient cycling and estuarine water quality, and to quantify the roles of these species in estuarine food webs

Burrowing shrimp occur in dense beds (>300 m^{-2}), dig extensive burrow systems (>1 m deep), and can dominate >75% of the intertidal and shallow subtidal area of PNW estuaries A combination of anoxic incubations, porewater peepers, and benthic chambers are used to measure the effects of shrimp species, shrimp population density, season, and inter-estuary variability on organic matter (OM) remineralization and nutrient fluxes across the sediment-water interface In shrimp-dominated habitats the flux of reactive OM into sediments and the rate of sediment oxygen uptake were ~2-4 times greater, and the efflux of dissolved inorganic nitrogen (NH_4^+ and NO_3) from the sediments to overlying water was ~2-20 times greater than areas lacking shrimp Our data indicate high rates of nitrification and subsequent denitrification in *Upogebia* burrow walls which can be significant in the removal of OM and N from the ecosystem Shrimp bioturbation results in the rapid burial of macroalgae, benthic microalgae and other OM, leading to a large inventory of reactive OM in sediments dominated by burrowing shrimp relative to "no-shrimp" habitats The high flux of DIN in shrimp dominated habitats ensures that the products of decomposition of the OM are recycled back to the overlying water, rather than accumulating in the sediments as appears to occur in habitats lacking burrowing shrimp

Benthic chambers were used to determine the effects of *Z marina* and *Z. japonica* (a non-native species) on seasonal and diel rates and directions of nutrient flux between the benthos and the water column Flux rates were also compared among *Z japonica* beds of different biomasses, and with unvegetated sediment *Z japonica* beds take up NH_4^+ and nitrate year-round, and in both daylight and darkness Unvegetated sediments released ammonium and nitrate during the day, and took up nitrate at night The mean rate of nighttime DIN uptake by *Z japonica* beds was an order of magnitude higher than that of unvegetated sediments It appears *Z japonica* generates enough reducing power during the day to maintain rapid DIN uptake at night There was little net flux of phosphate associated with either *Z japonica* beds or unvegetated sediment, except during daytime runs at the highest temperatures of the year, when there was net phosphate uptake by *Z. japonica* beds There were no differences in ammonium and phosphate flux rates associated with *Z japonica* and *Z. marina* beds, but *Z. marina* beds took up nitrate at significantly higher rates than *Z. japonica*, on a per unit area basis
Quantification of nutrient flux rates from different estuarine habitat types will allow estimation of the changes in functional properties of the estuary if habitat alteration takes place

Spatial and temporal patterns of water column chemistry

Robert Ozretich and Anne Sigleo

The development of the estuarine food web stress response model is being calibrated in Yaquina Bay This model is intended as a tool to explore how anthropogenic changes in estuarine nutrient loading alter the food web To support calibration of both the food web model and the SAV stress response model, we are collecting an extensive time series of estuarine phosphate, silicate, nitrite, nitrite+nitrate, and ammonia concentrations at multiple sites in the Yaquina Bay estuarine system with the goal of describing the spatiotemporal patterns A continuous monitor for nitrate concentration has also been deployed at the freshwater end member of Yaquina Bay, and provides a measure of nitrate input from the surrounding watershed every fifteen minutes River inputs of nitrate occur primarily during winter periods of high rainfall, with very low values of nitrate additions occurring during low rainfall, low flow summer months Interannual variation in nitrate loadings from the watershed to the estuary are primarily the result of winter rainfall variation

2 Nutrient Effects - Submerged Aquatic Vegetation

Seagrass stress response modeling of *Zostera spp.*

Peter Eldridge, Jim Kaldy, Scott Larned, Robert Ozretich, Anne Sigleo, and Walt Nelson

The goal of this research is the development of a series of models to address the response of seagrass to nutrient and other anthropogenic and natural stressors The principal model is time dependent, mechanistic, and can predict changes in the biomass of the above- and below-ground components of seagrass standing stock The seagrass model will be coupled to a sediment diagenesis model which will allow prediction of changes in seagrass biomass resulting from changes in deposition of organic matter to the sediments A seagrass physiology model is being developed to assist in calibration of the principal seagrass model A third model will assess variations in areal distribution of seagrasses in response to stressors The research effort will couple field monitoring and direct experiments with model development to test the predicted responses of seagrass to stressors

The seagrass models are a composite of numerical and empirical relationships that provide a quantitative prediction of seagrass growth, loss or metabolism Each model component will be tested individually and in concert with other relationships that make up the model For example, light attenuation, direct sedimentation, and sediment toxicity may combine to control the distribution and biomass of *Zostera marina* Because of the difficulty in controlling important parameters in the natural environment, we plan to use mesocosm experiments to verify model components

The seagrass models require a suite of biogeochemical and biophysical measurements such as sediment geochemistry and nutrient concentrations which are being acquired from supporting field work Data required for model development also includes long-term continuous monitoring of parameters such as spectral irradiance, temperature, salinity, and exposure during the tidal cycle These data sets are required to determine if variability expressed in a system is a consequence of natural stochasticity (e g , storm events) or true anthropogenic impacts

A primary research benefit will be a reduction in the uncertainty associated with setting seagrass based nutrient criteria for coastal waters An improved understanding of the factors affecting nutrient-seagrass loss relationships will provide water quality managers with better tools to manage nutrient input to our nations waters while protecting these important habitats

Disturbance factors limiting submerged aquatic vegetation.

Bruce Boese, Ted DeWitt, and David Young

Submerged aquatic vegetation (SAV) in the Pacific Northwest is affected by multiple physical disturbances including macroalgal accumulation, physical disruption by burrowing shrimp, and human recreational activities To correctly model the responses of SAV to principle stressors of concern, such as nutrients, the responses to these other potential stressors are being examined

Preliminary field experiments have demonstrated that bioturbation by *Neotrypaea californiensis* result in the disappearance of *Z japonica* shoots Non-overlapping field distributions of *N californiensis* and *Z marina* similarly suggest that disturbance by the shrimp can negatively affect eelgrass Conversely, high densities of the shrimp *Upogebia pugettensis* and *Z marina* commonly co-occur, suggesting either a neutral or positive interaction between these species Future experiments will quantify the strengths and mechanisms of interactions between burrowing shrimp and *Zostera* spp , including competition for space (*Neotrypaea*-seagrass) and facilitation by nutrient enhancement or reduction of hydrogen sulfide (*Upogebia*-seagrass)

The effect of recreational clam harvesting on *Z marina* was experimentally tested by raking or digging for clams in experimental 1-m^2 plots Results indicated that clam raking did not appreciably impact eelgrass biomass, primary production (leaf elongation), and percent cover In contrast, clam digging reduced measures of eelgrass cover, above-ground biomass and below-ground biomass made one month after the last of three monthly treatments Although differences between control and treatment plots persisted ten months after the last clam digging treatment, these differences were not statistically significant As only about 10% of the eelgrass of Yaquina Bay is subjected to recreational clamming and as this activity is generally less intense than that employed in this study, as a whole it is unlikely that recreational clamming has a major impact on eelgrass beds in the Yaquina estuary

Field work has shown that decomposition of the large seasonal accumulations of algae that occurs in Yaquina Bay can increase the sediment sulfide concentrations to values reported to be toxic to SAV Laboratory experiments to define dose response relationships for SAV and sulfides are now being planned and the results will be used to evaluate the SAV stress response model predictions for sediment chemistry alteration

Physical factors limiting submerged aquatic vegetation

Robert Ozretich, Anne Sigleo, David Specht, Bruce Boese, and Walt Nelson

The research goal is to define the factors that control distribution and abundance of seagrass

(*Zostera* spp) in Pacific Northwest estuaries to support stress response model development One aspect of research is to define patterns of estuarine nutrient dynamics within Yaquina Bay, the primary estuary being used in model development The annualized input to the estuary of dissolved nitrate from the watershed is determined at the upper reach of the Yaquina River using hourly readings from ion-specific electrodes Estimates of nitrate concentrations of dense upwelled off shore water have been made from algorithms relating continuous records of local upwelling index, salinity and temperature, and nitrate concentrations from discrete water samples Data on other parameters is obtained by continuous monitoring of PAR, turbidity, temperature, salinity and water depth at fixed station locations within Yaquina Bay in order to allow us to determine the temporal variation (seasonal, monthly and daily) of factors influencing the *in situ* light field In addition, continuous determinations of temperature within specific elevations in the intertidal zone allow us to assess the potential effects of temperature on the vertical distribution of seagrass and infaunal animals

Research on determination of the upper limit of *Z. marina* supports both the seagrass stress response model and Goal 8 seagrass indicator development The impact of desiccation, macroalgae, erosion, and light on the distribution of *Z marina* is being evaluated across tidal and bathymetric slope gradients Shoot number and canopy height were inversely related to tidal height and slope steepness Tide height differences in leaf turnover rate may be related to summer abrasion by macroalgae, desiccation during extreme low tide events, and winter wave/currents Winter erosion appeared to limit the lower intertidal plants on steep slopes Laboratory desiccation experiments showed that a 50% loss of wet wt inhibited blade recovery when rehydrated Survivorship and growth of seagrass can be strongly influenced by microtopographic features of the intertidal zone Thus, the interaction of several different physical factors appears to control the upper intertidal boundary for *Z marina*

3 Habitat Alteration

Estimation of changes in habitat value at estuarine scale

Steven Ferraro, Faith Cole, David Young, David Specht, Ted DeWitt, and Tony D'Andrea (NRC Postdoctoral Research Associate)

The goal of this research is to develop methods to predict estuarine scale changes in relative habitat value resulting from anthropogenic habitat alteration Pacific Northwest estuaries are frequently dominated by a few species that are characterized as "ecosystem engineers", meaning that their presence and activities strongly influence the physical, chemical, and biological attributes of the surrounding estuarine ecosystem Two important types of ecosystem engineers are seagrasses and burrowing shrimp Patches of seagrass stabilize the sediment, affect the surrounding water column chemistry, and most importantly provide food and shelter for a wide number of other estuarine organisms Burrowing shrimp also affect water column chemistry, and are capable of extreme bioturbation of the sediment, resulting in the exclusion of seagrass and commercially important oysters To evaluate the ecological consequences of habitat alteration at estuarine scale requires 1) the ability to estimate relative values of habitats through structural or functional ecological measures, and 2) the ability to quantify habitat extent at estuarine scale which requires remote sensing approaches Measuring the comparative areal extents occupied by seagrass beds and burrowing shrimp may also be important direct indicators of overall estuarine health (See Goal 8 poster on SAV indicators)

Assessing habitat value at the estuarine scale

Steven Ferraro, Faith Cole, Ted DeWitt, and Tony D'Andrea (NRC Postdoctoral Research Associate)

Habitat-based ecological risk assessments rely, in part, on estimates of the relative ecological value of the habitats at risk Ecological value may be estimated both in terms of structural and functional measures Methods being tested include relative habitat values with respect to structural parameters associated with benthic macrofauna and nekton communities, and the functional parameter of nutrient recycling associated with burrowing shrimp populations Structural parameters are being assessed in major Pacific Northwest (PNW) estuarine habitats including eelgrass, Atlantic cordgrass, burrowing shrimp, oyster, bare substrate, and undredged subtidal areas

To evaluate structural parameters , benthic macrofaunal studies were conducted in Willapa Bay and Grays Harbor (Washington), and Yaquina and Tillamook Bays (Oregon) Nekton community studies were conducted in Yaquina Bay Results to date indicate some large (up to 100×) and temporally consistent differences in relative benthic macrofaunal community structural metrics such as number of species, total abundance, and biomass among habitats Relative habitat values have typically shown the following rank order *Z japonica* ≈ oyster ≈ *Z. marina* > *Spartina* > *Upogebia* > bare mud > *Neotrypaea* ≈ bare sand ≈ subtidal, undredged The results of these studies will validate an approach to determining relative structural habitat values for large-scale ecological risk assessments in PNW estuaries

Relative functional habitat value was compared for burrowing shrimp and bare sand habitats of Yaquina Bay by examining patterns of geochemical fluxes between the sediments and the water column Field measurements showed burrowing shrimp enhanced organic matter (OM) remineralization 2-4× and dissolved inorganic nitrogen fluxes across the seawater interface 12× relative to bare sand habitat (see Sediment Geochemistry poster) The ultimate goal is to be able to scale measurements of fluxes due to individual shrimp, first to a description of benthic-pelagic fluxes at the habitat patch scale, and finally to an estimation of relative functional role of shrimp in determining estuarine water quality and eutrophication

Remote sensing of estuarine habitats

David Young, Ted DeWitt, and David Specht

At the scale of a habitat patch up to that of the entire estuary, changes in habitat extent are a prime indicator of response to stressors Two projects are using remote sensing to quantify spatio-temporal changes in key intertidal and subtidal habitats in Pacific Northwest (PNW) estuaries The first project combines false-color near-infrared aerial photography with digital photogrammetry to delimit different vegetation habitats on exposed mud flats Both large (23 x 23 cm diapositive) and small (35 mm) photographic formats are used The large format provides high resolution seasonal images of the entire estuary, while the small format allows lower resolution images of selected sites to be monitored monthly GPS-located ground surveys are conducted at several sites to provide training data for the image analyst and independent data sets for assessment of the accuracy of resultant habitat classifications A hybrid method combining automatic and manual classification of the digital images has been developed to separate dense beds of eelgrass from those of the green macroalgae

A companion study compares the ability of four hydroacoustic systems, underwater video, and aerial photography (CIR) to accurately detect and classify habitats as seagrass-dominated, burrowing shrimp-dominated, and sand or mud "no-shrimp" unvegetated habitats Preliminary analysis of hydroacoustic data using a mine-detecting sonar showed 89% accuracy of uniquely classifying seagrass habitat, 76% accuracy for classifying shrimp-dominated from "no-shrimp" habitat, and less than 50% accuracy for classifying shrimp habitat by species or population density Underwater video imagery accurately (>90%) classified seven different habitat types when the sediment surface was not obscured by green macroalgae, but required laborious manual transcription and interpretation of the data Preliminary photogrammetric analysis of the CIR imagery distinguished unvegetated shrimp-dominated habitat, unvegetated "no-shrimp" habitat, and seagrass-dominated habitat, however, it is unclear whether aerial photography can usefully distinguish areas dominated by specific shrimp species, or between high or low shrimp densities Aerial CIR photography is also limited to mapping intertidal habitats Study results will be used to select a remote sensing approach for mapping distributions of burrowing shrimp and "bare" sediment habitats in the intertidal and subtidal, and for mapping subtidal seagrass distributions

Abstracts – Goal 2, Aquatic Stressors, Freshwater Streams

Comparative Watershed Study

Jim Wigington, Joan Baker, Robbins Church, Jana Compton, Scott Leibowitz, and Denis White

The Comparative Watershed Study will serve as the focal point for integrating field studies and modeling, to evaluate the effects of human activities at the landscape and watershed scales on wild Pacific salmon and native fish assemblages The study will involve a core of approximately 9 watersheds in the Coastal Ecoregion of Oregon The watersheds will be selected from 20 watersheds currently monitored by the Oregon Department of Fish and Wildlife (ODFW) and other agencies to quantify total numbers of adult salmon returning to the watershed each year and the total number of salmon smolts migrating out of the watershed each year The ratio of wild smolts produced per adult (with a 2-year offset) provides an index of watershed-scale coho salmon recruitment success The 9 watersheds will be selected to represent a gradient of recruitment success, from little or no recruitment to relatively high numbers of smolts per adult

Using both field studies and fish response modeling, we will address two basic questions

1. Why do these watersheds differ in their coho salmon recruitment success?
2. Do watersheds with low salmon recruitment also have depauperate fish assemblages? Are the causes for among-watershed variations in native fish assemblages the same as for variations in salmon recruitment?

For question 1, initial efforts will concentrate on characterizing these 9 watersheds for factors that may play a role in salmon recruitment success, such as differences in in-stream physical habitat structure (e g , percent pools, large woody debris, gradient), elevated stream temperatures, variations in nutrient availability/stream productivity, influence of hatcheries, barriers (e g , culverts), and freshwater fishing pressure Given the large effort required to quantify salmon recruitment success, it's not surprising that ODFW and others are already expending substantial effort on these watersheds, in particular on in-stream physical habitat, hatcheries, barriers, and fishing pressure (creel surveys) EPA field efforts will be designed to complement work being done by others, and will likely focus on temperature, nutrients and, to a lesser degree, stream flow Some field work may also occur outside these 9 watersheds, to take advantage of particular opportunities to enhance our understanding of the effects of these stressors (e g , to monitor responses to additions of nutrients or salmon carcasses to streams by industrial forest owners) The current coho population model (see associated fish modeling abstract) deals only with in-stream physical habitat If field studies suggest that other factors are also important, starting in year 3, EPA will take the lead in modifying the model as needed to help evaluate the combined effects of multiple stressors on salmon recruitment success and long-term population viability As we add complexity and additional factors to the salmon response model, does it increase our ability to accurately predict the measured among-watershed differences in recruitment success?

For question 2, fish sampling (electrofishing and/or snorkeling) will be conducted at selected sites in each of the 9 watersheds to characterize the presence/absence of native fish species Observed differences in fish community composition will be compared to (a) among-watershed differences in coho salmon recruitment and (b) patterns of in-stream physical habitat, temperature, nutrients/productivity, and barriers, using the same data collected for question 1 Data will be statistically analyzed to assess associations The fish assemblage modeling (see associated fish modeling abstract) will also be used to help interpret observed patterns Data for these 9 watersheds will be supplemented by statistical analysis of fish survey data collected in other areas by EMAP and the Oregon Department of Environmental Quality

Fish Modeling

Scott Leibowitz, Denis White, and Joan Baker

The purpose of the Fish Modeling sub-component is to examine the biological response of fish to management activities aimed at improving salmon habitat, with a specific focus on the effects of spatial structure and connectivity within streams Our approach is to adapt and develop models that can provide meaningful results on a simpler set of questions in a 2 year time frame, and then to continue model development so as to address more complex issues in the longer (5 year) term A model of coho salmon developed by NMFS will be adapted to address questions of salmon response, and an assemblage-level model will be developed to investigate how salmon management activities might affect non-target native species The NMFS model is a stream reach model which computes salmon numbers as a function of the local quality of overwintering habitat, basin-level annual variability, and ocean-wide effects on adult survival Straying of returning spawners allows recolonization of reaches that experience local extinctions This model is not spatially explicit, for example, strays are distributed equiprobably to other reaches By adding a simplified, spatially explicit network to the model, the effects of stream spatial structure and connectivity can be investigated – through stray dispersal – without altering the fundamental structure of the model (i e , requiring fish to be tracked between stream reaches) Such a modified model could be used to address the importance of source-sink dynamics on salmon abundance and overall sustainability, and how changes in habitat quality – through various management activities and natural variability, e g , landslides – affect these source-sink dynamics A second question that this model could be used to address would be the effect of competition from hatchery-raised fish on native coho populations In the upcoming months, we will select one of these two options as the major focus of the first two years of research The model would be run for the 9 watersheds described in the Comparative Watershed Study sub-component At this point there is no easy way to incorporate watershed level effects, such as land use change, into the model, this requires a better understanding of how these watershed effects translate into changes in physical habitat (i e , channel width, gradient, beaver dams, and percent pools) Such information, along with effects of nutrients and temperature, could possibly be included in the longer time frame depending on results from the Comparative Watershed Study sub-component and other on-going research The other aspect that could be addressed in the longer time frame is to modify the model to explicitly track reach to reach movement and movement between winter and summer habitat This could allow us to determine if the spatial location of habitat quality is a significant factor

The coho modeling effort will eventually allow us to examine the effects of various management strategies on coho abundance and survivability, and could provide a framework for prioritizing where watershed management efforts should be sited Given EPA's responsibilities under the Clean Water Act to protect and restore the biotic integrity of the nation's waters, it is desirable to understand how management efforts targeted at salmon would impact other native fish Exploratory work will be done to construct an assemblage-level model that tracks overall species richness as a function of stream network and habitat characteristics Using the same watersheds and spatial network developed for the salmon modeling effort will allow the assemblage modeling to be run with the same spatial structure This will then allow a common set of management scenarios to be run for both models, so that biological response of coho and the broader fish assemblage can be compared

The effects of stream nutrients on salmon and other native fishes

Robbins Church, Jana Compton, and Jim Wigington

The sustainability of Pacific Northwest (PNW) salmon runs is influenced by a suite of freshwater factors, such as stream habitat, flow regimes, temperature and nutrient concentrations, as well as climate-driven oceanic conditions and fishing pressure Researchers in the PNW have determined that returning salmon provide nutrients (N and P) that maintain in-stream productivity and provide food for juvenile salmon, and that declining runs of salmon has a negative feedback on salmon populations in many rivers The link between salmon and nutrient availability leads to the hypothesis that there is a positive relationship between salmon returns and stream nutrients, if all other factors are the same We propose to examine the relationship between stream nutrients and fish assemblages throughout a large scale (Oregon and Washington?), and at a smaller scale on the Oregon Coast Range We will use two approaches, a large-scale correlative approach to examine the link between stream chemistry and fish abundance, and manipulative experiments to determing whether in-stream fertilization increases fish abundance and production in streams of low and high nutrient concentrations

The Oregon Coast Range landscape has a variety of bedrock types and nitrogen supply, resulting in tremendous variability in streamwater nutrient concentrations Using available stream chemistry and fish data, we will determine whether the abundance and community composition of native anadromous and non-anadromous fish in the PNW are related to stream nutrient concentrations This information will also allow us to compare the role of different landscape factors (habitat, flow, temperature and nutrients) in maintaining healthy salmon populations

Another link between stream chemistry and salmon runs is the role of salmon-derived nutrients in maintaining instream productivity For decades, managers in British Columbia have been applying inorganic fertilizers to streams and lakes in order to improve habitat quality for juvenile salmon Stream nutrient fertilization is now being advocated throughout the range of salmon However, there are many conflicting issues surrounding the fertilization of PNW streams with organic or inorganic nutrients For example, stream nitrogen concentrations are highly variable in the Oregon Coast Range (0-3 ppm nitrate-N), and stream fertilization could pose a water quality issue in some of these watersheds Recognizing the underlying patterns in stream nutrient concentrations could be helpful in determining where salmon carcass planting would be most successful and least harmful Our ongoing work linking landscape factors to stream chemistry has determined that stream nutrient concentrations are a function of nitrogen-fixing red alder coverage in the watershed, and the proximity to the Pacific Ocean In some areas, physical habitat may be so degraded that stream fertilization will have little effect We propose to examine the impact of three types of stream fertilization (inorganic nutrients, synthetic organic nutrients, and salmon carcasses) on salmon populations, chemistry and other biota (algal production, invertebrates) This research will provide managers with information to determine the effects of instream fertilization on water quality, and to determine whether this practice will improve salmon habitat

Restoring Wild Salmon to the Pacific Northwest

Robert T Lackey

Throughout the Pacific Northwest (northern California, Oregon, Idaho, Washington, and the Columbia Basin portion of British Columbia), many wild salmon stocks (a group of interbreeding individuals that is roughly equivalent to a "population") have declined and some have disappeared Substantial efforts have been made to restore some runs of wild salmon, but few have shown much success

Society's failure to restore wild salmon is a policy conundrum characterized by (1) claims by a strong majority to be supportive of restoring wild salmon runs, (2) competing societal priorities which are at least partially mutually exclusive, (3) the region's rapidly growing human population and its pressure on all natural resources (including salmon and their habitats), (4) entrenched policy stances in the salmon restoration debate, usually supported by established bureaucracies, (5) society's expectation that experts should be able to solve the salmon problem by using a technological scheme and without massive cultural or economic sacrifices (*e g.*, life style changes), (6) use of experts and scientific "facts" by political proponents to bolster their policy positions, (7) inability of salmon scientists to avoid being placed in particular policy or political camps, and (8) confusion in discussing policy options caused by couching policy preferences in scientific terms or imperatives rather than value-based criteria

Even with definitive scientific knowledge, which will never be complete or certain, restoring most wild salmon runs in the Pacific Northwest to historic levels will be arduous and will entail substantial economic costs and social disruption required Ultimate success cannot be assured Given the appreciable costs and social dislocation, coupled with the dubious probability of success, candid public dialog is warranted to decide whether restoration of wild salmon is an appropriate, much less feasible, public policy objective Provided with a genuine assessment of the necessary economic costs and social implications required for restoration, it is questionable whether a majority of the public would opt for the pervasive measures that appear necessary for restoring many runs of wild salmon

Through the 21st century, there will most likely continue to be appreciable annual variation in the size of salmon runs, accompanied by the decadal trends in run size caused by periodic changes in climatic and oceanic conditions, but many, perhaps most, stocks of wild salmon in the Pacific Northwest likely will remain at their current low levels or continue to decline in spite of heroic, expensive, and socially turbulent attempts at restoration Thus, it is likely that society is chasing the illusion that wild salmon runs can be restored to the Pacific Northwest to anything approximating the 1850 level without massive changes in the number and lifestyle of its human occupants, changes that society shows little willingness to seriously consider, much less implement

EFFECTS OF PESTICIDES ON NON-TARGET PLANT COMMUNITIES

GPRA GOAL 4: PREVENTING POLLUTION AND REDUCING RISK IN COMMUNITIES, HOMES, WORK PLACES, AND ECOSYSTEMS, Objective 4 3 Safe Handling and Use of Commercial Chemicals and Microorganisms, Sub-Objective 4 3 4 Research to Support Reducing Risks in Communities, Homes, Work Places, and Ecosystems Human Health and Ecological Risk Assessment

EPA is responsible for implementing the Toxic Substances Control Act (TSCA) and Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) These laws give EPA the responsibility to register chemicals and various biologically-active "agricultural" substances to ensure their safe use, and ensure that humans and ecological systems remain healthy after these substances have been approved for use In the EPA Office of Research and Development (ORD), the Safe Communities Ecological Effects Research Program addresses these risk issues The purpose of this research program is to evaluate the effects of environmental exposures and their consequences on wildlife and plant species for both individual anthropogenic stresses and combinations of anthropogenic and natural stresses Through this research program, ORD develops the methods to evaluate effects that are used in the regulation of pesticides and toxic substances in ecosystems Both TSCA and FIFRA mandate that EPA issue test methods guidelines, and that those guidelines be periodically updated to incorporate scientific advances This research program will develop and validate methods and models to identify, characterize, predict and assess ecological effects, and will culminate in more holistic risk assessment and risk management strategies for use by the Office of Pesticide Programs (OPP) and the Office of Pollution Prevention and Toxics (OPPT)

AGENCY PROBLEM:

In recent years, with the rapid advances made in molecular genetics, highly-specific, low-dose pesticides are being developed Such compounds pose new concerns for the Agency since current testing guidelines are inadequate to address the wide variety of new ecological circumstances that are possible because of the use of these compounds Typically, application rates of these lose-dose substances are such that traditional, chemical analytical methods fail to detect the compounds in the environment One example of a new class of compounds that has heightened this concern is SU (sulfonylurea) herbicides Historically, EPA registration test guidelines focused on the initial life stages of plants to assess effects of pesticides The SU herbicides target physiological processes involved with the reproductive stages of plants Thus, under current test guidelines, SU herbicides were successfully registered for use It was determined after their commercial release that detrimental ecosystem effects are possible Two critical issues have been expressed by the pesticides program office concerning this new generation of pesticides 1) new evaluation methods for the registration process, and 2) new methods to identify the presence and ecological consequences, of releasing such low-dose herbicides

SCIENCE QUESTIONS:

EPA is faced with two ecological, scientific questions concerning pesticides and toxic substances

1) What are the relevant, efficient and up-to-date test guidelines to use in the registration process to evaluate new chemicals?

2) How can these low-dose compounds be detected in the environment in order to provide continued oversight of their use and safety after they have been released commercially?

Both of these scientific questions apply to both target and non-target species, including plants and animals, with both direct and indirect exposures to pesticides or toxic chemicals Regardless of the species of interest (i e , assessment endpoints), inherent in the evaluations is the necessity to include supporting ecosystem components and processes

APPROACH:

Research planning within NHEERL to formulate a long-term research approach to address EPA's needs concerning pesticides is currently underway However, based on preliminary discussions between scientists and managers in ORD and OPP the pressing research needs appear to center around risk assessment uncertainties associated with pesticide registration, with bird populations and non-target plants as primary assessment endpoints WED is the only division with the capability in ORD to address plant effects The goal of WED's program will likely be to improve the ecological risk assessment process for non-target plants A key area of uncertainty is the effect of low-dose, high-potency herbicides on physiological processes and soil systems associated with non-target plant communities Hence, at this point in time, WED will initially focus goal 4 efforts on 1) reviewing, evaluating and filling in gaps in OPP's Plant Toxicity Test Guidelines, 2) determining the mechanisms of action of low-dose, high potency herbicides, and 3) develop appropriate methods, including molecular markers, that can be used in the FIFRA registration process

RESEARCH CAPABILITIES

Due to the preliminary nature of the research planning process, we are unable to discuss a specific research approach to this Agency problem The following, however, discusses WED's capabilities we feel will be useful in conducting this research

During 2001, WED researchers have been identifying research methods which can potentially be used to address these scientific problems while participating in the NHEERL planning process The following activities have been identified by WED scientists as possible research efforts The research areas discussed here represent a range of possibilities within the capabilities of this division The NHEERL planning process and ultimately, peer review, will provide the information that will focus this research during implementation

For the first two activities initial, "proof-of-concept" research has begun to prepare for a greater, long-term undertaking These efforts are discussed here and presented as posters Efforts on the other activities are in the conceptual stage, and are meant to be presented as ideas during the planning process

Research activities that are represented with posters are indicated One poster (Activity 1) presents on-going evaluations and development of new potential molecular biology-based testing techniques The other poster presents results from past WED research on the adequacy of current registration test guidelines (Activity 2)

1) Assessing molecular methods for pesticides research A new generation of high-toxicity, low dose herbicides has been developed that severely compromises our ability to protect non-target plant populations, plant communities, and ecosystems from the damaging effects of herbicide drift These "designer" herbicides are tailored to kill a narrow range of target species and can be used in many formulations High-toxicity, low-dose herbicides are used at concentrations undetectable in the atmosphere with standard chemical analyses and their residue on target and non-target organisms is not detectable with standard chemical analyses Our inability to detect the presence of these herbicides in the field makes it impossible to determine if they are responsible for damage that may appear in non-target plants in adjacent fields or non-agricultural areas after application To protect non-target plants and ecosystems from drifting herbicides, new highly sensitive and herbicide-specific testing and evaluation methods are needed

The high-toxicity, low-dose herbicides are designed to affect specific enzyme pathways in the target plants which gives low mammalian toxicity and allows them to be used without damaging crops of interest This molecular basis of effect provides a new highly-sensitive and -specific approach for testing and monitoring pesticide effects on non-target organisms We propose to use the recent and rapid development of molecular biology-based methods to develop new tools to assist OPP in their pre-license testing, and to develop methods to determine if high-toxicity, low-dose herbicides are the cause of damage to non-target organisms We will develop molecular techniques for screening tests and methods to assess impacts on non-target organisms

We will assess molecular methods potentially applicable to pre-license testing of high-toxicity, low-dose herbicides, and for assessing damage caused by non-target drift of those compounds in the field Initially in developing molecular methods, we will evaluate four broad areas

a) Initial screening tests to identify genes affected by pesticides -We will use a messenger-RNA microarray technique to screen for effects of pesticides on gene expression

b) Tracking genes responsible for specific ecosystem functions in environmental samples - Herbicide drift can affect critical functions within ecosystems The presence of specific genes responsible for key ecosystem processes in environmental samples will be detected, tracked and quantified using a variety of molecular techniques

c) Tracking affected organisms - The ability to track whole organisms affected by pesticides will be useful in assessing non-specific, lethal and non-lethal pesticide effects on non-target ecosystems This approach is particularly useful for organisms which are not easily tracked by traditional gross, morphological methods

d) Tracking changes in the genetic diversity of populations/communities (tracking genes and organisms simultaneously) - While a species may not disappear due to pesticide exposure, a reduction in genotypic diversity can occur unnoticed at the species, whole organism level Thus, a genetic bottleneck might occur, thereby potentially affecting the species' relative ability to compete for niche space, and withstand future anthropogenic stresses At the ecosystem level, such reductions in genetic diversity have the potential to reduce system productivity, stability and sustainability One focus of this work will be to evaluate changes in genetic diversity (at the species level) by tracking the genes in individuals of a species We will assess methods used among geneticists and plant breeders as they track specific alleles in populations and/or communities

2) Development of Risk Assessments at the Population, Community and Ecosystem Levels
Within EPA,OPPTS is responsible for the registration and re-registration of pesticides under FIFRA and other chemicals under TSCA The protection of non-target plants is EPA's responsibility under these Acts

Effects research will be designed to address significant gaps in the existing plant testing scheme and in the transport of pesticides and other toxicants through ecosystems The latter processes cause high levels of uncertainty for making assessments of risk in terrestrial and aquatic systems Key uncertainties related to plants include whether a) crop plants can serve as surrogates for non-crop or native plant species, b) annual plants can serve as surrogates for perennial or woody plants, c) terrestrial vascular plants can serve as surrogates for emergent rooted aquatic vascular plants, d) one taxonomic group of plants can represent other taxa, e) monocot macrophytes can serve as surrogates for dicots, f) there is a correlation between early growth toxicity and reproduction or survival, g) there is/are a most/more sensitive plant stage(s) of growth, h) the choice of endpoints is dependant on the chemical mode of action, i) laboratory results can be extrapolated to field conditions, and j) the appropriate species are being used for modeling and monitoring efforts

Work in this component of the project will be designed to provide a) data relevant for predicting pesticide impacts, b) test material for detecting biochemical and molecular markers for pesticides Additionally, the work will include endpoints, such as indicators of ecosystem structure and function, and linking them to efforts to extrapolate to larger scales to make risk assessments on using pesticides and toxic substances This latter activity will emphasize impacts of pesticides on wildlife through habitat alteration

Specific effects research activities are

a) Identify whole-plant test species - Research will establish how plant species selected for testing represent specific segments of the overall taxonomic and ecological diversity present in affected ecosystems Criteria for selecting the families/species to be used in pesticide testing will be a) species' sensitivity to pesticides using toxicity, or non-target incidents data , b) species' role to serve as important sources of food for wildlife, c) the likelihood a species will be recommended for phytotoxic testing in the literature, c) whether a species is already being tested for reproductive endpoints, and d) whether a species is sufficiently common so it can be easily acquired

b) Develop higher level plant tests - Research will be done to develop plant reproductive, life cycle and field tests that have relevant endpoints for risk assessments

c) Physiological and biochemical endpoints - Targeted research will be done to improve upon the toxicological plant physiological database Areas of concern include a) plant response to different classes of chemicals, b) plant's ability to degrade toxicants, c) cross-taxonomic differences in toxicant uptake and response, and d) the physiological basis for differential sensitivity to toxicants

d) Soil processes governing plant responses to pesticides - Research will be done on soil processes and organisms controlling pesticide entry into and elimination from plants, soil and sediment foodwebs These webs represent the key functions in ecosystems, and therefore, are important for determining effects of pesticides that may occur into food supplies for wildlife and humans Controlled mesocosm work where pesticides can be labeled with stable isotopes and tracers linked to field studies is recommended

3) Linking Physiology with Modes of Action to Assess Risks to Non-Target Communities and Ecosystems Efficient use of pesticides is consistent with the mandate specified by FIFRA by reducing the risk of unnecessary exposure to human health and the environment Variability in biological, ecological and physical conditions have been shown to influence a) the susceptibility of plants to pests, and b) the size and distribution of pest populations themselves Understanding this variability can lead to the development of predictive models to maximize the effect of pesticides while minimizing their application rates For example, research has shown that some plants are more susceptible to attack by insects and plant pathogens when they are physiologically weakened, while other plants are more susceptible when growing rapidly and are healthy Although the reasons behind increased susceptibility to pests are poorly understood, growers frequently control the effects of increased susceptibility by increasing the use of pesticides Increased use of pesticides occurs frequently when the affected plants have some commercial value

Mechanisms of increased susceptibility in response to stress are poorly understood, however, they are often linked with energy availability (photosynthate) for the synthesis of defense compounds (secondary metabolites) Plants allocate energy to secondary metabolite synthesis after maintenance and growth needs are met Therefore, stresses that reduce net carbon fixation may result in insufficient energy for secondary metabolite synthesis, increasing plant susceptibility to pest attack It has also been suggested that stressed plants release aldehyde compounds that may serve as chemical attractants [as jointly proposed by WED and the Human Safety Division (HSD) as part of the cross-divisional NHEERL Synergy program] Stresses that are known to increase plant susceptibility to certain insects and pathogens include ozone, elevated CO_2, drought, high temperature, nutrient deficiency, and competition

Alternatively, some plants are most susceptible to pest attack when rapidly growing and healthy Increased susceptibility in these cases may be related to tissue 'quality' For example, heavy fertilization to promote plant growth can make foliage nutrient-rich, and more palatable to certain insect predators

Understanding the factors that lead to increased plant susceptibility to diseases and pests will allow reduced pesticide applications Many farmers are intuitively aware of conditions that favor insect or disease outbreaks, yet a limited number of assessment tools are currently available to assist them in the selection and timing of pesticide applications We are proposing to conduct field and laboratory research to a) understand underlying mechanisms leading to increased susceptibility to pests and disease, and b) modify existing plant growth models in order to allow better prediction of factors that lead to pest outbreaks These models will then be used to produce (annual, seasonal) vulnerability estimates for a range of economically and ecologically important plant species By using the results of the research, growers will know when crops are most susceptible to pests, and conversely, when pesticide application may not be necessary, leading to reduced use and more targeted applications of pesticides

Data derived from this research project will link to that conducted under Goal 8 1 2 Sound Science Processes and Modeling In particular, two other proposed research activities would be incorporated into Goal 8 1 2 research

- Develop GIS as a Tool for Species Selection, and Identifying and Monitoring Location of Plant Communities and Wildlife Habitats at Risk from pesticide use
- Conduct Probabilistic Assessments of Risks to Ecosystems Associated with Pesticide Use

These activities will be introduced to the planning process as appropriate

TIME LINE:

The "proof-of-concept" work on molecular ecology techniques is anticipated to take 1-2 years Additional molecular work will be done in the latter years in conjunction with the other activities in the project The GIS technique development is also expected to be a 1-2 effort The research on effects of plants and ecosystem processes, and the issues of susceptibility to pesticides is expected to take 3-4 years Much of this time line and specific research foci are dependent on the outcome of the NHEERL implementation planning process

PRODUCTS:

FY 02 - 03 Initial assessments of molecular procedures and preliminary, modified, molecular ecology procedures for use in screening tests and as methods to assess impacts on non-target plant communities and supporting ecosystems

FY03 WED is responsible for the following APM An evaluation and recommendations for upgrading test guidelines pertaining to non-target species in agricultural crop systems

FY 03 A system of maps that includes overlays of current patterns of pesticide use, anticipated use patterns, climate (especially wind speed), crops, natural vegetation, endangered plant/animal species, water resources and wildlife habitats/ranges

FY 04 and 05 Identify effects of pesticides on ecosystems processes relevant for predicting pesticide impacts to plant communities and wildlife habitat including recommendations for test material for detecting biochemical and molecular markers for pesticides

FY 06 - 07 1) Results of field and laboratory research to understand underlying mechanisms leading to increased susceptibility to pests and disease, and modify existing plant growth models in order to allow better prediction of factors that lead to more efficient use of pesticides 2) Probabilistic assessments of risks to ecosystems associated with pesticide use (See section Goal 8-062 Process Modeling-Effects)

RESOURCES:

FY 02 - 4 FTE Allocation of resources in subsequent years will be dependent on the outcome of the NHEERL implementation planning process, the actual scope of the project will be sized accordingly

ABSTRACTS: GOAL 4: PLANT EFFECTS RESEARCH

Molecular Methods In Pesticides Effects Research

Lidia S Watrud, Paul Rygiewicz, L. Arlene Porteous, Kendall Martin and Brenda Shaffer

Molecular methods can provide highly sensitive and specific approaches for testing and monitoring pesticide effects on non-target organisms We will assess molecular methods potentially applicable to pre-license testing of high-toxicity, low-dose herbicides, and for assessing damage caused by non-target drift of those compounds in the field In the portion of the Pesticides Project which deals with developing molecular detection methods, we propose to focus on the following areas

Focus 1 Initial screening tests to identify genes affected by pesticides We will use a messenger RNA microarray technique to screen for effects of pesticides on gene expression

Focus 2 Tracking genes responsible for specific ecosystem functions in environmental samples Herbicide drift can affect critical functions within ecosystems The presence of specific genes responsible for key ecosystem processes in environmental samples will be detected, tracked and quantified using a variety of molecular techniques

Focus 3 Tracking affected organisms The ability to track whole organisms affected by pesticides will be useful in assessing non-specific, lethal and non-lethal pesticide effects on non-target ecosystems This approach is particularly useful for organisms which are not easily tracked by traditional gross, morphological methods

Focus 4 Tracking changes in the genetic diversity of populations/communities (tracking genes and organisms simultaneously) While a species may not disappear due to pesticide exposure, a reduction in genotypic diversity can occur unnoticed at species, whole organism level Thus, a genetic bottleneck might occur, thereby potentially affecting the species relative ability to compete for niche space, and withstand future anthropogenic stresses At the ecosystem level, such reductions in genetic diversity have the potential to reduce system productivity, stability and sustainability One focus of this work will be to evaluate changes in genetic diversity (at the species level) by tracking the genes in individuals of a species We will assess methods used among geneticists and plant breeders as they track specific alleles in populations and/or communities

Low-Dose, High-Toxicity Herbicides on Non-Target Plant Reproduction

Tom Pfleeger, John Fletcher, Hilman Ratsch, and Bob Hayes

In response to environmental problems associated with traditional pesticides such as persistence, and non-selective effects, pesticide manufactures started to introduce new classes of herbicides in the mid 1980's These new herbicides, the first of which were the sulfonylureas, were applied at concentrations at a fraction of traditional pesticides For example, Glean is applied at a rate of 1/3 oz per acre where as 2,4-D is applied at 2 5 lbs per acre The first problem arising was the new herbicides could not be detected in the environment if they moved off target In fact, in many cases they cannot be detected on the targeted crop Traditional methods for determining the source of plant damage from off target movement of pesticides no longer worked and the affected growers no longer could prove their cases in court

In the late 1980's south-central Washington growers repeated complaints to EPA Region X led Regions X's Karl Arne to request assistance from WED John Fletcher toured the affected areas in Washington and visited with growers Of the various complaints registered, the one that drew the most concern was the diminished reproductive output of many crop plants This was of concern because prior to pesticide registration many tests are required by the registrant to prove the safety of the product but no test is required on plant reproduction In fact, the plant testing portion is very minimal consisting of seedling emergence and early seedling growth lasting at no longer than 28 days There was concern that the new herbicides may be producing a serious environmental effect that was not being picked up in the registration process

With a small amount of funding from Region X, we started to investigate the effects of sulfonylureas on cherry fruit Cherries were selected as they were one of crops affected in the Horse Heaven Region of Washington Our findings are listed below, but the major point was that the growers concerns were justified, something that could not be shown except under controlled conditions Our methods were crude and were routinely criticized by industry for the inability to quantify the amounts of chemical residing on plant tissue We won a major capital equipment improvement grant and purchased a track sprayer This allowed the application of an exact amount of pesticide to be delivered to plant tissues With the track sprayer, we expanded our work to include several taxonomically diverse species This work validated our earlier work and determined the window of vulnerability when plant reproduction was susceptible Our work was further validated by researchers at Washington State University

EMAP-BIOASSESSMENT RESEARCH AND DEVELOPMENT PROJECT
EMAP-WESTERN COASTAL PROJECT

GOAL 8.1.1 ECOSYSTEMS RESEARCH - MONITORING RESEARCH Developing indicators, monitoring systems, and designs for measuring the exposures of ecosystems to multiple stressors, and the resultant responses of ecosystems at local, regional, and national scales

AGENCY PROBLEM

Monitoring and Reporting: EPA's Office of Water is responsible for reporting on the condition of the Nation's waters (i e , what has been the cumulative effect of all the laws, regulations and policies affecting aquatic systems) and for conducting an assessment of the relative importance of stressors having an impact on them The Clean Water Act requires, under section 305(b), that the States report to EPA and that EPA report these findings to Congress Under GPRA, Office of Water has provided goals that also require the ability to report on the extent to which all waters in the Nation support their designated uses Over the past 30 years, EPA has repeatedly been criticized for producing reports that the Agency knows do not reflect the condition of our Nation's waters The monitoring that provides this information is collected by the States, reported to EPA and then summarized for Congress The Agency problem is that EPA must provide the tools and the guidance that would allow the States to monitor the condition of all their waters in such a way that EPA could aggregate this information into a defensible description of all the Nation's waters EMAP was established as a research program within ORD to fill this void

SCIENCE QUESTIONS:

WED has the lead responsibility for developing the tools necessary for the States to monitor and assess all freshwater systems (lakes, streams, and wetlands) within the State WED also has the responsibility for contributing to the development of these tools, along with other parts of NHEERL, for estuarine and coastal systems In order to monitor and assess all waters, 3 sets of tools are necessary biological indicators of condition, survey designs, and indicators of anthropogenic stresses The major science questions are

1 What are effective indices of ecological condition in freshwater ecosystems and what reference condition(s) should they be compared against?
2 What sample survey design(s) will allow inference from the sample of surface waters to all surface waters in a State or Region?
3 What are the primary indicators of anthropogenic stress that can be used in a monitoring effort?
4 How are these three sets of tools brought together to produce an effective assessment of condition and relative ranking of stressors?

APPROACH

EMAP is a program within the EPA Office of Research and Development (ORD) for which NHEERL has the lead Within NHEERL, WED and MED (Duluth ecology division) are the primary divisions working on inland aquatic systems with WED providing the overall leadership For coastal components of EMAP, Gulf Breeze (GED), Narragansett (AED) and Corvallis (WED) are all active participants with GED providing the overall leadership and WED playing a key role in implementing the coastal components of the western pilot

Development of the monitoring tools necessary to conduct comprehensive assessments of the condition of surface waters in the U S occurs in two major areas, with research designed to answer the four science questions (above) occuring in one or both areas Research on indicators and indicator development, discussed in more detail below, focuses on developing conceptual models of indicator response to anthropogenic stress, finding effective indices of ecological condition that correspond to the elements of the conceptual models, testing the indicators (to see that they are practical, responsive and repeatable), and creating valid estimates of reference conditions for each indicator so that their responses to stress can be evaluated against a known benchmark Research on statistical design and analysis, also described in more detail below), is focused on developing and improving sample survey designs for a variety of resources (streams, rivers, lakes and wetlands) and on developing the statistical tools (e g , population estimates, estimates of variability) necessary to evaluate the indicator data collected in surveys

Indicator Research and Development Research

The development of indicators occurs in several stages The first is the development of conceptual models that hypothesize the important characteristics (metrics or indices) of the biological communities and their expected response to varying natural changes and anthropogenic alterations These conceptual models provide a foundation for scientifically evaluating the subsequent data analyses

The second stage is the evaluation (i e , testing) of the response of the biological communities (i e , the individual metrics and indices selected based on the conceptual models) to univariate and multivariate gradients The gradients selected are again based on the conceptual models These analyses either confirm the expected response of the metrics based on the conceptual models or, in some cases, cause us to reevaluate the conceptual models

The third stage is to distinguish between the portion of the response resulting from natural variation and anthropogenic alterations We know, for example, that biological communities vary across the country based on their historical biogeography and many patterns can be explained by these biogeographic variations One would not want to interpret some patterns as evidence of anthropogenic disturbance when they are actually a result of natural conditions based on biogeography Other natural factors such as elevation and gradient impact the patterns seen in biological conditions Again these patterns must be accounted and factored out of the signal of human disturbance we are trying to detect Watershed area, stream flow, and channel morphology are among the factors that are natural and represent gradients that must be muted out when looking for the signal of human disturbance

The final stage is the development of the reference conditions against which current conditions can be compared and upon which the evaluation of impairment will be based Concurrent with the development of condition indicators based on biological measurements is the development of indicators of physical, chemical, hydrologic and habitat characteristics These indicators undergo a similar development process and a parallel set of steps Within the indicator research and development portion of the projects the priorities fall in the same order as the stages described above

The EMAP Western Coastal Project has adopted a set of indicators of environmental condition derived from experience in east coast estuaries PCEB is evaluating additional indicators of relevance to western estuaries, including seagrass distribution, degree of invasion by nonindigenous species (NIS), benthic amphipod composition, and morphometric perturbations of juvenile flatfish (see poster abstracts for further descriptions)

Design and Analysis Research and Development

Research and development in the design and analysis portion of the project focuses primarily on the development of survey designs and the analytical tools to interpret data resulting from such surveys The first stage in this process is the development of the sample survey tools, including global grids and hierarchical process for selecting representative samples of varying sizes with varying spatial resolution and the algorithms for estimating variance of survey results

The second stage is development of straightforward tools to select survey samples of specified characteristics that can be transferred to the regions and states

The third stage of our research and development on design and analysis requires the intersection of information from the indicator research and development and design features The data on variability of indicators is analyzed in the context of specific survey designs to determine the ability of the combined features of indicators and designs to describe status and detect trends

The final stage of design and analysis research is the development of approaches for evaluating the relative ranking of stressors impacting aquatic systems Priorities in the design and analysis research and development component of this project parallel the four phases of the work outlined above

Regional Demonstration Studies

One of the unique features of this EMAP is that the two sets of tools must be brought together and demonstrated in real world conditions with the EPA Regions and States This demonstration of the tools in regional studies such as the Mid-Atlantic Integrated Assessment (MAIA) EMAP-West, Regional-EMAP, TIME/LTM (Temporally Integrated Monitoring of Ecosystems/Long-Term Monitoring) and State monitoring programs allows us to evaluate the effectiveness of our research and development efforts in actually meeting the needs of our clients and partners In addition to serving as a demonstration ground for the application of our research, these demonstration projects result in data that then feeds back into our research and development efforts to evaluate assumptions and hypotheses in order to refine our approaches This cyclic feedback between our research and development activities and real world applications ensures that our research and development is focused on the critical pathways to improved monitoring and assessment Moreover, constant interaction with the EPA client of our research is achieved via this process

EMAP-West

As described above, a unique feature of this project is that the data for the research is collected via large collaborative regional studies These regional studies also serve as the focal point for bringing the tools together to demonstrate them in real world situations that result in assessments intended for application in Regional, State and Tribal management decisions The first regional study of this type was the Mid-Atlantic Integrated Assessment study (MAIA) The current regional study is EMAP-West For inland aquatic systems, particularly streams and rivers, this is a collaborative effort with the three western EPA Regions and the twelve western states Working with these organizations, over 1200 locations will be sampled for indicators of stream and river biological quality as well as indicators of human disturbance or stress to the systems The Pacific Coastal Ecology Branch is leading the effort for coastal systems which is a collaborative effort between NHEERL, Regions 9 & 10 and the five coastal States, including Hawaii and Alaska These data are then used in our research on indicators, design and analysis and the results will be incorporated into State, Tribal, Regional and West-wide assessments as prototypes of desirable 305(b) reports for the Agency EMAP Western Coastal Data will also be included in a major report on the condition of coastal resources of the United States

TIMELINE:

The EMAP-Bioassessment Research and Development Project has been operating since 1990 It has evolved from (1) studies on lakes in the northeastern United States to (2) surveys of streams and rivers in the mid-Atlantic region of the U S and (3) now the western EMAP study The EMAP-West study of aquatic inland resources began in 1999 with an evaluation of the stream and river resource as represented by River Reach File, Version 3 (RF3) and the current National Hydrologic Database (NHD) Field sample collections began in 2000 and will continue through 2003 with 2004 and 2005 devoted to data analysis and assessment activities The EMAP Western Coastal Project began with sampling at 210 sites in the small coastal estuaries of Washington, Oregon and California in 1999 Sampling at 150 sites within the larger estuarine systems (Puget Sound, Columbia River, San Francisco Bay) was completed in 2000 Hawaii and Alaska will conduct sampling in 2001 and 2002 Sampling of emergent marshes and the continental shelf, both of which represent new resource types for the EMAP Coastal program, will be sampled along the West Coast in 2002-2003

PRODUCTS:

The products resulting from this project include tools, data and assessments The tools will include biological indicators and a process for setting the expectation or reference conditions against which to evaluate the indicators It will also include a prioritized set of indicators of anthropogenic stress that can be associated with biological quality As important as the specific indicators will be the process for their development and evaluation We know that aquatic biota vary across the country So it is important that we have a consistent process for developing and evaluation the relevant biological measures that are appropriate for each region Monitoring designs and a design development process are also critical tools to be developed in this project While developing and demonstrating these tools is important, it is equally critical that we devote the time necessary for transferring these technologies to the Regions, States and Tribe who will ultimately have the responsibility for conducting this type of monitoring long term

EMAP-West and the EMAP/Bioassessment Project will also result in the largest consistent and comprehensive dataset of stream ecological condition yet collected in the western U S The effort and resources required to produce a validated dataset of this type, with data for fish assemblage structure, macro-invertebrate relative abundance, algal composition and biomass, and a comprehensive description of chemical and physical stream and riparian habitat, are seldom sufficiently recognized

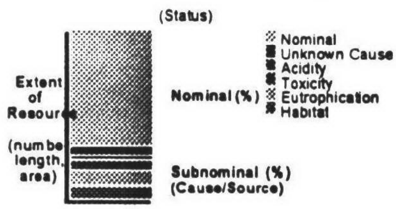
The other products will be the actual assessments that result from the surveys in the West The mid-Atlantic streams and rivers work resulted in a report providing an assessment of the condition of streams in the mid-Atlantic highlands This document is already being used to structure discussions about management and restoration directions in this region of the country Similarly for the inland aquatic resources study, we intend to work collaboratively with our partners to ensure that three levels of assessment are completed State, Regional and West-wide The coastal resources studies will also provide reports of condition at the state, region, and west-wide levels, but will also provide data for the National Coastal Assessment which report on the coastal resources condition for the nation The first state level reports for the coastal studies are targeted for completion by the end of 2001 These assessments can be viewed as examples of what is possible to produce via the Office of Waters 305(b) report to Congress when these indicator, design and analysis tools are adopted

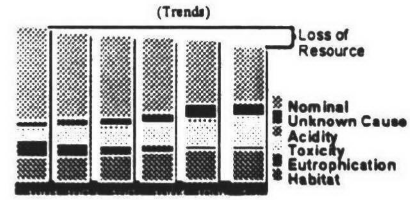
RESOURCES:

Inland Aquatic Systems - This research currently is being conducted with 17 3 FTE, with 11 3 focused on bioassessment issues and 6 on EMAP-West Available to them is $1 05M of research support funds and $3 18M above-infrastructure support This later figure is used primarily to conduct the field surveys and manage the data produced across the 12 western states, above-infrastructure funding is largely transferred via cooperative agreements to the States

Estuarine Systems - The EMAP Western Coastal project and estuarine indicator research is supported by an approximately 5 FTE equivalent effort Research funding consists of approximately $0 3M per year of infrastructure funds from WED The regional field sampling efforts are supported by $1 5M per year of above-infrastructure support administered through the Gulf Ecology Division

Research and Assessment Process
Assessment Questions

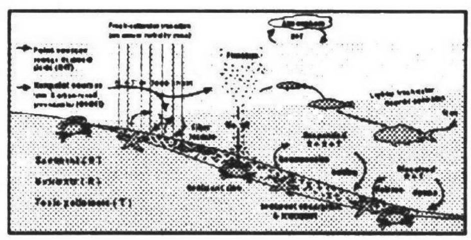




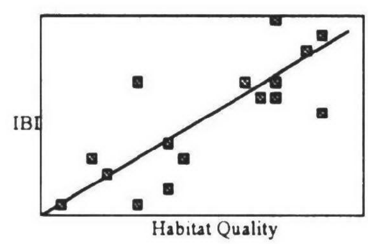
Tools Needed

Indicators

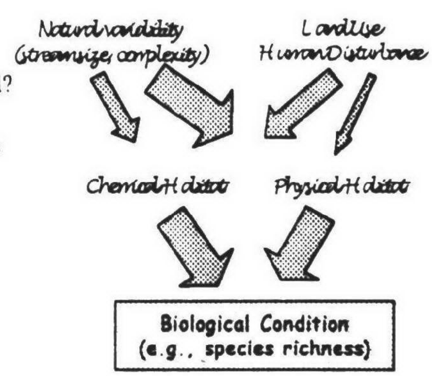
I1. What to measure?
Conceptual models
biotic qualities
stressors



I2. Does it work?
Responsiveness
Uni- & multi-variate



I3. Can we see the signal?
Natural drivers
Anthropogenic forces



I4. What scale do we compare results to?

Design & Analysis

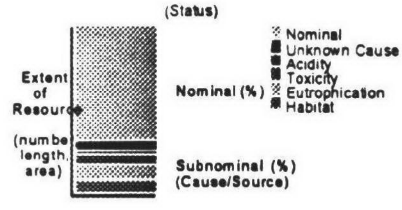
D1. Develop inference approach
sample surveys
model based approaches

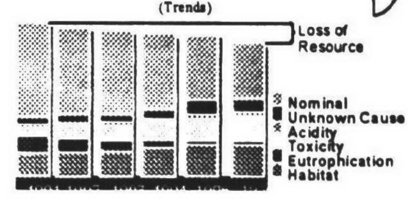
D2. Identify Population and subpopulations.
Describe frequency distributions

D3. Evaluate effect of variability on design
Determine accuracy & precision of status
Evaluate power to detect trends

D4. Develop association approach
Weight of evidence
Multiple regression analyses
Multivariate analyses

Demonstrate tools in regional monitoring and assessment - e.g., MAIA, EMAP-West, R-EMAP, States





Goal 8.1.1 Abstracts – EMAP-Bioassessment

1. Ecological Indicators

Development of an index of biotic integrity for the Mid-Atlantic Highlands Region.

Frank H McCormick, Robert M. Hughes, Philip R Kaufmann, Alan T Herlihy, David V Peck and John L Stoddard

From 1993-1996, fish assemblage data were collected from 313 wadeable streams in the U S Mid-Atlantic Highlands region as part of the United States Environmental Protection Agency's Environmental Monitoring and Assessment Program Stream sites were selected with a probabilistic survey sampling design that allowed regional estimates of stream condition We examined responses of 58 fish assemblage metrics to physical, chemical, and landscape indicators of disturbance Univariate and multivariate analyses of relationships among fish metrics, habitat integrity and anthropogenic disturbance were used to develop a fish index of biotic integrity (IBI) for the assessment of stream condition in the entire region Nine of the 58 candidate metrics were selected and scored continuously from 0-10, the resulting IBI was scaled so that it ranged from 0-100 Regional estimates of stream conditions showed that only 24% of the stream length in the Mid-Atlantic Highlands had fish assemblages in good or excellent ecological condition Thirty-five percent of the total wadeable perennial stream length in the region was fair and 13% was impaired There were insufficient data for calculation of IBI values for 28% of the stream length in the Mid-Atlantic Highlands

Response designs for biological indicators: Sampling adequacy re-visited

David Peck, David P Larsen, Robert Hughes, Yong Cao, Ian Waite, and Scott Urquhart

Developing appropriate indicators of ecological assemblages for bioassessment and biocriteria requires an adequate and representative sample for a particular indicator from each site "Response design" is the interface between the survey design for a particular monitoring effort and the corresponding indicator development Response design refers collectively to the set of statistical, field, and laboratory protocols required to acquire a sample for a particular indicator from each site, such that results remain representative, are consistent with conceptual models of assemblage response to various stressors, and are amenable to indicator development approach and evaluation processes WED is currently evaluating several aspects of response designs for bioassessment including optimizing the level of effort in the field, preparing composite samples (rather than individual replicates) and "fixed count" subsamples, and identifying organisms at "coarser" levels of taxonomic resolution

Optimizing field collection effort for fish Optimizing the level of field effort for aquatic vertebrates (primarily fish) historically has been evaluated after the fact through examination of species-effort curves An alternative approach, based on the similarity among replicate samples, allows an immediate estimation of the proportion of the local species pool sampled, and therefore an indication of sampling sufficiency Results suggest this approach provides a more unbiased approach for standardizing samples from different sites to compare variables based on taxon richness

Macroinvertebrate composite samples and fixed-count subsampling The use of composite samples and fixed-count subsamples for evaluating macroinvertebrate assemblages in streams has increased in recent years Composite samples induce physical averaging in contrast to the mathematical averaging implied by collecting and evaluating individual replicate samples However, subsampling the composite sample can introduce significant variation if samples are not mixed well before subsampling We compared the two approaches using simulation and an appropriate variance components model to illustrate how creating a composite sample can be more efficient than traditional replicate sampling and under what conditions composite sampling might not be effective Additional research shows that fixed-count taxon richness actually estimates number of taxa that occur at a relative frequency of 0 5/n, where n is the number of organisms counted

Influence of taxonomic resolution on assessment results How much information is lost if macroinvertebrate samples are not classified to the finest level of taxonomic resolution is of continuing interest in the bioassessment community WED compared how well family vs genus level classification distinguished among several independently defined stream classes based on both human disturbance and natural features The results suggest that family was as effective as genus if human disturbance was high (i e acid mine drainage, high nutrient loadings), and genus was only slightly more effective if disturbances were moderate (e g , moderate nutrient loadings)

These case studies illustrate the ongoing effort at WED to improve the cost-effectiveness of indicator performance through improved response designs

Multi-Scale, Multi-dimensional Evaluation of Habitat and Biotic Relationships in Streams and Rivers.

Philip R Kaufmann and Dixon H Landers

Physical habitat forms the template upon which biointegrity and native biodiversity depend Habitat structure in rivers and streams is altered through many avenues, including land use changes, resource extraction, hydrologic alterations, and direct channel modifications A major problem facing the USEPA is to quantify relevant aspects of fluvial habitat and relate them to the condition of biotic assemblages found in lotic resources throughout the United States Although the practical approaches for obtaining information about channel and riparian habitat structure differ substantially between wadeable streams and non-wadeable streams and rivers, the important general aspects or dimensions to be considered do not qualitatively differ

1 Habitat space as expressed in river system size and channel volume
2 Water velocity conditions resulting from slope, discharge, and water depth
3 Substrate size, type and stability
4 Channel complexity and cover, including large wood
5 Riparian vegetation composition and structure
6 Riparian land use and human alterations
7 Connectivity among river channel, riparian, and flood plain

All of the seven listed habitat aspects are characterized to an acceptable degree in wadeable streams by observers wading up the channel, making thalweg, cross-section, and bank measurements, estimating the areal cover of fish concealment features in and bordering the channel, estimating riparian vegetation cover and structure, and tallying human land use activities and disturbances in the channel, riparian, and beyond We have applied standardized EMAP field techniques to more than 1500 stream reaches and are evaluating the adequacy of physical habitat indicators in terms of their accuracy in depicting the aspects of interest, their precision based on repeatability of their measurements, and the strength of their associations with aquatic biota and human disturbances

We have developed a relatively rapid field protocol for measuring the seven listed channel and riparian habitat aspects in non-wadeable rivers Simply as a consequence of scale, however, these in-channel observations are less informative in larger channels than in wadeable streams To exacerbate this situation, our more intensive examination of river habitat structure and function suggests that the lateral component of habitat space and complexity may have great importance in large rivers Using 1 12,000 color infrared aerial photographs on sample streams where rapid field evaluations have been made, we are independently quantifying habitat components that have been found to be very important components of the overall riverine habitat complex These habitat components will be evaluated with regard to biotic indicators and other habitat parameters measured *in situ*

2. Ecological Regions

Quantitative Description and Evaluation of Ecoregions of the United States

Tony Olsen, Denis White, Mostafa Shirazi, Jean Sifneos, and Jim Omernik

Ecoregions are areas of similarity regarding patterns in the mosaic of biotic, abiotic, terrestrial, and aquatic ecosystem components, with humans being considered as part of the biota They are intended to serve as a framework for ecosystem management in a holistic sense and allow integration of assessment, research, and management activities across state and federal agencies that have different responsibilities and missions for the same geographic areas Ecoregions are defined by identifying areas within which there is coincidence in patterns of geographic phenomena that reflect spatial differences in ecosystems and their components

In addition to the development of ecoregions at multiple scales, research is being conducted to describe quantitatively ecoregion characteristics Characteristics being investigated include 30- year normal climate, landcover classifications, soils, and topography as well as other factors A major restriction is the availability of national GIS coverages The analysis demonstrates that ecoregions do have different characteristics and typically create more homogeneous units Investigations are continuing to determine if changing ecoregion scale changes homogeneity within ecoregions

When the focus is upon a particular resource, it is helpful to quantitatively describe the linkage between ecosystem properties and the resource Soils are important for food production and water quality, we used the nationwide State Soil Geographic Data Base(STATSGO) to examine the soils of 84 Level III Omernik ecoregions in the United States We described the ecoregions with respect to their boundary characteristics, soil patterns, soil property values and predictability compared with the national averages of soil characteristics of the United States Ecoregions were found to be distinct in these respects and our descriptions related to many ecosystem properties of Level III ecoregions that are understood mainly in a qualitative way

Research is also being conducted to evaluate of the utility of ecoregions in improving the understanding of ecological system characteristic In one study, we tested the correspondence of Level III ecoregions with the distributions of vertebrate species in the two Pacific Northwest states of Washington and Oregon, and in the five middle Atlantic states of Delaware, Pennsylvania, Maryland, Virginia, and West Virginia The vertebrate distributions were provided as presence/absence of each species in EMAP 650 sq km hexagons across the two regions We converted the ecoregion geography to the same hexagon grid To group the vertebrate distributions we used both agglomerative clustering with Ward's method and divisive grouping resulting from regression trees built with species richness as a response variable and explanatory variables representing climate, physiography, land cover, and human stresses We used the Uncertainty Coefficient, Rand Index, Kappa Coefficient and Constanza's goodness of fit statistic to measure agreement between the cluster and regression tree groups, and ecoregions Preliminary results ranged from a high of 65 0% agreement between the clustered mammals and ecoregions in the Pacific Northwest using the Uncertainty Coefficient and a low of 9 9% agreement between herpetofauna grouped by regression tree analysis and ecoregions in the Mid-Atlantic states using the Rand Index

3. Sample Survey Design and Analysis

Statistical Design and Analysis for Aquatic Monitoring

Tony Olsen, John Van Sickle, Mary Kentula, Don L Stevens, Jr., Tom Kincaid, Barb Rosenbaum, and Dave Cassell

Statistical design and analysis is integral to the development of scientifically defensible state, regional, and national aquatic monitoring programs Clean Water Act Section 305(b) requires that USEPA and the states report on the chemical and biological status of all waters within their boundaries Monitoring programs must estimate the stream length, lake area, and estuarine area that meets designated uses within the state This can be accomplished by a census of all waters, or by conducting a probability survey of all waters Our statistical research focuses on improving survey design and analysis procedures to answer these questions

Initial research focused on the development of statistical survey methods appropriate for aquatic resources We extended finite population survey methods to continuous populations Fundamental to this effort was the development of a continuous population version of the Horwitz-Thompson theorem The importance of spatially-balancing a sample across an aquatic resource led to a new probability sampling method - the generalized random tessellation stratified design (GRTS) GRTS can be described as a compromise between simple random sampling and systematic sampling It can be implemented using equal or unequal probability selection, stratification, nested subsampling, panels for surveys over time, subpopulation intensification integrated with an underlying overall population, and provision for over samples when selected sites can not be sampled These features respond to the issues identified in working with state monitoring agencies We also have developed algorithms for selecting sites using the GRTS A critical part of the research is the corresponding development of design-based estimators to match the GRTS design In particular, we developed a new neighborhood variance estimator and have demonstrated that it can lead to improved precision estimates

A probability survey design requires a sampling frame to implement a survey for an aquatic resource In some cases this is straightforward, such as a list of specific lakes In others, it is difficult, such as constructing a GIS coverage of all wetlands in a state We are creating a national stream and a national lake sampling frame based on the National Hydrologic Database We are also investigating approaches for constructing frames for wetlands based on studies in the Nanicote and Juniata watersheds

Design-based estimators provide answers to many of the key objectives for monitoring Other questions require the development of model-based estimation approaches An example is the spatially-explicit estimation of fish community characteristics for all streams within a study region, e g the Willamette Valley We are investigating regression-based procedures to determine if this is possible given the auxiliary data that is available for the entire stream network An alternative Bayesian hierarchical modeling effort will be investigated in the Willamette Valley and the Mid-Atlantic

We provide technology transfer to States, EPA Regions, Tribes, and Office of Water on survey design methodology This occurs through our completing survey designs for their monitoring programs and supporting their statistical analysis by providing SAS and S-Plus functions Working on actual survey designs provides a rich array of problems which directs where our research efforts are focused We have developed a web page to aid our technology transfer efforts http //www epa gov/wed/pages/EMAPDesign/
index htm

Effects of spatial and temporal variation on the estimation of regional status and trends for lakes and streams

David P Larsen, N Scott Urquhart, Tom M Kincaid, and Phil Kaufmann

Spatial and temporal variation and variation introduced by making measurements affect our ability to describe the status of natural resources and to track changes or trends Understanding both the relative and absolute magnitudes of these components of variation among various indicators allows us to evaluate and modify our designs as a monitoring program progresses as well as to inform others about the potential success of current designs Also, by quantifying the important sources of variation, we can better choose indicators for various monitoring objectives We identify four major variance components as follows

Variation among lakes or streams

An important objective of regional surveys is to estimate true differences among lakes or streams with respect to key indicators Variation in lake surface area or volume across a population of lakes in a region is a clear example of inherent differences among lakes The status of a regional population of lakes or streams can be described as the frequency distribution of indicator scores representing these differences

Year-to-year temporal variation

Year-to-year temporal variation is superimposed on innate differences This temporal variation consists of two parts, a coherent component and an >interaction= component The coherent component (year variance) reflects consistent yearly variation in the indicator scores across all the lakes or streams For example, temperature in a set of lakes might be consistently higher than normal during a warm summer, but consistently lower during a cold summer An underlying regional trend would also appear as part of this component of variation The second temporal component, interaction variance, is the independent year-to-year variation at each lake or stream It arises from local, site-specific forcing factors such as the variation in water, nutrient, or sediment inflows to a stream The combination of these factors, as well as others, causes differential temporal responses among indicators across a regional population of lakes or streams

Index variation

The remaining variation is combined into a category called index variance Sampling often occurs over a specified temporal window, an index period Index variance captures this local-scale within-year temporal variation It also includes local spatial variation, measurement error (both in the field and during subsequent laboratory sample processing), and crew-to-crew differences in applying the same sampling protocol

We illustrate the use of this framework along with estimates of the relevant variance components to compare the performance of

1 A variety of chemical and biological lake indicators potentially useful for estimating regional lake status, and
2 Several common stream physical habitat indicators for trend detection

4. Ecological Assessment

Mid-Atlantic Highlands Streams Assessment

Steven G Paulsen, John L Stoddard, Alan T Herlihy, Kent Thornton, and Tom DeMoss

The primary purpose of this assessment and the monitoring on which it is based, is to provide an unbiased evaluation of the biological quality of streams in the mid-Atlantic highlands region of the U S and a view of the relative ranking of anthropogenic stressors impacting these streams During 1993 and 1994, almost 500 stream locations were sampled for biological, physical, chemical and watershed information The stream locations were selected using a sample survey design (a k a probability survey) so that inferences about the total stream resource in the highlands could be made from the sample Over 31% of the stream length was determined to be in poor condition based on fish assemblage information while 27% of the length was rated as poor based on the aquatic invertebrate indicators Conversely, 17% and 25% of the stream length were found to be in good condition based on fish and invertebrate assemblage indices, respectively Riparian habitat degradation and in-stream sedimentation were major stressors throughout the region High nutrient concentrations were local rather than regional problems The extent of the biological degradation varied by geographic region of the highlands with the north-central Appalachian ecoregion showing the greatest impairment The relative ranking of stressors also varied by ecoregions suggesting that, to be most effective, protection and restoration strategies should vary with geographic area of the mid-Atlantic highlands

Recovery of lakes and streams from acidification: regional trends in North America and Europe, 1980-95

John L. Stoddard, Dean S Jeffries, Anke Lukewille, and Brit Lisa Skjelkvåle

We describe regional trends between 1980 and 1995 in indicators of acidification (alkalinity, and sulfate, nitrate, and base cation [C_B] concentrations) for 205 lakes and streams in North America and Europe Dramatic differences in trend direction and strength between the two decades prompted us to examine trends separately for the periods 1980-89 and 1990-95 Regional groupings were based on site geographic proximity, chemical homogeneity, and similarity in atmospheric deposition patterns during the 1980s and 1990s In concordance with general trends in acidic deposition, decreases in lake and stream SO_4^{2-} concentration were universal across regions, with most exhibiting stronger downward trends in the 1990s than in the 1980s In contrast, regional changes in NO_3^- were dominated by increases in the 1980s and decreases in the 1990s Recovery in alkalinity, expected from strong regional declines in SO_4^{2-}, was observed in all regions of Europe, especially in the 1990s, but in only one region of North America The lack of recovery in three regions (South/Central Ontario, the Adirondack/Catskill Mountains and Midwestern North America) was attributable to strong regional declines in C_B, which exceeded those measured for SO_4^{2-} The similarity of the current trend patters in these three regions to those observed in the Nordic Countries in the 1990s, where recovery is now occurring, suggest eventual increases in acid/base status may follow after some as yet unpredictable lag in recovery

EMAP-West

Roger Blair, John Stoddard, Walt Nelson, Dan Heggem, Tony Olsen, and Steve Hale

The Environmental Monitoring and Assessment Program (EMAP) is one of the key components of ORD's research to support the Agency's role in promulgating the Clean Water Act EMAP-West is the newest regional research effort in EMAP From 1999 through 2005, EMAP-West will seek to develop and demonstrate the tools needed to measure ecological condition of the aquatic resources in the 14 western states in EPA's Regions 8,9, and 10 The primary demonstration vehicle will be a series of reports on the ecological condition of water resources at the state and regional level The transfer of monitoring technology to regional, state and tribal personnel is the intended legacy of EMAP-West

EMAP-West consists of several components **Design and Analysis, Coastal, Surface Waters, Landscapes and Information Management** The **Design and Analysis Team** is responsible for the working with the resource groups to define the sample population and subsequent design by which field data are collected Data analysis is primarily the responsibility of the resource groups, but they will require statistical support from the

Design and Analysis team The **Coastal** component sampled small coastal estuaries in Washington, Oregon and California during 1999 and 2000 In 2001/2, Alaska and Hawaii will be the focus for field sampling while analysis of 1999 and 2000 data for the other states is underway **Surface Waters** began sampling in the 12 state area covered by EPA Regions 8,9, and 10 (Alaska and Hawaii not included) in 2000 The sampling design calls for sampling of streams (except the "great rivers," Columbia, Colorado and Missouri) that is adequate for making a statistically sound estimate of condition at the state level **Landscape** data are collected are collected via remote imagery across the entire west, unlike the sampling regime used by Coastal and Surface Waters The main source of data is the Multi-Resource Land Classification (MRLC) covering the entire western United States From these data and other remote sensing sources, indicators of landscape status will be generated and their values associated with aquatic indicators of condition Finally, the **Information Management** component of the Program dedicated to assuring that all data collected in EMAP-West are fully documented and made available to the public in accessible formats, according to national data management standards The individual data sets from the resource groups will be added to the EMAP web site, EPA's Office of Water STORET database and ORD's Environmental Information Management System

5. EMAP Coastal Research

Development of Indicators of Estuarine Condition

Bruce Boese, Ted DeWitt, Janet Lamberson, Henry Lee, Walt Nelson, Jim Power, David Specht, and David Young

The EMAP Western Coastal Pilot has adopted a set of indicators of environmental condition derived from experience in east coast estuaries PCEB is evaluating additional indicators of relevance to western estuaries, including seagrass distribution, degree of invasion by nonindigenous species (NIS), benthic amphipod composition, and morphometric perturbations of juvenile flatfish

Seagrass distribution is being evaluated as an estuarine scale indicator integrating several aspects of estuarine water quality Seagrass indicator research is strongly tied to Goal 2 seagrass efforts Research seeks to define a theoretical baseline condition for *Zostera marina* for PNW estuaries by defining the lower depth limit as set by water column light availability, by establishing determinants of the upper intertidal boundary, and by determining spatial variation due to wind-generated wave stress, sediment type and quality, salinity tolerance, and extent of potential biological competitors Actual seagrass distribution will be determined and compared to the theoretical distribution using aerial photography, various SONAR technologies, and underwater video on towed sleds and ROV's

The alteration of coastal systems by NIS is of steadily expanding concern A variety of indicators of impact of NIS are being evaluated for use as part of the Western Coastal Pilot, including percent abundance of NIS, percent frequency of NIS, percent of total species composed of NIS, number of NIS species, and density of NIS

Two indicators are currently in the developmental stage Amphipods are among the most sensitive of benthic invertebrate taxa to sediment contaminants, and as a result, are standard laboratory bioassay organisms Research is being conducted to determine whether changes in benthic amphipod assemblage can be used as a field indicator of stress in the estuarine benthic community Impacts to amphipod may result in impacts to higher trophic levels such as fish (including salmonids) As an indicator at the consumer level, the thin plate spline method of morphometric analysis is being applied to estuarine flatfish to determine its utility for detecting environmental stress

EMAP-West Coastal Pilot

Walt Nelson, Henry Lee, Janet Lamberson, and Dixon Landers

The EMAP Western Coastal Pilot Project is a five year program designed to 1) assess the condition of the coastal ecosystems of the West Coast, and 2) build the scientific basis and increase the ability of local, state and tribal agencies to monitor the status of Western coastal ecosystems Sampling of small coastal estuaries of Washington, Oregon and California began in 1999, with sampling of the larger systems (Puget Sound, Columbia River, San Francisco Bay) conducted in 2000 Two intensification studies that were integrated into the overall design were also conducted in 1999 Possible impacts of a large dairy industry were assessed in Tillamook Bay, Oregon Condition of Northern California small, river dominated estuaries was compared between TMDL versus non-TMDL listed systems

Hawaii will assess coastal condition along the main island chain in 2001, and will conduct an intensification study of urbanized estuaries of Oahu in 2002 Alaska will conduct a survey of the coast line of south central Alaska in 2002, with intensification studies in Cook Inlet and Prince William Sound Washington, Oregon and California will sample tidal wetland habitats in 2002 The Western Coastal Pilot will complete field work with a survey of benthic condition of near coastal waters on the continental shelf in 2003

The 1999 Western EMAP results are being used to assess the use of nonindigenous species as a condition indicator for the soft-bottom benthic communities of west coast estuaries The biogeographic pattern of invasion and the relationship of invasion to estuary size has been examined The "small" West Coast estuaries are moderately invaded compared to the highly invaded San Francisco estuary Based on percent abundance and percent species, Oregon and Washington estuaries have more invaders than California systems Estuaries less than 1 km^2 were the least invaded size class in Oregon and Washington, but were equally or more invaded than the larger size classes in California

These results the utility of incorporating probabilistic sampling into the national monitoring for invasive species that is called for by the National Invasive Species Management Plan

TERRESTRIAL HABITATS: EFFECTS, MODELING, AND EXTRAPOLATION

GOAL 8.1.1.2 ECOSYSTEM PROTECTION—PROCESS MODELING-EFFECTS Under GPRA Goal 8, EPA's ecological research program seeks, through scientific leadership, to increase understanding in order to assess, improve, and restore the integrity and sustainability of ecosystems over time Specifically, research in this area—Processes and Modeling Research—will develop models to understand, predict, and assess the response of ecosystems to multiple stressors at multiple spatial and temporal scales

AGENCY PROBLEM

By 2008, ORD is committed to develop a new generation of environmental modeling tools to protect ecosystems at the local, watershed, and regional scales These models will support decision makers in their efforts to make better ecologically sustainable choices

To address these objectives, NHEERL has developed an Implementation Plan for research to address wildlife population endpoints through terrestrial habitat quantity, quality, and distribution and as affected by multiple stressors across many temporal and spatial scales The plan calls for WED scientists to take the lead in terrestrial habitat and wildlife population modeling while collaborating with the other Ecological Research Divisions to address the overall Agency problems

Under these plans, this research project will respond to Program Office needs in three specific problem areas First, the Scientific Advisory Panel for the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) specifically recommended that the Office of Pesticide Programs conduct probabilistic assessments of risks to ecosystems associated with pesticide use Second, the Office of Prevention, Pesticides, and Toxic Substances needs efficient methods, including models, to review, register, regulate thousands of chemicals in a timely fashion Finally, the Office of Water has a need for improved methodology for probabilistic assessment of the impact of habitat alteration on aquatic-dependant terrestrial wildlife Thus, while the research is conducted under Goal 8, it specifically supports activities under Goal 2, Aquatic Habitat, and Goal 4, Safe Communities/Pesticide Effects

SCIENCE QUESTIONS

There are common threads to the Agency problems that we have identified all three can be addressed by developing models that relate stressor exposure to effects on wildlife populations through effects on the structure and function of plant communities and ecosystems, and all three require the ability to extrapolate effects in biological scale, space, and time We have identified three over-arching questions to guide our research First, do changes in habitat quantity, quality, and distribution explain quantitative changes in wildlife populations?, Second, what are the characteristics of habitat that are susceptible to stressors, resulting in changes in diversity, foodweb structure, and ecosystem function? Third, what is the likelihood that stressor exposure will affect non-target animal and plant species over variable spatial and temporal scales?

To address these key questions, and the Agency problems, we propose the following specific science questions be addressed in our research

1 How do wildlife populations respond to anthropogenic stress?

2 How do we utilize data collected at one biological level (e g , the individual) to protect at a different level (e g , populations, landscapes, or regions)? Specifically, how can response to stressors in individuals be extrapolated to populations, communities/assemblages, ecosystems, and regions, and how can uncertainty in the response of individuals to stressors be quantified and propagated through spatial and temporal extrapolations?

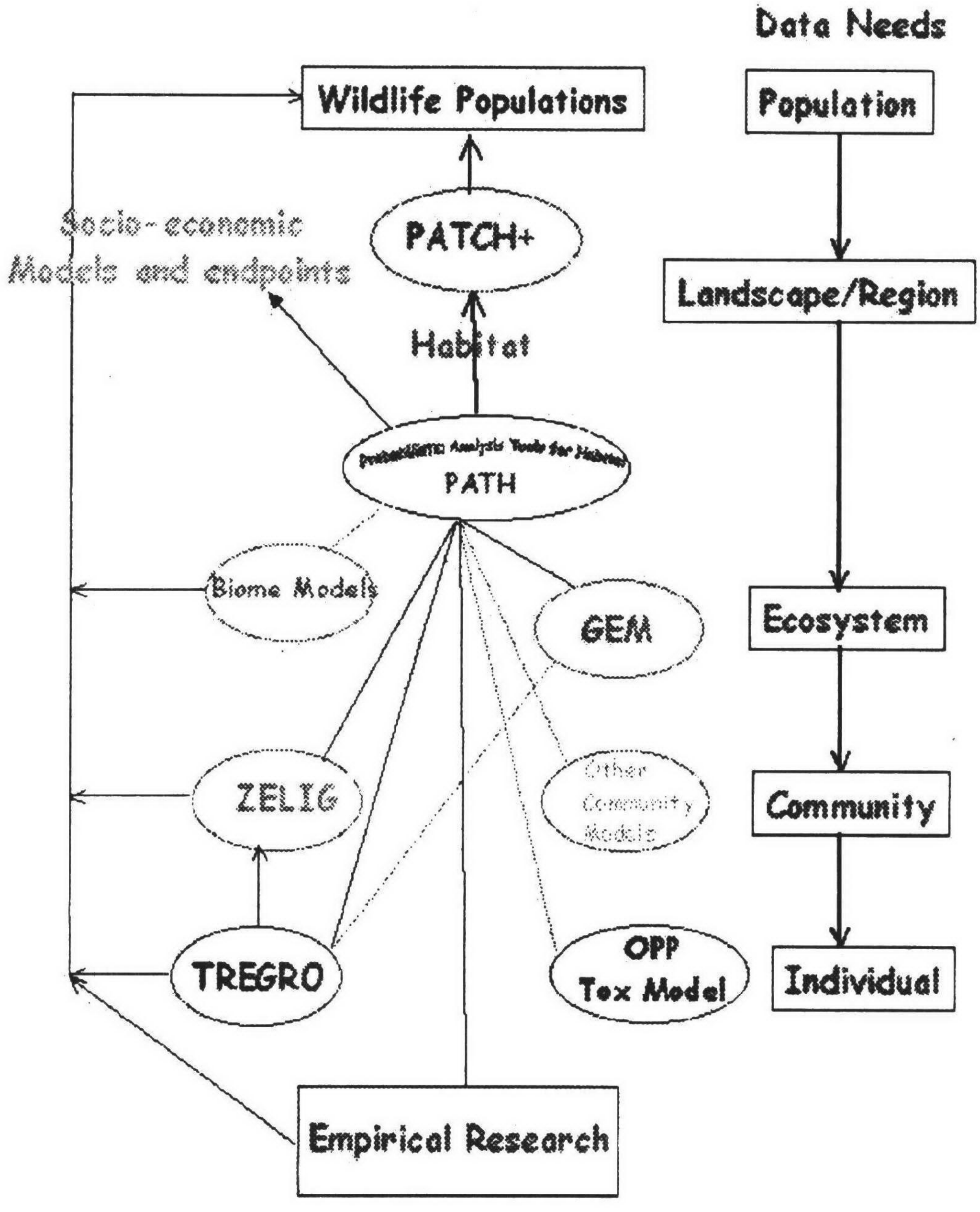
3 What are the mechanisms by which stressors affect critical habitats?

4 What characteristics of structure and function of habitat affect populations of aquatic-dependent terrestrial wildlife?

5 How do interactions among stressors, or between stressors and the natural environment, influence the above questions?

RESEARCH APPROACH

We will address the Agency problems through the development and use of simulation and statistical models at a number of levels As mentioned above, our research is a part of a much larger, multi-divisional (and most likely multi-laboratory) effort to understand stressor effects on wildlife We will take the lead in modeling terrestrial habitat and wildlife The figure below provides an overview of our approach It is important to note that the framework we describe is amenable to input from a variety of research efforts, including those underway at Program Offices, other laboratories, our other NHEERL collaborators, and the scientific community at large



In the figure above, ovals represent existing or proposed models. GEM, other community models, and the OPP Acute Toxicity Model, may also directly address wildlife populations as indicated for TREGRO, ZELIG, and biome models–the connecting lines are not shown.

Essentially, we propose to bring together a series of models that we currently use, other existing models from the literature that address our specific problems, and new models that we will develop to fill critical gaps in our understanding Empirical research will be driven by the needs of the models we link to address our research problems The resulting tools will quantify the effects of stressor exposure on wildlife populations and scale those effects through space and time

At the first level, we will use wildlife population models to study how birds initially, and other vertebrates later, are affected by anthropogenic stressors in the environment We completed a prototype model, PATCH (a Program to Assist in Tracking Critical Habitat) in 1998 (Schumaker 1998) PATCH is a spatially-explicit probabilistic model that tracks the effects of changes in habitat quality and pattern on populations of territorial birds and mammals having a single set of habitat requirements Over the next five years, PATCH will be adapted to capture species interactions and to address a broader array of taxa and other stressors (in particular chemical contaminants and introduced species)

In PATCH, the influence of the landscape on wildlife populations will continue to be mediated through the individual The behavior and contribution of each individual to the population will be affected by its survival rate, reproductive rate, and ability to locate a suitable breeding site The individual organism will respond to both landscape quality and pattern, which may change through time Organisms will also respond to the presence of other individuals, which will allow the model to capture the influence of invasive species by tracking competitive and predator-prey relationships

The presence of contaminants or invasive species in portions of a landscape will initially be modeled as changes in habitat quality, which in turn lower the fertility, survival, or dispersal ability of organisms trying to utilize the affected areas A stressor-exposure module will be added since the exposure of individuals moving through contaminated or altered areas could change their vital rates on a temporary or permanent basis, even after those individuals have left the site or the area has been restored

The PATCH model will not deal with contaminant fate and transport, but could be linked with other models that do This modeling approach can be applied to address "what if" scenarios regarding the spread and attenuation of contaminants on the landscape, altering habitat quality according to distance from source, time of year, or time since the contamination took place At the same time, it will be important to keep in mind the inherent limitations in such a model's ability to track the action of the contaminants For instance, there are likely to be many consequences for wildlife of exposure to toxins that cannot be meaningfully collapsed into an effective change in habitat quality

A critical input for PATCH is the distribution of habitat in space and time, which depends, to a great extent, on the structure and function of vegetative communities At the next level of our research, we propose to build PATH—Probabilistic Analysis Tools for Habitat—to predict features of habitat through biological and chemical processes Through this research, we will address the problem of biological and temporal scaling PATH will initially be one or more probabilistic hierarchical models of vegetation development on a landscape as affected by stressors Specifically, we will develop a mathematical approach in which the growth of vegetation will be simulated using a simple carbon budget model embedded in a Monte Carlo framework Monte Carlo techniques have been used successfully to quantify the relative contribution of the uncertainties in model inputs at lower levels of ecological organization to the overall variance and range of model results for plant productivity at the stand and regional levels (Smith et al , 1998, Woodbury et al , 1998, van der Voet and Mohren, 1994, Graham et al , 1991, Dale et al , 1988)

Our proposed methodology uses a minimal model structure of physiological processes that may include photosynthesis, transpiration, respiration, allocation, phenology, litter production, decomposition, and nitrification along with monthly time step climate data to predict the annual growth rate of species of interest The processes modeled will depend on the species or community to be simulated Data from the published literature as well as from our empirical research will be synthesized and integrated to identify basic mechanisms controlling the acquisition and utilization of resources and the stress-induced compensatory changes to resource allocation for individuals of different ages

Because of the form of PATH, input can be supplied from other models as well as from empirical research and published data For instance, other validated simulation models of appropriate species or communities could be used to produce stressor exposure-response functions for use in PATH This allows us to use vegetation models at the individual, and community levels, and ecosystem models, to provide summary functions of important mechanisms and processes to PATH Thus, we will be able to build on the capabilities we have developed in linking individual, community, and ecosystem simulation models as we develop these new tools While we have substantial experience with a set of models we have used over the last 10 years (i e TREGRO, ZELIG, and GEM), other models will be added, as needed, to address the individuals, communities, and ecosystems appropriate to our endpoints

For temporal and spatial extrapolation to the landscape and regional scale, data on present community structure and growth, species composition and distribution, and quantitative effects of stressors on vegetative growth rates will be used as model inputs with uncertainty These uncertainties reflect either gaps in our knowledge or inherent variability in the model inputs and are incorporated in the probabilistic hierarchical model as stochastic variables with assigned probability density distributions For example, experimental results provide summary functions relating individual plant response to one or more stressors and are transformed to stochastic functional relationships by allowing any or all parameters, or the function itself, to be defined in terms of probabilities

At the most fundamental level, empirical research will be conducted to provide the information needed for model development and improvement Research will be targeted at critical processes and at mechanisms that are poorly understood and, therefore, control uncertainty in the models These studies are important *vis à vis* the last three specific science questions described above as there is little known about the interaction of stressors and about stressor influence on the control of structure and function of habitat We believe both of these areas are critical in order to model correctly the quality, quantity, and distribution of terrestrial habitat and dependent wildlife populations

WED has outstanding capabilities in the areas of whole-plant physiology, ecophysiology, soil science, and nutrient cycling We will use these capabilities to address the information gaps in the models

RESEARCH PRODUCTS

The primary products of this research will be tools useful for program offices to address Agency problems We anticipate producing a probabilistic modeling framework, adaptable to a variety of biomes or ecosystems This framework will address multiple stressors and be flexible enough to address new Agency problems as they evolve In addition, we expect to build linkages between existing or new simulation models to allow extrapolation across biological, spatial, and temporal scales The progress of this research will be published in peer-reviewed journal papers and reports, as well as presented at national and international scientific meetings

TIMELINE:

This is a new project, building on the capabilities of the division in simulation of wildlife, ecosystems, and habitat, scaling and extrapolation, and plant physiology In the next 12 months, a peer-reviewed research plan will be put in place We expect the first phase to last 5 years During that time, we will build linkages between existing models (years 1 and 2), parameterize existing models for new ecosystems and biomes (years 1 and 2), select additional models for use (year 3), modify and improve PATCH (years 1 through 3), and develop PATH (years 1 through 5)

RESOURCES

Fifteen scientists providing about 10 FTE (+1 IPA) are currently associated with this research In FY 2001, approximately $520,000 was available to support their efforts

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ABSTRACTS: GOAL 8.1.1.2 TERRESTRIAL HABITATS: EFFECTS, MODELING, AND EXTRAPOLATION

Presentations of research in Goal 8 1 2 will begin with two interactive posters that establish our capabilities in the areas of individual, community, and ecosystem modeling, as well as scaling and extrapolation across biology, space, and time The first abstract describes the effort to parameterize MBL-GEM for several ecosystems The second abstract lays the background for our multi-scale modeling efforts The remaining abstracts describe future directions for research planned under this goal

Forest Ecosystem Indicators: Monitoring, Assessment, Prediction (FEIMAP)

David T Tingey, Robert B McKane, Mark G Johnson, Peter A Beedlow, William E. Hogsett, Jana Compton, and Ronald S Waschmann

Our objective is to develop ecological indicators for Pacific Northwest forest ecosystems to (1) predict and/or assess the response of forests to anthropogenic stressors, (2) detect and quantify changes and trends in forest condition, (3) link changes in condition to likely stressors, and (4) identify early warning measures for loss of integrity and sustainability of ecological resources Our approach has been to develop, test and apply process-based simulation models for use as ecological indicators at scales ranging from the individual/populations to landscapes A major focus is to parameterize and test the MBL-General Ecosystem Model (GEM) for this purpose MBL-GEM is a lumped-parameter model of carbon, nitrogen and water cycling in terrestrial ecosystems that has successfully been applied to temperate, tropical and arctic ecosystems To constrain MBL-GEM for the broad range of biotic, edaphic and climatic conditions found throughout the Pacific Northwest, we are collecting detailed biogeochemical and climatic data for 10 field sites located across a 230 km transect in west central Oregon The parameterized model will then be tested against data collected across a west-to-east transect of four sites in the Olympic National Park (ONP) in Washington Data for all the field sites describe the distribution and fluxes of carbon and nitrogen among the various vegetation and soil compartments and concomitant changes in environmental drivers for 2 to 5 years We have emphasized collection of process-level data, i e , net primary production, nitrogen uptake and retranslocation by vegetation, detritus production, soil respiration, gross and net mineralization of soil nitrogen, soil nitrogen retention using 15N tracers, leaching of soil nitrogen, and soil water dynamics The ONP sites are intended to provide a severe test of the parameterized MBL-GEM because they represent biotic, climatic and edaphic conditions outside the range of conditions found at the Oregon sites The tested model will be then be used to assess how specific scenarios of environmental change will affect ecosystem processes and function The results for the modeling activities will provide input to the PATH model to incorporate the effects of various stress factors on habitat Further, the successful parameterization of MBL-GEM across a broad range of biomes including tundra, wet temperate forest, dry forest-shrub, and grasslands, provides an excellent tool for predicting ecosystem productivity and habitat value

Extrapolating Anthropogenic Stress Effects: Individuals to Forests, Ecosystems, and Regions

William Hogsett, John A Laurence, Christian P Andersen, J Renée Brooks, Jana Compton, John Fletcher, Jillian Gregg, E Henry Lee, Robert McKane, Thomas Pfleeger, Donald L Phillips, Paul Rygiewicz, D T Tingey, and Lidia Watrud

Understanding the effects of air pollutants and global change on vegetation to provide the scientific basis for legislative mandates such as the Clean Air Act has involved collection of experimental data on species at the individual and population levels However, the scale of the resources protected under this Act is the scale that is the least experimentally tractable—communities, ecosystems, and regions As a result, data from experimental studies at biological, temporal and spatial scales that are tractable are extrapolated with varying degrees of uncertainty to scales that are not amenable to experimentation To make these extrapolations with acceptable certainty, underlying biological mechanisms must be understood and then linked through conceptual and computational models to address the scales of interest Our fundamental goal has been to understand the processes that control the function of important ecosystems and watersheds and to be able to use that understanding to predict system character and integrity across larger spatial and temporal scales

To meet this goal our focus has been on the following objectives

1) Determine the relationships between the above- and below-ground components of a plant community, based on information derived at a reduced

2) Characterize the resource acquisition/utilization across biological scales considering above- and below-ground components of the community

3) Develop linkages between models of individual and community growth and biogeochemistry to aid in the interpretation of experimental observations and measurements and to provide a linkage from individual- and community-specific information to longer and larger temporal and spatial scales

The following accomplishments will contribute significantly to the proposed new research on terrestrial habitat

1) We developed improved functions and parameter sets for TREGRO, a process based individual tree (perennial plant) growth model for a number of species and used these to simulate ozone and/or CO_2 impact on tree growth across the range of a number of species

2) We linked TREGRO with ZELIG, a forest community model, to estimate impact of anthropogenic stressors on stand composition over 100 years

3) We developed a GIS framework with data layers of stressor exposure, climate, nutrient availability, species extent, and model-derived exposure-response functions with relevant landscape factors to estimate effects on growth and stand composition across spatial and temporal scales

4) We have conducted studies of processes identified as sensitive to pollutant impact for improvement of individual (TREGRO), stand (ZELIG) and ecosystem models (MBL-GEM), including (a) studies of belowground linkages between trees of different ages and stands for nutrient and carbon flow, (b) studies of root turnover and root demography for improving

TREGRO ability to simulate growth in different age trees, (c) studies of tree age/size and carbon and nitrogen acquisition and allocation with anthropogenic stressors such as ozone and natural stresses such as water and nitrogen availability, and (d) studies of water acquisition and redistribution with size/age of trees and stands

This research will provide input to developing a probabilistic hierarchial model of forest growth to be used in conjunction with GIS for spatial extrapolation of our hypothesized processes and for estimation of uncertainties in predictions of impact of anthropogenic strèssors of species on wildlife habitat or other ecosystem services such as water quantity/quality

Modeling Capabilities, Mission, and Goals (Science Questions 1, 2, and 3)

John Laurence

WED has a long history of using simulation models to address critical Agency problems Our modeling efforts extend from statistical models of single plant functions (e g Yield, leaf area), to simulations of individual plants, plant communities, ecosystems, and wildlife populations Division researchers have led the way in developing methods to extend simulation results by extrapolation and interpolation of stressor exposure-response The results of our research have been used by the Office of Air Quality Planning and Standards within the Agency to address significant policy issues

Currently, we use and link the outputs of simulation models of individuals, communities, and ecosystem biogeochemistry to understand vegetation productivity and community structure and how carbon, water, and nutrients cycle in ecosystems under stress Further, we use real or hypothetical distributions of vegetation to drive models of wildlife populations We collect empirical data to better understand the processes we are modeling and to reduce uncertainty in our estimates

Under this research area, we have the opportunity to integrate our skills in plant and animal modeling, ecosystem simulation, and spatial scaling to predict the distribution, quality, and quantity of wildlife habitat as affected by stressor exposure We will develop models that quantify the uncertainties associated with our predictions—a feature that will contribute to the credibility of risk assessments performed by the Agency and that will guide our empirical research as well The presentations that follow will describe our past accomplishments to illustrate our capabilities and will outline our future directions

Wildlife Population Modeling (Science Question 1)

Nathan Schumaker

As part of WED's Pacific Northwest Ecological Research Consortium (PNW ERC) research effort, a model was developed to evaluate the response of terrestrial vertebrate species to past and future landscape change The result, the PATCH model, is a stochastic, individual-based spatially, explicit, life history simulator designed for territorial wildlife species This modeling effort is continuing as part of NHEERL's Wildlife Research Strategy and under Goal 8-062

A principal goal of this research is to better anticipate the consequences for wildlife populations of multiple interacting stresses, including habitat alteration, toxic chemicals, and invasive species, acting at large (watershed to regional) scales The approach being developed was designed to help EPA better meet its goal of extending its risk analyses from the level of the individual organism up to populations or sub-populations The PATCH model is an ideal tool for this investigation because it works with digital maps of real or predicted landscapes, and it follows every member of a population individually The model links each individuals' survival and reproductive rates, and their movement behaviors, to the quality of habitat currently occupied Habitat quality is allowed to change through time, and the consequences of landscape alteration for a population are built up from an aggregation of individual responses to changes in the local environment

Future work will include building more flexibility into the life history simulator so that PATCH can be used with a wider range of species We will also develop a new module designed to simulate the application of multiple chemical compounds, with differing toxicities and decay rates, to various portions of a landscape The model will track the exposure of individuals as a result of patterns of movement and chemical application, and changes in chemical toxicity taking place through time The fate of a population will be determined not only by individuals' ability to locate and remain in high quality habitats, but by their histories of exposure to the various chemical compounds as well A second module will be added to permit the simulation of species interactions This feature will greatly improve PATCH's applicability to meaningful risk analyses, since in many instances the impacts of invasive species rival those due to habitat loss Such analyses might uncover consequences of the patterns and timing of chemical applications that could never be identified from the kind of traditional risk analyses conducted by the Agency

Finally, linked with vegetation models under development, PATCH will make use of the probabilistic analysis of habitat quality and distribution to predict likely effects of stressors on wildlife populations

The General Ecosystem Model: Linking biogeochemical stress responses to habitat change. (Science Question 2)

Robert McKane, David Tingey, Mark Johnson, Peter Beedlow, William Hogsett, Jana Compton and Ronald Waschmann

The ability to predict changes in the structure and function of terrestrial ecosystems is an important component of assessing stressor effects on fish and wildlife populations This capability is particularly important where multiple stressors can act synergistically over long time-scales to alter terrestrial habitat and downstream water quality As part of the PATH (Probabilistic Analysis Tools for Habitat) modeling framework, we are using the General Ecosystem Model (MBL GEM) to predict features of habitat subject to changes in biogeochemical processes The MBL-GEM is a process-based model of terrestrial ecosystem carbon, nitrogen and water dynamics that simulates the responses of plants and soils to changes in atmospheric CO2, temperature, precipitation, irradiance, nitrogen deposition and management Our current work is focused on developing MBL-GEM as a risk assessment tool for major habitat types (biomes) within several regions across North America, including the Pacific Northwest, Great Plains, and Alaskan arctic For each of these regions, our approach is to develop a single, well-tested parameterization of MBL-GEM responsive to natural environmental gradients, climate change and other stress factors For example, our work in the Pacific Northwest aims to develop a single parameter set of MBL-GEM that can be applied with confidence to all major forest types (coastal rainforest to semiarid savanna), soils, and climatic conditions within the region By providing a synthesis of our empirical data (20 field sites in Oregon and Washington), the 'regionalized' MBL-GEM will be used to predict how specific environmental changes will affect ecosystem structure and function Specifically, we will use the model to predict changes in vegetation productivity and growth form under different management and climate change scenarios We will also use MBL-GEM to predict changes in nitrogen and water outputs from forests, thereby providing a means for assessing how stress effects may affect downstream aquatic ecosystems Output from MBL-GEM will provide key biogeochemical stress responses for the PATH model so that spatial and temporal changes in habitat can be more accurately predicted

Probabilistic Hierarchical Modeling and Uncertainty Analysis (Science Question 3)

Don Phillips, E Henry Lee, John Laurence, and Nathan Schumaker

Two key problems in assessing the effects of stressors on terrestrial habitat for wildlife populations are how to scale these effects up to larger areas, and how to account for variability in component processes and their propagation to affect overall uncertainty of response We will focus on stressor responses of vegetation, which provides the basic physical habitat structure for wildlife populations In developing a general modeling tool for assessing stressor effects on habitat, parallel efforts will be directed at a forest case and an agricultural or grassland case Probabilistic hierarchical modeling and uncertainty analysis represent an approach to scaling our knowledge of specific processes, gained through experimentation or mechanistic modeling, to larger biological assemblages (e g , individual plant to field to landscape) In essence, a reduced-form model, based on the collection of processes we deem critical, and the associated variability, either measured or hypothesized, is built to describe vegetation growth under a variety of environmental conditions The model is then run many times in a Monte Carlo simulation to generate a distribution of outputs that describe the range of vegetation responses to the prescribed conditions

To take advantage of work already well underway, our initial application of this approach will be to examine the response of ponderosa pine growth, over its entire U S geographic range, to stressors including elevated CO2, climate change, and ozone Ponderosa pine is very widely distributed in the western U S and the characteristic openness of its mature stands provides a unique habitat for many wildlife populations At the individual level, a simple C budget model will be used to mathematically formulate the linkages between stressors and plant processes The C budget model will link published experimental and model simulation results on the amount of C allocated to assimilation, respiration, turnover, and growth of different plant parts over time, and how those processes are affected by specific stressors Separate simulations will be done for individual trees of a number of size classes Extrapolation from the individual level to forest stands and the species' geographic range will be based on data from the USDA Forest Service FIA database This database will provide historic growth rates for each tree size class under current stressor levels at different points across its range Additional stressor scenarios will be imposed and Monte Carlo simulations of the individual C budget model will provide a distribution of growth rate responses Stand level responses will be aggregated from individual tree size class responses based on stand structures in the FIA plots, which will in turn be aggregated to produce landscape level responses in a GIS framework Stressor scenarios will be imposed on a 0 5 degree grid to allow realistic spatial variations, such as VEMAP climate scenarios

At the same time, we will select and begin work on an application of this modeling framework in an agricultural or grassland setting We hope through these applications to develop this probabilistic hierarchical modeling framework as a general tool that could be applied to multiple types of vegetation that are important as habitat for terrestrial wildlife populations

Review of

U.S. Environmental Protection Agency's

National Health and Environmental Effects Research Laboratory

WESTERN ECOLOGY DIVISION

February 19-21, 1997

Corvallis, Oregon

Western Ecology Review Panel

March 31, 1998

TABLE OF CONTENTS

SUMMARY

This report provides an in-depth review of the Western Ecology Division (WED or Division) of the U.S. Environmental Protection Agency's (EPA) National Health and Environmental Effects Research Laboratory (NHEERL). Twelve independent scientists from across North America were commissioned by the EPA in early 1997 to provide Division and Laboratory management with perspective and information that would facilitate planning, implementation, and resource allocation within the Division and NHEERL. The review panel was provided summaries of divisional programs, staff, and publications. An on-site briefing and facility tour was held in Corvallis, Oregon on February 19-20, 1997.

The Western Ecology Division is one of four geographical ecological effects divisions of the nationwide NHEERL. Risk Assessment is the overall theme of the NHEERL. The Division's missions are to (1) provide EPA with national scientific leadership for terrestrial and regional-scale ecology, and (2) develop the scientific basis for assessing the condition and response of ecological resources of the western United States and the Pacific Coast. Division scientists conduct research in a range of scientific disciplines, usually working in teams. The Division has recently altered its emphasis from primarily the first mission to an increasing emphasis on the second mission with a focus on risk assessment. The research facilities are located at Corvallis (main complex surrounded by the Oregon State University campus plus the nearby Willamette Research Station) and Newport, Oregon (Hatfield Marine Station, the marine campus of Oregon State University)

In general, the panelists felt that the Division was a premier research facility with unique capabilities which not only serve EPA's needs, but are truly advancing the "state-of-the-art" in environmental science. The past record of the Corvallis laboratory is outstanding in terrestrial and regional-scale ecology not restricted to the U.S. West. The marine science laboratory at Newport also has a fine history.

However, there was a general feeling that reorientation of the Division towards a Western U.S. regional focus of research for environmental risk assessment is diluting extant collaborations, lessening opportunities for synthesis, and introducing unaccustomed efforts at technology transfer. The predominantly national focus of the Corvallis laboratory in selected areas of strong expertise had been its strong point. There was the feeling that this is being diminished as the Division is reshaped into a regional focus more broadly geared to ecological research to estimate ecological risks. The review appeared to take place in an awkward period of mission transition, with accompanying uncertainty among staff and a certain disconnect between the Division's traditional mission and that of EPA headquarters and the NHEERL. Although disturbing, the transition may be temporary.

The review provides several overall observations related to the questions posed in the terms of reference regarding research, advice/review, and leadership. These are explained further in the main text.

- Although risk assessment is a nominal objective for use of research by the Division, there was little evidence that it was being used as a common framework in designing or rationalizing the work
- There is ambiguity in the separation of research at the Division from risk assessment carried out by others.
- Understanding of "risk assessment" differed throughout the briefing materials and staff contacts, suggesting the need for further conceptual refinement before research ("risk science") can be readily focused.
- The health effects model for risk assessment may not be the best model for ecological risk assessment.
- There seems to be less emphasis on characterizing environmental stressors than on defining ecological effects.
- Outside interactions based on the previous national scientific role may diminish as the Division becomes more regional, and scientists may need to be aggressive in maintaining them.
- The Division does not have an impressive array of regional linkages.
- The Division will need to keep, recruit, and use "good thinkers" who will forge the new mission's programs.
- The Division can exploit its unique capabilities and special expertise to maintain a critical mass for the future.
- Geographic scope of Division work is confusing and disorganized.
- The Division's ability to do research related to risk assessment seems to go beyond the U.S. West in some of its programs more than others
- The effectiveness of the various research themes appeared to vary from high potential to currently inadequate.
- Overall productivity of the Division in terms of products for funds expended seemed low compared to other research institutions

• There was a "caste" structure between EPA employees and contractors that was seen as counterproductive and contrary to effective team integration.

• Internal collaboration seems lacking in some areas and could be improved.

• The Newport facility and staff could be better integrated into the culture and work of the Division, for the staff seemed isolated both geographically and intellectually.

• There are many environmental issues in the U S West that are pertinent to EPA's role but are not now being pursued or apparently considered for Division activity, but which might be included.

• Linkage to the EPA grants program is unclear under the present role compared to the previous role of the Corvallis facility as contract administrator and scientific integrator

• There may be too much staffing from local universities to provide the breadth of capabilities needed for the future.

Despite some negative comments in detailed critiques by the panel, the themes of the Division are advancing knowledge, serve EPA's mission, and provide unique capabilities on which to build a future for the Division the Corvallis/Newport facilities

• The **rhizosphere** work to determine effects of atmospheric pollutants and global change components on key processes at the root-soil interface is unique and provides an important link to our understanding of carbon cycling. The work may be stretching the envelope of relevance to risk assessment but it is excellent science. More focus on variability in the field may be important for future research and information use. For example, additional work might contrast rhizosphere dynamics in clear-cut versus undisturbed forests or after natural disturbances versus logging.

• The **multiscale monitoring** effort is on-going and successful. It is progressing in a logical manner to reach well-defined goals to improve integrated monitoring and classification schemes that can be applied widely. Consolidation of findings will be especially important for this group if the work is ultimately to be transferred to users outside the agency. The work seems ripe for a synthesis volume or symposium.

• The theme on **extrapolation of plant response** to provide a mechanistic understanding of the effects of various stressors on forests so that risks to the forests can be assessed and managed is of high quality and serves the mission of the Division well. Greater integration of efforts by team members across levels of biological organization seem desirable. The effort could benefit from expansion to encompass a greater number of attributes and processes inherent in forest ecosystems at various scales.

• **Indicators of condition of ecological resources** are being sought to monitor the ecological status of surface waters and forests over large geographic areas. The Division program is effective at evaluating both the biotic health of aquatic ecosystems and the physical and chemical stressors that affect them. Most developed for Northeast lakes (when the Division had national responsibility), this work is being extended successfully to Oregon. Peer-reviewed publications for this large effort are needed. The development of forest indicators has only recently been initiated.

• Research on the **ecological role of land/water interfaces--riparian areas and wetlands**--has made important contributions through external cooperators but does not appear to have settled into its new role in wetlands research across NHEERL divisions and its areas of future emphasis on research on wetland functions in the US West. The theme is clearly evolving, but the direction is not clear. As parallel research efforts are to be conducted at each NHEERL laboratory, there is a need for NHEERL-wide vision and strategy for national responsibilities and the roles and relationships of various divisions.

• The Division's theme on **Pacific Northwest estuaries** is also a component of the EPA's Pacific Northwest Research Program which seeks to develop science to advance ecosystem management concepts on a regional scale. The overall program focus is on multiple, often cumulative, effects of stressors on whole estuaries. The focus of the Division's research on a single species was puzzling. There appears to be an awkward transition of this research group from its traditional and highly successful focus on contaminant chemistry and toxicology to ecosystem considerations and non-toxic stressors Considerable effort will be required by Division and NHEERL management and staffs to guide the evolution of this group and to foster interactions between the Newport and Corvallis staffs and between EPA staff and those of the broad array of agencies affecting watershed-estuary interactions.

INTRODUCTION

Purpose/Assignment

This report provides an in-depth review of the Western Ecology Division of the U.S. Environmental Protection Agency's (EPA) National Health and Environmental Effects Research Laboratory (NHEERL). The Western Ecology Division is headquartered in Corvallis, Oregon; the NHEERL is a nation-wide complex of national laboratories under the EPA Office of Research and Development, headquartered in Washington, DC. Twelve independent scientists from across North America were commissioned by the EPA in early 1997 to provide Division and Laboratory management with perspective and information that would facilitate planning, implementation, and resource allocation within the Division and NHEERL.

The terms of reference for the Western Ecology Review Panel were provided in a January 8, 1997 memorandum from Randall Bond, Senior Peer Review Official to panel members (Appendix 1). The terms of reference included several questions for the panel's consideration, grouped under headings of Research, Advice/Review, and Leadership. The questions were designed to elicit overall conclusions regarding the breadth and depth of the Division's program from scientific and resource-utilization perspectives.

The review panel was provided summaries of divisional programs, staff, and publications, as described further below. An on-site briefing and facility tour was held in Corvallis, Oregon on February 19-20, 1997. The panel briefed Division and NHEERL management on its initial perceptions at the close of the on-site visit.

Background on the Western Ecology Division

The Division's Mission

The Western Ecology Division is one of four ecological effects divisions of the National Health and Environmental Effects Research Laboratory. The four divisions are distributed bio- geographically. WED's mission is 1) to provide EPA with national scientific leadership for terrestrial and regional-scale ecology, and 2) to develop the scientific basis for assessing the condition and response of ecological resources of the western United States and the Pacific Coast.

The Division addresses scientific issues of major importance in formulating public policies, programs, and regulations to protect and manage ecological resources. WED scientists conduct research in a range of scientific disciplines, usually working in multi-disciplinary teams. In addition to their work at the Division's facilities and field sites, they collaborate with leading scientists at research institutions throughout the world. The research addresses the ecological processes that determine the response of biological resources to environmental change and to land and resource use. Priority is given to those ecological systems at greatest risk, with emphasis on the scientific uncertainties that most seriously impede ecological risk assessment.

WED's research approach comprises two aspects: 1) developing an understanding of the structure and function of ecological systems, and 2) conducting holistic analyses of ecological phenomena at the ecosystem, landscape, and regional scales. Key scientific disciplines include: terrestrial biology, aquatic biology, marine biology, ecology, geography, statistics, microbiology, soil science, plant science, biogeochemistry, plant physiology, landscape ecology, and oceanography.

The Division seeks to advance scientific understanding through 1) experiments conducted
in the laboratory and in specialized exposure chambers, 2) field studies, 3) modeling, and 4) analysis of large-scale environmental and ecological data sets.

The Division has undergone recent changes in structure and mission. Previously the Corvallis laboratory had developed expertise in analyzing the effects of single pollutants on single species. It had pools of funds to sponsor extramural research (e.g., at universities) on topics that EPA itself could not cover effectively. There was close integration of the extramural and intramural activities. The laboratory has been expanded recently to a "division" that includes EPA research facilities elsewhere in the U.S. West. It has come administratively under a national "laboratory" with ecological risk assessment objectives. The nationwide focus has shifted to whole ecosystems and a variety of stressors. Extramural contracts are now developed, processed, and administered from EPA headquarters without direct contact with Division staff and programs. The Division staff and programs are in transition from the old mode of operation to the new.

Current Research Programs

The Division's research is organized into several programs, each of which was described in briefing materials and in oral presentations at the site visit

- Terrestrial impacts of climate change
- Terrestrial impacts of atmospheric pollution (tropospheric ozone, acidic deposition)
- The role of the rhizosphere in the response of terrestrial systems to stress
- Terrestrial, aquatic, and estuarine indicators of ecological condition
- Cumulative impacts of multiple stressors on estuarine resource condition
- Design of multi-tier monitoring systems for assessing the condition of ecological resources
- Watershed-scale methods for comparative risk assessment in the Pacific Northwest
- Landscape/regional-scale response of wetlands and watersheds
- Regional analysis of biodiversity

Organization Of The Division

Approximately 325 federal, cooperative, and contract employees currently work at the Division. Research is carried out by three branches, two in Corvallis and one in Newport:

Terrestrial Plant Ecology Branch (Corvallis)

Scientists in the Terrestrial Plant Ecology Branch conduct research on the effects of pollutants and other anthropogenic stressors on terrestrial ecosystems, such as agroecosystems, forest ecosystems, and rangelands Research ranges from physiological studies of individual plants through global-scale process modeling. Current programs include research on:

Geographic analysis of multiple stress effects
The role of tree age and size in stress response
Ecological complexity and the response of terrestrial ecosystems to anthropogenic stress
Effects of elevated CO_2 and climate change on forest ecosystems
Response and feedback of terrestrial ecosystems to global climate change
Impacts of tropospheric ozone on forest ecosystems
Indicators of condition and trends in Northwest forests
Role of the rhizosphere in terrestrial ecosystems

Regional Ecology Branch (Corvallis)

The Regional Ecology Branch develops tools for quantitatively describing ecological condition and response at watershed and regional scales—the scales at which most environmental protection and management decisions are made. Research involves regional surveys, process studies, and predictive modeling of the nation's waters, watersheds, and wetlands. Research topics include:

Indicators for determining the status and trends in condition of surface waters, wetlands, and associated riparian zones

Role of riparian areas in maintaining ecological condition of surface waters and providing terrestrial and aquatic habitat

Criteria for evaluating and maintaining the function of wetlands and riparian zones

Design of regional-scale monitoring systems

Effects of habitat loss and alteration on biodiversity

Methods for projecting and comparing the ecological consequences of alternative environmental protection and management actions at watershed scales

Response of watersheds to atmospheric deposition

Design of systems to delineate ecological regions

Coastal Ecology Branch (Newport)

The Coastal Ecology Branch conducts research on the effects of anthropogenic and natural stressors in coastal watersheds and estuarine ecosystems. The research focus is on cumulative effects of stressors on ecologically and economically important assessment endpoints (e.g., fish and oyster production) in Pacific Northwest estuaries. Current projects include research on:

Productive capacity of estuaries and habitats within estuaries

Areal extent and distribution of habitats of special concern

Effects of habitat-altering stressors on fish, invertebrate, and wildlife populations and communities

Research activities include large-scale (estuary-wide) field studies and laboratory investigations of relationships between stressors and effects. The research goal is to predict the effects of watershed alterations and introduced species (*Spartina* and exotic benthic invertebrates) on Pacific Northwest estuaries.

The Division's Research Facilities

The Division's research facilities are located at Corvallis and Newport, Oregon. The main research complex is located on 14 acres in Corvallis, surrounded by the Oregon State University campus. It includes a variety of laboratories, plant and animal research facilities, a library, a computer center, and office buildings. The Willamette Research Station (WRS) comprises laboratories and field research facilities on a 10-acre site adjacent to the Willamette River in Corvallis, approximately 4 miles south of the main lab. The Coastal Ecology Branch carries out research in laboratory facilities at the Hatfield Marine Science Center, the marine campus of Oregon State University. The Center is located on Yaquina Bay on the Pacific Ocean at Newport, 55 miles west of Corvallis.

A terrestrial ecology laboratory within the Corvallis complex includes a number of greenhouse and field research modules. These units provide the capability for research on: 1) effects of gaseous air pollution, 2) effects of heavy metals, 3) effects of toxic substances, and 4) plant propagation and growth assessments.

Also located at the main complex, a field exposure facility includes 21 large open-top exposure chambers, a nursery site, an automated irrigation system, an experimental rhizotron site, and a control center containing automated pollutant delivery-control and data-acquisition/management systems. This field site provides a unique setting for research that addresses environmental issues of national importance, such as tropospheric ozone effects on conifers, deciduous trees, and crops

To complement the plant exposure facilities described above, WED constructed a highly sophisticated Terrestrial Ecophysiology Research Area (TERA) in 1994 The facility consists of a large polyhouse to shelter the data acquisition and control computers, and a field of sunlit plant growth chambers. Ambient temperature, dewpoint and CO_2 concentration in each outdoor enclosure are carefully controlled by programmable microprocessors. This facility plays an important role in long-term global climate change research. It will be used to conduct long-term studies on conifers and hardwoods, with experiments designed to evaluate the response of forests to climate change.

The Coastal Ecology Branch is housed in a state-of-the-art laboratory building at a seaside location ideal for marine and estuarine research. Wet labs are available for a variety of experiments, including tests with exotic species and chronic pollutant exposures. Analytical laboratory facilities provide for low-level analysis of organic pollutants, metals, and natural products. Adjacent facilities of Oregon State University, Oregon Department of Fish and Wildlife, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, and U.S. Fish and Wildlife Service offer opportunities for collaboration.

The Division operates a fully integrated and distributed VAX and UNIX based computer facility, including a large Geographic Information System, digitization hardware, and over 300 microcomputers and workstation terminals. These facilities permit precise analysis of spatially distributed landscape data (e.g., vegetation, soils). Agency and Oregon State University supercomputers are also available to Division scientists via a high-speed communication network.

The Cooperative Dimension

The Division supports numerous extramural scientists who work cooperatively with WED researchers on both on-site and off-site projects The Division also provides research associateships for post-doctoral and senior research fellows through the National Research Council and a cooperative agreement with Oregon State University. Most senior WED scientists also hold courtesy faculty positions at Oregon State University

Frequently, research at WED takes on an international flavor as world-renowned scientists work cooperatively with Division personnel for extended periods WED scientists have also been involved in cooperative programs with Canada, Mexico, Brazil, Chile, the Philippines, India, England, France, Germany, Norway, Sweden, Poland, Romania, Russia, and other former Soviet republics. Students from U.S. and foreign universities work under internships and other programs at WED.

The division cooperates with EPA program offices and other Agency laboratories on complex research problems. Other government agencies, universities, and private industry are involved, often through formal interagency agreements and contracts to fund specific research projects. Most of these extramural research projects are with university scientists who work closely with their WED counterparts.

The Corvallis/Newport ecological research community is large and highly diverse. Federal and state agencies (e.g., EPA, U S. Forest Service, Bureau of Land Management, National Park Service, USDA Agricultural Research Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, National Oceanic and Atmospheric Administration), together with Oregon State University, constitute one of the largest geographic concentrations of ecological research programs in the U.S.

The Panel

The Western Ecology Review Panel was an ad hoc group composed of the following twelve scientists. All have extensive background related to terrestrial or aquatic ecology and the operation of research institutes. The panel members were grouped into smaller subsets to review particular program elements. A list of names and addresses is given in Appendix 2. Dr. Randall Bond, EPA Senior Peer Review Official served as facilitator.

Dr. Ronnie Best (National Biological Service)
Dr. Paul Bloom (University of Minnesota)
Dr. Don Boesch (University of Maryland)
Dr. Charles C. Coutant, Chair (Oak Ridge National Laboratory)
Dr. Judith Grassle (Rutgers University)
Dr. David Grigal (University of Minnesota)
Dr. Richard Houghton (Woods Hole Research Center)
Dr. Jeoffrey Klopatek (University of Arizona)
Dr. William Lewis (University of Colorado)
Dr. Henry Regier (University of Toronto, retired)
Dr. Terry Shank (Utah State University)
Dr. Douglas Sprugel (University of Washington)

Review Format

The overall review consisted of (1) briefing materials on the Division sent to panel members by mail, (2) preparation of draft comments by panel members on Division programs, (3) an on-site visit to Corvallis on February 19-21, 1998, and (4) follow-up preparation and review of the panel's report. The very complete briefing book included a Division overview, descriptions of the seven major research themes, titles of posters to be presented at the review, and a biography of each principal investigator and senior scientist followed by a two-page description of each principal investigator's research (Appendix 3).

The onsite meeting at Corvallis included two and one-half days of briefings, tours, posters, meetings with staff and managers, and panel deliberations (Appendix 4). Dr. Bond and the panel chair, Dr. Coutant, first met with the panel to discuss the purpose of the review and administrative items. The panel was officially welcomed by

Dr. Lawrence W. Rieter, Director, National Health and Environmental Effects Research Laboratory, Research Triangle Park, North Carolina and Dr. Gilman D. Veith, Associate Director for Ecology, National Health and Environmental Effects Research Laboratory Research Triangle Park, North Carolina, and Dr. Bond. They described the goals and objectives of the review and the relationships between the Division, NHEERL, and the Office of Research and Development. Dr. Tom Murphy, Director of the Western Ecology Division, provided an overview of the Division. Theme leaders presented an overview of research in their area, with participation by research staff The panel and staff entered into lively dialogue during and after the presentations. Staff provided the panel a walking tour of the Corvallis facilities, including demonstrations of important research apparatus such as that used for rhizosphere research There were several opportunities to view poster demonstrations of selected research projects with relevant staff present.

The panel developed its comments by sharing initial critiques (prepared in advance of the meeting), meeting as subcommittees on particular program themes, consolidating initial comments, and discussing views as the full panel in executive session late in the afternoon of February 20 and the morning of February 21. Overall impressions of the Division were prepared by the whole panel as bullets. Each theme's strengths and weaknesses were characterized by the whole panel in table format. Each theme was (subsequent to the Corvallis meeting) discussed in text format, with description of the goals, critique, summary of resources and facilities, and an evaluation and summary. The theme-specific discussions reflect focus by a few panel members assigned to that theme.

Documents Provided

Numerous documents and reprints were provided to panel members for their review. The briefing book has already been described (Appendix 3). A packet of selected reprints from each theme was also provided (Appendix 5). Among other documents, the Strategic Plan for the Office of Research and Development gave insight into the overall structure of the Office and the relationships of NHEERL, its divisions, and the national labs (Appendix 6).

Panel's Products to EPA

The panel's products to EPA include initial discussions with Division and NHEERL management on the final morning of the Corvallis visit and preparation of this final written report. Draft segments of the final report and briefing materials for the managers were consolidated by Dr Bond, reviewed by the panel members, and developed into a report format by Dr Coutant (with subsequent review and approval by the panel).

MAJOR IMPRESSIONS

The panel developed a general summary and a bulletized listing of major impressions related to the questions posed in the terms of reference (Appendix 1). The panel felt that this list would be more useful than a direct response to each question (many such responses are imbedded in the briefing materials supplied). The summary and bullets, with brief explanations, are listed below.

In general, the panelists felt that the Division was a premier research facility with unique capabilities which not only serve EPA's needs, but are truly advancing the "state-of-the-art" in environmental science. The past record of the Corvallis laboratory is outstanding in terrestrial and regional-scale ecology and is not restricted to the U.S. West. The marine science laboratory at Newport also has a fine history in areas of effects of marine and estuarine contaminants and toxicology

However, there was a general feeling that reorientation of the Division towards a Western U.S. regional focus of research for environmental risk assessment is diluting extant collaborations, lessening opportunities for synthesis, and introducing unaccustomed efforts at technology transfer. The predominantly national focus of the Corvallis laboratory in selected areas of strong expertise had been its strong point. There was the feeling that this expertise is being diminished as the Division is reshaped into a regional focus more broadly geared to ecological research to estimate ecological risks. The review appeared to take place in an awkward period of mission transition, with accompanying uncertainty among staff and a certain disconnect between the Division's traditional mission and that of EPA headquarters and the NHEERL. Although disturbing, the transition may be temporary.

The panel made several overall observations related to the questions posed in the terms of reference regarding research, advice/review, and leadership. They were

• *Although risk assessment is a nominal objective for use of research by the Division, there was little evidence that it was being used as a common framework in designing or rationalizing the work.* The Division staff needs urgently to address this problem and solve it. If risk assessment is an infeasible basis for unifying Division work, then some other basis needs to be found and developed

• *There is ambiguity in the separation of research at the Division from risk assessment carried out by others.* Although the distinct and separate roles of research in the Division and assessment generally carried out elsewhere were stressed in management briefings, it was apparent that there was ambiguity among staff and in how programs were being implemented.

• *Understanding of "risk assessment" differed throughout the briefing materials and staff contacts, suggesting the need for further conceptual refinement before research ("risk science") can be readily focused.* Not everyone agrees on how risk assessment or risk science are defined. Staff scientists need to reach agreements among themselves about common ground for ecosystem risk assessment, either by adopting their own conventions or by adopting published conventions of other groups.

• *The health effects model for risk assessment may not be the best model for ecological risk assessment.* It is understandable and laudable that EPA should seek a common ground for its enforcement-related research mission, and the panel felt that the general concept of risk assessment serves that function quite well. However, the direct application of the health-effects risk assessment model to ecological systems has much uncertainty both conceptually and in practice. The Division, along with the general field of ecological risk assessment, will need to further refine the application of risk assessment concepts to ecosystem assessment and management.

• *There seems to be less emphasis on characterizing environmental stressors than on defining ecological effects* Excellent and unique approaches are being developed by the Division for studying and defining biological effects. However, the range of stressors being used is small in comparison to the types of environmental perturbations found even in the Northwest. On the other hand, the panel supports monitoring programs that can identify patterns of change (effects such as changed growth rates or mortality in forests) whether or not specific stressors have been identified through risk assessment. A balanced approach is to maintain elements of both stressor-based risk research/ assessment and monitoring for change that can detect surprises, often related to the unanticipated interactions of multiple stressors The theme, "Indicators of condition of ecological resources," exists to address the monitoring aspect, but most progress has been made in freshwater indicators. More work could be directed toward forest indicators.

• *Outside interactions based on the previous national scientific role may diminish as the Division becomes more regional, and scientists may need to be aggressive in maintaining them.* The panel viewed the Division previously as the EPA Corvallis Laboratory, which had research programs and collaborators nationwide by virtue of its role as EPA contract administrator for terrestrial and ecosystem ecology. To many panelists, this was a major strength To see these connections and interactions diminish as a result of the reorganization of the Office of Research and Development would be a major loss for ecosystem science and the Corvallis staff. The Division staff will need to be aggressive in maintaining the contacts that previously came so easily.

• *The Division does not have an impressive array of regional linkages.* This would be expected of a regional laboratory. This may be due partly to the recent shift of Division activities from project management to project execution. If the Division is to operate on a par with university programs, then it needs to become an active part of the communication and collaboration network for these programs, in a truly regional manner

• *The Division will need to keep, recruit, and use "good thinkers" who will forge the new mission's programs.* New directions need fresh ideas and take careful and thoughtful planning. Staff will be especially valuable when they think freely and expansively with respect to the new roles given them by NHEERL. It may not be possible, however, for the new roles (as defined by NHEERL) to be filled as a result of research currently carried out within the Division. If the new roles are, indeed, outside of existing programs and expertise, then new staff may be required to address them. The panel encourages an upward flow of programmatic vision and research ideas to NHEERL management as well as program redirection from above.

• *The Division can exploit its unique capabilities and special expertise to maintain a critical mass for the future.* Despite the appearance of "new" missions, the Division has an excellent scientific reputation, unique facilities, many superb staff with special expertise, and capable administrators with which to forge a new future The panel encourages building on these strengths explicitly. A major challenge is to leverage the staff expertise and facilities to get the biggest return under the new mandates. Some research theme groups have done better at this than others.

• *Geographic scope of Division work is confusing and disorganized.* The confusion is an impediment to the mutual reinforcement of Division programs, and gives to the outsider no impression of the regional focus upon which the Division is nominally based. Although quick redirection of programs is not feasible, the Division needs a long-range plan for defining and consistently explaining its region of interest.

• *The Division's ability to do research related to risk assessment seems to go beyond the U.S. West in some of its programs more than others.* The Division should have national relevance even though it focuses on the U.S. West In the context of the slogan, "Think globally, act locally," the Division can have (maintain) national importance while researching at the western regional scale and in Northwest locations This ability differs among themes, however.

• *The effectiveness of the various research themes appeared to vary from high potential to currently inadequate.* The themes are discussed further below.

• *Overall productivity of the Division in terms of products for funds expended seemed low compared to other research institutions.* The panel did not attempt a rigorous analysis, but nevertheless came away with this impression. It may derive partly from the common academic backgrounds of many panel members who are less involved with agency advice and review than Division staff. For many academic scientists, publication is the main measure of performance, whereas Division staff have other responsibilities. The concern is worthy of further evaluation.

• *There was a "caste" structure between EPA employees and contractors that was seen as counterproductive and contrary to effective team integration. Frankly, this system was offensive to the reviewers* It was difficult to see how a supposedly integrated research structure could operate as well as it has under such conditions

• *Internal collaboration seems lacking in some areas and could be improved.* Division personnel working on problems that use similar technologies often are not working together. This is difficult to explain in an organization that is specifically designed as a collaborative center.

• *The Newport facility and staff could be better integrated into the culture and work of the Division, for the staff seemed isolated both geographically and intellectually.* The lack of connectedness between this group and the rest of the Division was evident in briefings (they attended only their own session) and in the conceptual and practical divergence of their programs from the rest of the Division. A strong effort toward integration will be needed.

• *There are many environmental issues in the U.S. West that are pertinent to EPA's role but are not now being pursued or apparently considered for Division activity, but which might be included.* Environmental problems abound in the U.S. West and many are related to EPA's traditional roles in water and air quality. For example, there are water temperature concerns for salmonids throughout the region.

• *Linkage to the EPA grants program is unclear under the present role compared to the previous role of the Corvallis facility as contract administrator and scientific integrator.* Now that the EPA grants program is handled from headquarters rather than from laboratories such as Corvallis, a major strength for integration of extramural and intramural research and synthesis seems missing. Clarification of this new relationship and explicit attention to maintaining the once-strong ties seem desirable.

• *There may be too much staffing from local universities to provide the breadth of capabilities needed for the future* Perhaps this is a minor point, but many staff seem to have come locally from Oregon State University. This may indicate intellectual inbreeding, which is to be avoided The panel simply raises a cautionary note.

THEME/PROGRAM DISCUSSIONS

The panel summarized its observations on the research themes in two ways. One way was via a group discussion of their individual strengths and weaknesses (opportunities). A table was prepared as each theme was discussed by the whole panel This table has nuggets of information not easily captured in text format. Because of brevity, some points may need reference to the text. We reproduce the table here (Table 1). The second way was by text summaries prepared by 2-3 panel members familiar with the topic. The following text (1) describes each theme, (2) provides a critique of each theme usually in the form of strengths and weaknesses of approach taken, progress to date, appropriate skill mix, future directions, and resources and facilities, and (3) provides an evaluation and summary comments.

Theme 1. Role Of The Rhizosphere

Description

The goal of this theme is to "determine the effects of atmospheric pollutants and global change components ... on key processes in controlling the exchange of C and N between the root/soil and the plant canopy" (p 1, theme detail). This goal is being pursued by a wide range of studies dealing with C in terrestrial ecosystems. The theme focuses on the rhizosphere with an overall goal of determining the effects of environmental stressors (CO_2, climate change, N fertilization, ozone, and biotechnological products) on trees and soil microorganisms. The rhizosphere includes plant roots, associated myccorhizae, and the surrounding soil. It is the microsite where mineral cycling occurs, where water uptake occurs, and where important fluxes of carbon occur. The theme's research is heavily committed to using the TERA (Terrestrial Ecophysiological Research Area) facility, an array of sunlit controlled environmental chambers (terracosms). The work has emphasized the effects of elevated CO_2, N fertilization; and tropospheric ozone on the growth of seedlings (14 years), root dynamics, soil food webs, soil organic matter, and below ground respiration.

Table 1 Summary of strength and weaknesses (opportunities) of research themes:

STRENGTHS	OPPORTUNITIES
Role of the Rhizosphere	
• strong program	• model needs testing as well as use
• filling an important niche	• assumptions need testing
• good team	• need soil scientist
• excellent facilities and good use of them	• model needs more staff allocated
• good microbiology	
• good collaborative area	
Multi-Scale Monitoring	
• strong	• EMAP history checkered
• good motivation	• where is the work going? Nationally from Regional tests?
• relates directly to Agency concerns over monitoring	• portability to terrestrial is a challenge
• new leadership is competent	• challenge to patch existing data collections (eg , State) to EPA/EMAP framework
• use of outsiders is good (eg , ASA)	• could provide a "guidebook" for monitoring by anyone
• solid progress (publications)	• remote sensing use and applications–ecoregions, scales (not duplicative of Las Vegas, NASA)
• goal to link probabilistic sampling with intensive studies (eg , LTR)	• write-up was weak relative to briefing and poster
	• no apparent impact on estuaries program
Extrapolation of Plant Response	
• pioneering work with seedlings, single plants	• some aspects better developed than others
• good contributions to standards and risk assessment	• slow integration of work by team members
• good plans to go to other stressors	• few cross-scale authorships of papers, others lack staff involvement
	• extrapolation from trees to forests is slow (more than physiological)
	• pine/grass experiments seem less important than other directions
	• whole-tree level needs work or coordination with other labs with towers
	• species other than trees are needed, animals/communities
	• do work in other ecosystems (eg , deserts)

- push top-down as well as bottom-up planning

Indicators of Ecological Condition

- one logical endpoint of process involving all other themes--builds on others to the "real world"
- heading toward a "state-of-the-environment" report methodology
- aquatic indicators are well developed and useful, regional data are being collected (longer history beyond EPA), rule-based expert system possible
- appropriate scales/time frames aquatic is structural, terrestrial is process-oriented
- important for EPA to do (universities will not be motivated)
- extension of ideas to terrestrial environment is good, if embryonic

- linkage to "state of environment" unclear (multi-hazard, multi-scale, multi-jurisdiction); how to use the methods unclear
- communication with the risk assessment team is essential, not clear now
- terrestrial indicators need work
- needs regionalization of indicators (ecoregions)
- for aquatic could do an ecosystems guide for a region
- need to get ecosystem based indicators that link the aquatic and the terrestrial
- insufficient innovation and creativity shown generally Nobody "pushing the field"
- not clear what is being learned about this theme which contributes to the others (should be highly interactive)
- terrestrial indicators need collaboration from outside of WED
- seek diagnostic stressor relationships, also synoptic
- physiological indicators may be useful for terrestrial
- basically, think of what can be measured that is suitable for intramural EPA effort, among indicators suggested over past 25 years

Land-Water Interfaces (wetlands)

- valuable studies-both local and National (old model)
- good conclusions already
- coordination with ARS (USDA)
- good relationship to regulatory needs

- struggling with old way of operating vs new mode Will it really be national?
- test site is very local, not even PNW
- needs to be coordinated nationally
- need to apply current conclusions in land management
- not at cutting edge of several fields (biogeochemistry, hydrology, soil science)
- doubtful this group can be competitive in wetlands science as a single lab
- needs to better define their niche
- public action record not extensive, much soft literature exists

Land-Water Interfaces (Riparian Zone)

- focus on PNW agriculture makes sense and presents good opportunities
- good rationales for linking this effort with wetlands and forest work
- difficult to draw conclusions from existing sites
- need to couple mass balance approaches to piezometers
- many riparian functions not yet considered
- need for better integration of program
- work is generally not state of the science
- could include other landscapes-range, pastures, forests
- what is the rationale of N? P?
- no clear hypothesis
- where does toxicology fit in?
- low productivity (publications)

Estuaries

- multiple cumulative effects is a Nationally important issue, and appropriate for EPA
- PNW is a logical place to do it
- EPA lab system provides a way to accomplish efforts, but not alone
- there is a impression that the underutilized facilities at Newport could be brought to bear on these problems
- Willapa Bay provides problems as well as opportunities
- more homework on the system would have helped (context, background info)
- focus on a single species for the ecosystem is risky at best
- processes that affect recruitment may be more important than stressors
- model of linear responses/additivity are not realistic
- a Newport Team with a toxicology focus (lead lab) is awkward as a leader of broad ecosystem questions (sediment, habitat change, nutrients, etc.)
- Terrestrial/land interfaces not yet integrated
- interactions with ERC (U of Wash) unclear
- would benefit from addition of expert on West Coast estuaries
- recruit top-notch experts for staff (ecosystem types)
- encourage retraining (seminars, courses, details IPAs)
- make important point of workshops, recruitment, retraining
- need to recognize that such systems are disturbance-dependent in equilibrium
- must foster collaborations, not just contracts
- must work with existing WED mapping capabilities

Critique

The team regarded this program as one of the most successful of the programs we reviewed. The group is doing cutting-edge research that would be welcomed at any research institute. It is making excellent use of the facilities that the Division has to offer. Nonetheless, the team offers several comments.

The title of this theme is unfortunate and the way it is written seems to lead to some confusion about objectives. Webster's 9th Dictionary defines "rhizosphere" as "the *soil* (emphasis added) that surrounds and is influenced by the roots of a plant". This definition matches the usage of most ecologists in which the rhizosphere doesn't include the roots themselves, although it does include soil flora (including mycorrhizae) that may be associated with roots. However, in this theme the rhizosphere seems to mean everything below ground. Even that is not a very good description of the program because the research includes a good deal of above-ground physiology, including effects of effects of heat and CO_2 on bud morphology. Relating all this work to impacts on the rhizosphere makes for a very complex system. What is being done in this project is a solid, well-rounded program of studies of plants growing in controlled environments (and some in uncontrolled environments) with a somewhat heavier than usual emphasis on below-ground processes. This is a perfectly reasonable topic for EPA/WED. The benefit of understanding what is happening in the rhizosphere is a logical focus, but not the entire reason for the research.

The panel viewed the rhizosphere research in the context of its suitability for an EPA laboratory. Research conducted at EPA laboratories should be different from research that could be done extramurally, especially at universities. Research carried out at EPA laboratories should be unique in some sense. Among the measures of uniqueness may be a special expertise or talent that is unavailable elsewhere, a critical mass of investigators that are focused on a common theme, a special kind of equipment or other facility that similarly is unlikely to exist elsewhere, or the kind of study that requires a continuity in funding that may or may not occur in a competitive University environment. In many cases, such a group is unlikely to exist at a university.

The Rhizosphere theme is an excellent example of a research group making use of a unique facility (TERA) that is unlikely to be duplicated elsewhere and requires a strong continuity of funding to be successful. In particular, the work on below-ground processes and responses, both "natural" and in response to stress, are impressive in their scope, and illustrate a logical role for EPA research. The studies of fine root dynamics, of soil food webs, and partitioning of soil respiration into its sources seem clearly linked to the theme.

The work on "above ground carbon assimilation and allocation" on the other hand was not seen as especially unique on its own, and gains most of its value from its linkage with the work on below-ground processes. This linkage, however, did not seem to be as strong as one might have hoped. It is also suggested that perhaps the overall scope of the project was too large to allow a well-defined direction and central focus. There may be other (extramural researchers) who are dealing more effectively with above- ground processes who could be brought into the studies.

The soil organic matter focus (p. 9) is logical in the context of the rhizosphere, but the scientists need to take care to restrict their extrapolations to the available data. For example, it is unclear that they have adequately investigated whether or not "forest management practices that leave organic residues will have less impact...". That assessment does not seem to be either the focus of the research or even a direct derivation.

The use of models in attempting to synthesize the varied data into a whole as described in the activity referred to as "Coupling the cycling of C and N" is strongly endorsed Because modeling is relatively inexpensive compared to intensive instrumentation and data collection (such as the terracosm development), modeling should be a component of any research program But there were concerns about the specific approach, as noted below.

Similarly, (although there is question about the global relevance of research in the Mojave desert) panelists endorse the coordination of EPA-financed below ground work with ongoing above ground work. This helps to leverage the resources that are available to both research groups.

There were both strengths and weaknesses in the approach taken to this theme. They are:

Strengths: The TERA facility allows controlled micro-level research, including below ground processes. Considerable work is going into testing for chamber's effects on plant growth and soil food webs. To complement the micro-level, chamber work, field work is conducted in the Douglas fir forests of the Cascades. In addition, the investigators are developing biochemical and isotopic techniques to better determine the partition coefficient of respiratory CO_2 among soil, root, and litter respiration.

Weaknesses: A weakness of the proposed work is the reliance on a specific model (the MBL/GEM) that may not be the best for their purposes. While a model is required to address questions over long time periods and large areas, the reliance on one particular model, with no efforts to evaluate it, seems inappropriate. The investigators will collect data to parameterize it, but how will they judge its results? The investigators describe two features of the model, but it is not clear whether these features are hypotheses or actual processes. The model includes the paradigms that warmer temperatures will increase soil respiration, that the increased nitrogen mineralization resulting will lead to greater tree growth, and that carbon will be accumulated in the forest (because the C/N ratio is greater in wood than in SOM). What is important is not what the model will show, but what actually happens to forest growth and carbon storage in soils. The model should be useful for testing such assumptions, primarily by iteratively comparing model results with real-world data. The investigators seem to be in a position to evaluate the short term response, and they should consider losses of N from the system and immobilization of N in soil particles, as well as CO_2 flux from soils.

Another weakness of the approach is that the work is confined to seedlings. For obvious reasons the experiments are easier on small trees, but the question always remains will mature trees respond in the same way? This is a common problem for mesocosm experiments, and the group's thoughts on this question would be useful.

It is unclear why forest ecologists are looking at the effect of elevated CO_2 on the fine roots of the Mojave desert (with funds from NSF-TECO?). One wonders how the effects of CO_2 on deserts would be important relative to its effect on forests, which seem to be the Division's main mission If opportunism is the main reason for the research, then the justification should be made clearer.

The panel understands why the development of ecological indicators of forest integrity and sustainability is important, and such development seems a worthy EPA goal. However, the briefing offered only vague ideas of what such indicators might be, and how they might be related to the rhizosphere. This approach may take more thought.

Likewise, there are strengths and weaknesses in the progress made to date The panel saw strength in numerous findings presented of the effect of elevated CO temperature, ozone, etc. on features such as root growth and respiration. The investigators are successful at designing tools that identify and measure effects. However, there is no indication of how these findings are integrated into an assessment or monitoring plan to use them and what the linkages are to other of the EPA's offices. It is unclear that there has been progress toward the NHEERL goal of transferring research results to the risk assessment community.

There was generally appropriate skill mix. The investigators are clearly good at designing tools that measure the functioning of the rhizosphere, and changes as a result of various stressors. The expertise is there for emphasis on the rhizosphere, as they have defined it. The investigators seem less experienced with scaling their results to whole trees, to ecosystems, or to the region. Perhaps this scaling is the task of other teams.

The future directions seem to be generally a continuation of existing research. The investigators are developing a novel system for measuring in situ soil respiration (the WAND) They are seeking to add a third isotope to help partition the CO_2 efflux from soils The effort to evaluate the effects of the release of biotechnology products is being phased out. The panel was unsure of the directions being taken to address risk assessment specifically, as noted above.

Resources And Facilities are excellent. The development of the terracosm facility is the kind of research activity that is appropriate to EPA. It is clear that it was developed at a significant cost, but the high probability of continuity of funding makes it a wise investment that is unlikely to be duplicated elsewhere. Similarly, the use of mini-rhizotrons, while not requiring a major monetary investment, requires a substantial investment in infrastructure, including hardware, software, and trained personnel. That, too, appears to be an activity that is appropriate for EPA research.

Evaluation and Summary

In general, the rhizosphere work (as the group defines it) is unique and provides an important link to our understanding of C-cycling Although some of the activities under this theme seem to be "stretching the envelope" with respect to relevance, the work is strongly endorsed. The actual rhizosphere work that is being done here seems to be of high quality and high relevance. Recent advances in molecular biology have allowed the development of a whole armament of new tools for identifying and quantifying soil biota, and it is appropriate for EPA scientists to take the lead in developing such tools. Among other things, this should provide the means to understand better what is going on whenever some environmental insult appears to affect ecosystem function through its impact on rhizosphere processes. Such phenomena have been suggested for some of the mysterious "declines" that occasionally strike forest trees. Rhizosphere biotic dynamics are so complex, however, that it is doubtful we will ever develop a useful predictive capability for the effect of environmental changes on rhizosphere activity (in the sense that one might predict that a 3 degrees C increase in temperature will cause changes in the rhizosphere of western hemlock that will result in fungus X becoming dominant over fungus Y with a resulting decrease in hemlock's vigor and competitive ability). However, it would be very useful to have better tools to investigate such situations when they occur.

There are a few areas in this theme that seem to be of questionable relevance to the rest of the work. It is not clear why the Cascade Elevational Field Sites were started in addition to the terracosms and mycocosms already in place. Most of the work falling under this theme deals with controlled environments, and it would seem that all the N and CO_2 treatments would provide plenty of work, and be more relevant to the basic EPA mission Adding a series of uncontrolled field sites may be a valuable adjunct to the controlled environment work, but its relevance (such as a field test of modeling results) needs to be better established Comparing control and clear-cut sites also seems rather far from the basic structure of this theme (unless these comparisons are really part of the PNW studies and are classified here for some administrative reason). The photosynthesis measurements at the Wind River Crane site seem even more peripheral to the work on this project, and would seem more relevant to the "Extrapolation" goal.

It is recommended that the team focus more on variability in the field, for example, clear cuts vs. undisturbed forests, or natural disturbances vs. disturbances associated with logging.

Theme 2. Multi-Scale Monitoring

Description

To apply sample survey design expertise developed for lakes and streams to riverine systems in diverse areas of the country. And, to extend classificatory work, and examine the effect of natural variability on the ability to determine status and trends in ecoregions. Explore linkages between intensively studied sites and sample survey data.

Critique

This theme is especially well-suited to EPA's mission and is well-aligned with the new emphasis on risk assessment. Furthermore, other institutions are much less able to conduct this type of research--i.e., the program is of national importance and seems very much on track It constitutes a praiseworthy attempt to determine how representative long-term, intensively studied sites are and to link the findings there to sample surveys.

Approaches used by EMAP have been criticized by review boards and some scientists outside of EPA. The Division should not be discouraged from using these approaches, however. Probabalistic studies of large data sets and of sampling strategies are the only means by which quantitative information can be assembled on large geographic regions. EPA's use of statistical skills outside of EPA is well advised and should reduce criticisms.

The theme's approach of continuing emphasis on survey design, classification, defining variability, and integrating sample surveys and data from intensively monitored sites is on target

The progress of this effort as described is excellent The group should keep up the good work.

The skill mix is appropriate and well tested. Individual scientists are strong, but in some cases should publish more vigorously

Regarding future directions, collaboration with groups in diverse regions of the country is a strength. The scope is now largely regional and should move to the national scale. Also, a stronger emphasis should be placed on running waters. Finally, it would be advisable to see more evidence of collaboration between this group and the PNW estuaries group.

Both resources and facilities seem adequate The briefing document provides no evidence of anything missing Computer capabilities that were addressed in the overview seem quite adequate.

Evaluation and Summary

This is an on-going, successful research group which seems to be progressing in a logical manner to reach well-defined goals to improve integrated monitoring and classification schemes which can be applied widely.

Consolidation of findings will be especially important for this group if the work is ultimately to be transferred to users outside of the agency. A summary volume or symposium would be desirable.

Theme 3. Extrapolation of Plant Response

Description

The main objective of this theme is to provide a mechanistic understanding of the effects of various stressors on forests so that the risks to these forests can be assessed and managed. While the current emphasis is on forests as ecosystems, the main effort to date has been on individuals of tree species, principally in the seedling stage. More recently efforts have been aimed at examining processes operating at various stages of the life cycle of trees, from seedlings to adults, and at higher levels of organization, from local ecosystems to landscapes and regions, with the accompanying challenges of extrapolating from empirical evidence at lower levels of organization.

Critique

The fundamental approach taken to meet the objective of this theme is basically sound. However, certain aspects are better developed than others. The program had its beginnings in determining the effects of atmospheric gaseous pollutants, principally ozone, on tree seedling performance. This work, conducted under controlled and semi-controlled environmental conditions, was pioneering and continues to be used in risk assessments by the agency. However, species responses were based mainly on trials from single seed sources at one location. Other stressors, including nutrients, habitat modification and land use, resources use and management, and climate change have only recently been added to the list to be examined. Still others, such as exotic species, have received virtually no attention, and perhaps correctly given the current funding levels and staff expertise.

Efforts at the Corvallis lab examining processes beyond the level of tree seedlings or leaves of mature trees have been limited, making it difficult to extrapolate to the whole tree or local ecosystem level. A recent study of the effects of plant age on fine root dynamics in seedlings and mature individuals of Douglas-fir may be a notable exception. Whole-plant physiological responses of adult trees have not been undertaken, nor have empirical studies of the effects of stressors on trees at the population and local ecosystem level. One recent limited-scale investigation of the effects of graminoid competition on the performance of ponderosa pine seedlings subjected to various levels of ozone begins to address community-level responses to stressors. Beyond this, investigations involving an array of organisms (i.e., species assemblages or guilds) at the local ecosystem level are lacking. In contrast, there exist several studies by WED scientists of the effects of stressors (chiefly land use and climate) on forests at the regional and landscape levels using spatially-explicit simulation modeling approaches which extrapolate from the life history traits of tree species growing in various regions of North America. Thus, there is a gap in empirical information from whole (adult) trees through local ecosystems, making the validation of landscape- and regional-level ecosystem models very difficult, if not impossible.

We recognize that the Corvallis lab has only recently been configured to address the effects of an array of stressors on forests at various scales, and thus would not be expected to exhibit a level of accomplishment commensurate with that of long-standing programs However, the integration of expertise represented by various members of the team seems to be proceeding at a slower pace than would be expected. For example, stand-level tree models developed by scientists from the southeastern U.S. are being used in Pacific Northwest landscapes instead of those developed for local situations by team members. Moreover, not one of the 117 publications listed in the references section of the team's report involves co-publication by members who work predominantly at the organismal and landscape/regional levels, respectively. Finally, it should be noted that the draft of the team's report that was given to us originally was subutled "from chambers to trees," while the version given us at the review meeting two months later was subtitled "from chambers to field to landscape." This indicates a need to more clearly define the steps to be taken to scale up to these "new" levels

In addition to better integration of scientists on the team, we recommend that greater effort be placed on process-level studies at the whole (adult) tree and local ecosystem levels, and that organisms in addition to tree species be considered in their responses to stressors given the difficulties in working with large, long-lived individuals. This approach is more in line with ecosystem science.

Given constraints that exist in terms of funding, we recommend that team members focusing on whole (adult)tree response to stressors consider collaborating with other scientists in the region who have already invested considerably in experimental setups (e.g., bole and canopy access towers) designed to measure responses in such individuals, and who in turn court benefit from the state-of-the art equipment (such as terracosms) available at the Corvallis Lab to measure seedling responses.

Moreover, we suggest that the project consider hiring a scientist with expertise in local ecosystem dynamics, preferably with some knowledge of both plants and animals as well as the physical environment, to complement the existing expertise on the team. The addition of a soil scientist would also be highly desirable, as would a remote sensing expert

Given the limitations of funding, it seems appropriate that the terrestrial ecology team focus on forest ecosystems given their predominance in temperate North America and their impact on such continental and global processes such as climate change. However, other ecosystems, such as deserts and grasslands, are also quite extensive in North America and elsewhere, so that the EPA should encourage collaborative research with other scientists on stressors in these systems through their grant program.

Finally, it seems that hypothesis testing has been used only sparingly to date by the team. Given the robustness of this approach to solving problems of an ecological nature, we encourage its use more in the future.

As discussed above, the resources and facilities available to the plant extrapolation team appear outstanding given the present scope of work. In fact, the equipment for measuring the responses of tree seedlings to gaseous stressors is among the best in the world. However, broadening the scope of work, as suggested above, would require additional resources (including human) and facilities. If such resources are not forthcoming, we would argue that it would be better for the existing team to continue to focus on lines of research that allow it to use the outstanding facilities already available

Evaluation and Summary

In conclusion, we would like to emphasize the fact that the research that is currently being conducted by scientists on the "plant extrapolation" team is in our judgment of very high quality and serves the mission of WED well. This is evidenced by publications in well respected, peer-reviewed journals, and results appear to be relevant to ORD's mission. Furthermore, the plant response team scientists appear to be well respected by their peers as evidenced by their participation on review panels and on editorial boards What is needed is greater integration of efforts by team members across levels of biological organization and an expansion of this effort to encompass a greater number of attributes and processes inherent in forest ecosystems at venous scales. Given existing budgets, it is incumbent upon those who are involved in allocating EPA grant dollars to non-EPA scientists, to do so in such a way as to complement the efforts of WED scientists. This may require some involvement on the part of WED scientists in the allocation process. Moreover, as WED scientists are no longer responsible for risk assessment and management, the higher administration should take the steps necessary to insure open communication between risk assessors/managers and WED scientists given the complexities in ecosystem responses to multiple stresses

Theme 4. Indicators of Condition of Ecological Resources

Description

The purpose of the research under this theme is to develop and evaluate ecological indicators for surface waters and forests that can be used to monitor the ecological status of these entities over large geographic areas. An intensive effort has been underway in three different geographic areas for some years evaluating aquatic resources. There has been significant progress in the development and application of indicators, much of it based on Karr's IBI concept. Indicator development for forest systems is just getting underway.

Critique

The emphasis at Corvallis is on physical, chemical and population phenomena. Some indices are based on sums and/or products of metrics from an expert-selected and/or statistically-selected set of relatively independent conceptual dimensions of the "ecological resources." These compound indices may require a kind of guild-like apprenticeship training to apply and then they appear to provide comparable data only in a particular ecosystemic context in which the various metrics were calibrated. As a general guideline it might be preferable to use more transparent indices with less reliance on context-specific prior knowledge and with more widely comparable results.

Nonetheless, the indicator development strategy has been well documented and represents a highly successful effort in the aquatic area. Clearly, the staff at WED have put together a program that is effective at evaluating both the biotic health of aquatic ecosystems and the stressors that affect them The Oregon stream section of this theme shows the applicability of the IBI. An interesting spin-off of this project may be the development of a riparian indicator, something that is needed. This research needs to be integrated with that in the Southwest where an intensive amount of research is underway as well as that in the Intermountain area already done by the USDA Forest Service. Despite the fact that this research has been conducted from 1992-1995, little published work is reflected.

The Northeast lakes section appears to have received the major share of this effort. Documentation in the report shows favorable results for a diversity of assemblages and biological and lake chemistry. While there are a number of references given, it appears that relative to the overall effort, there is a shortage of open literature publications resulting from this research. This is critical as this information needs to be made available to the public and to other researchers.

Application of indicators in the Mid-Atlantic Highlands Area (MAHA) show some interesting results, but again indicate a lack of peer reviewed publications. However, the review team did not know how much effort has been placed in this project. It should be noted that EPA Research Triangle Park laboratory is to lead a pilot project in the mid-Atlantic region as part of the Environmental Monitoring Research Initiative (EMRI) sponsored by the OSTP. This indicator effort should be integrated within that project.

In discussion of integration, it was pleasing to note that in the future studies section, a joint project with the US Forest Service has been initiated in the Pacific Northwest.

The development of the forest indicators is only recently initiated. The sections on the rhizosphere and ecosystem indicators leave a number of questions, but may be answered with further development. Of particular concern is the development of metabolic profiles of rhizosphere organisms. What will this research tell us if we cannot identify over 99% of soil bacteria (Tieje), there are over 2,000 potential ectomycorrhizae in the Pacific NW (Trappe), and populations change drastically in response to wetting and drying? There is a need to not just check the numbers of organisms, but to link it with the ecosystem processes that they control.

The researchers on the surface waters part of this theme are synthesizing the contributions of many efforts directed over a century of concern about the health of humans and fish. During the past three decades much work has been done with respect to the Great Lakes under the binational Great Lakes Water Quality Agreements, GLWQAs, of 1972, 1978 and 1987. The EPA is the lead agency on the U.S. side, with the Duluth Laboratory key to the research aspects. It is unclear to what extent there is cooperation now between the Corvallis and Duluth Laboratories on this part of the theme. The panel wondered if the two U. S. - Canada SOERs concerning the Great Lakes, of 1994 and 1996, provided any information useful to the Corvallis initiatives.

It seems that more emphasis on ecosystem-level phenomena, than was apparent in the report of the surface water theme description, would now be timely (see, e.g., Regier and Kay 1996).

Many conferences and workshops have been convened on this general theme in recent decades. It is somewhat frustrating that we collectively are not now further along in this enterprise. Perhaps we have had a moving policy target, in that earlier presuppositions of the sufficiency of simplistic aspects of utilitarian value no longer suffice (Lackey 1997). Should we deliberately aim at pluralistic value orientations in our SOERs and risk assessments? The leaders of this theme should be encouraged to bite off more than the present commitments.

Resources and facilities were not determined, but appear to be adequate as most of this research is done off-site

Theme 5. Ecological Role of Land/Water Interfaces—Riparian Areas And Wetlands

Description

This theme program is evolving. It had been one that emphasized characterization and restoration and landscape function through a large, cooperative extramural component implemented throughout the nation. It is changing to one that is based more on the research of WED investigators that focuses on freshwater emergent wetlands, urban wetlands, "drier" wetlands, and western riparian wetlands.

Critique

The theme team seems to be struggling in transition from the old model extensively involving cooperators to the new model of investigator research strictly within the Division. In the process there is a risk of becoming too focused on northwest regional questions and leaving a void in meeting EPA's national responsibilities. Under the reorganization wetlands research will be carried out in other NHEERL divisions as well as WED. This creates a need for a NHEERL-wide strategy which articulates a vision for the national program and the roles and relationships of the various divisions. In addition, ongoing coordination among these efforts is required

The studies that have been conducted by the wetlands group to assess the effectiveness of wetland protection (e.g. permitting) and restoration efforts have been very valuable and served a useful purpose of pointing out shortcomings. These studies have been conducted not only in Oregon but at many other places in the nation. Consequently, they provided a national perspective and have had national impact It is not clear where these efforts are going following the reorganization. Scientific needs to improve wetland protection and restoration require better predictive information on hydrologic, geochemical and biologic functions of wetlands. We were uncertain about where the contributions of the WED will focus and where WED can do cutting edge research. It is not clear that there is a basis for preeminence by WED in this field under the current organization.

The riparian zone research addresses important needs to understand the function of riparian zones of agricultural landscapes in the region.. but deals with too few sites and may not produce information on mass flux. Design of the studies should be reconsidered with the following principles in mind:

1. Sites must be sufficiently numerous to provide a basis for generalization.
2. Results must be available on the form of mass flux, which is the best means for comparing sites.
3. Interpretation should be made at the watershed level.

This program will require broadening and reorientation in order to be most effective Perhaps it should include rangelands as well as croplands. The current riparian zone research has some important limitations, however. The limited number of sites makes it difficult to sort out the multiple factors involved, such as soils, land use, stream order, flooding regimes, etc Flux of the groundwater is not being directly measured, but inferred. Mass balance approaches should be also applied to provide further verification of assumed flow rates. Most of the riparian work seemed to focus on groundwater transport of N and herbicides, but perhaps of more regional importance is the role of riparian zones in bank erosion, stream sedimentation, and aquatic and terrestrial biodiversity. In addition, although the lands or of low relief, soil loss and P inputs should be assessed The riparian zone process and structural research should be better applied to the watershed-scale assessments of the PNW project.

Resources and facilities seem to be adequate. With greater emphasis on research by WED investigators, development of experimental wetland sites of intense investigation may be appropriate.

Evaluation And Summary

This program has made important contributions but does not appear to have settled in its new role regarding wetlands research across NHEERL divisions and its areas of future emphasis on research on wetland functions.

Theme 6. Pacific Northwest Estuaries: Cumulative Effects Framework

Description

This thematic program is a component of the Pacific Northwest Research Program which seeks to develop science to advance ecosystem management concepts on a regional scale. The Estuaries component seeks to provide a scientific framework for assessing the multiple, and potentially cumulative, effects of multiple stressors related to landscape changes, delivery of materials from the watershed, resource extraction, pesticide and herbicide applications, and invasion by non-indigenous species on the estuarine ecosystem.

Critique

This is an ambitious proposal on a species (based on the evidence in the review document) that has not previously been intensively studied. It does seem to hark back to the single species approach, which in the overview, is said to have been reduced in importance in the new strategic plan. The justification for the choice of Willapa Bay as "typical" is not clear, and the claim that it is relatively pristine seems to be belied by the current use of a biocide and a herbicide, and land use changes with their consequences of increased nutrient and sediment inputs and other disturbances. Panelists understood that there was a population of the introduced oyster species, *Crassostrea gigas*, in Willapa Bay. It is not mentioned in the proposal, but one wonders whether this species is to be treated as "exotic" or not. Some of the questions generated by the proposal outline can be answered on-site. It will be interesting to hear the results of the 1996 benthic survey, and to know more about how easily some results can be transferred from Yaquina Bay to Willapa Bay

The focus on cumulative effects of stressors, many of which are not toxic contaminants traditionally addressed in EPA risk assessment approaches, on estuarine ecosystems is an important and appropriate goal, from the perspectives both of regional ecosystem management and for national science needs. The PNW research program provides an opportunity to advance on this goal. Moreover, the WED program offers the advantage of bringing sustained, multidisciplinary research to bear on the problem which few other organizations could do. The complexity of the issues of multiple stressors in estuarine ecosystems, however, means that the WED team cannot do it alone, but should develop integrated, collaborative links with the ERC and state partners.

Approaching this goal is, however, not an easy or straightforward matter. The selection of Willapa Bay as the primary study site was based on the importance of this estuary to the region and the opportunities afforded by the fact that its watershed is largely under control of one private land owner. However, this estuary is comparatively large and extensively used in shellfish aquaculture (including the application of pesticides) and this makes the assessment of cumulative effects—especially those related to regional landscape changes—more difficult to assess.

It is surprising that a description of what is known about Willapa Bay, how we think the ecosystem works, what effects stressors may have and how they may interact—a model if you will—has not been put together, or at least was not presented. Rather, there seemed to be an emphasis, a lament even, on what is not known. Without such a picture of how the ecosystem works, it is very difficult to determine what to measure in the study and how the measurements interrelate.

The focus on a population response of a single species as representative, sensitive or integrative is risky at best and is probably doomed to failure in meeting the broader objectives of the theme. While one can make the argument that meaningful effects should ultimately be understood at the population level, that strategic decision has resulted on focusing on a single species which may or may not be sensitive to the multiple stressors experienced by the estuarine ecosystem. Although in the initial review of their plans, the researchers were advised to focus rather than study a little of everything, the approach now seems too narrowly focused. In any case, populations of bivalves, such as *Clinocardium*, are more likely to be controlled by processes affecting recruitment and biological interactions (e.g. predation) than by the stressors being assessed. Furthermore, the approaches to modeling effects on the populations assume linear relationships and additivity of effects which may not be realistic. Community and ecosystem approaches have a higher probability of success than focus on a single population

The panel was unsure how the work on diuron and ammonia-based fertilizers on PNW amphibians fits into the overall theme. These seem to be toxicity studies and inappropriate for the theme. In fact, p. 5 of the overall WED description states that chemical stressors will principally be considered in terms of their interactions with non-chemical stressors. It is not clear if that is the case here.

It has been indicated that the atmosphere and ocean in the Willapa and Yaquina regions interact in complex ways. The El Nino Southern Oscillation and the North Pacific Oscillations, both not strongly cyclical, seem to interact but in ways that are not now clear. One consequence appears to be that the precipitation runoff and the coastal upwelling regimes as these affect the bay ecosystems are both unpredictable, now and perhaps for ever. If such major ecosystemic driving variable are unpredictable, how can models of phenomena that depend strongly on such large-scale variables produce predictable results?

Resources and facilities available to the theme team appear to be adequate. The facilities at Newport to support experimental research are excellent. It is not clear whether the field facilities for work in Willapa Bay are adequate.

Evaluation and Summary.

There seems to be a problem in the transition of this research group from its traditional and highly successful focus on contaminant chemistry and toxicology to ecosystem considerations and non-toxic stressors. To assist this transition and advance on the important theme goal the following recommendations are offered:

• Before proceeding rapidly on the highly risky single-species strategy, the WED should convene a focused workshop to examine various approaches to assess watershed-estuary interactions and changes at the ecosystem level in Willapa Bay. The participants should include the WED, ERC and state cooperator participants and a small number of national experts on estuarine ecosystem studies

• A senior scientific leader with experience in estuarine ecosystem studies should be recruited to the Newport staff and the other vacant positions should be filled in a very strategic way to build and enhance the team.

• Opportunities for "re-training" of the ecotoxicology-oriented staff should be provided, perhaps including visiting scientists or short-term assignment of Newport staff to other experienced research centers.

• WED contributions to estuarine ecosystem studies should build on WED strengths, including the excellent experimental and analytical facilities at Newport and the survey design, integration, and spatial analysis capabilities at Corvallis.

• Truer collaboration with partners in ERC and state agencies should be developed

The PNW program seems parochial, but has national and international implications It is not apparent that filling data gaps in agricultural areas of Oregon and Washington are unique and singling out the PNW region seems perhaps inappropriate. Much of the research, though relevant to the region is not generalizable in a national context.

It would be useful to see some discussion or rationale for dropping the synthesis activities of the former wetlands research program. Such data synthesis is very important and is a kind of activity for which EPA is uniquely suited to perform.

APPENDICES

APPENDIX 1. TERMS OF REFERENCE

Memorandum from Randall Bond to Western Ecology Review Panel, dated January 8, 1997 (attached).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL HEALTH AND ENVIRONMENTAL EFFECTS
RESEARCH LABORATORY
RESEARCH TRIANGLE PARK, NC 27711

January 8. 1997

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: Review Material and Assignments

FROM: for Randall Bond
Senior Peer Review Official

TO. Western Ecology Review Panel

Enclosed is the document for your review prior to the Western Ecology Division review meeting on January 29-31. The document contains an agenda for the meeting, a Divisional overview, reports concerning six research themes and one cross-cutting program, titles of posters to be presented at the meeting, biographical sketches and 2-page project descriptions for each principal investigator As communicated to you earlier, we are seeking an in-depth review of the Western Ecology Division that will provide the Divisional management, the NHEERL Laboratory Director, and Associate Laboratory Director with perspective and information that will facilitate planning, implementation, and resource allocation within the Division and NHEERL. A copy of up to five representative reprints per research theme is also included for your information.

We are asking you to review the material with several questions in mind, including:

Research:

In order to draw overall conclusions regarding the breadth and depth of the program from a scientific and resource utilization perspective, please consider the following:

1 How is the Division addressing Agency problems and advancing the science?

2. Is the program asking the right question?

3 Are the approaches and skills mix appropriate to answer the questions?

4 Is the progress and productivity to date satisfactory given the available resources?

5. Are the future directions appropriate?

Advice/Review:

1. Does the information presented suggest that the Division places a priority on this function in supporting Agency goals?

2. What is the evidence that the program is providing advice to the Agency? To others? How is the information being used?

Leadership:

Does the information presented suggest that the Division and its scientists are exerting leadership roles as evidenced by:

1. Inclusion in significant national and international symposia/workshops

2 Invited participation in prominent research planning exercises with national or international impact

3 Collaboration and/or coordination on related research projects at the national and international level

4. Invited reviewer of research programs of other organizations/agencies that are prominent in environmental effects research

5 Leadership role in professional societies and publications

In addition to providing an overall assessment of the program, we are asking that you provide comments on 2-3 research themes assigned to you. A copy of the Office of Research and Development's Research Strategy is also included for your perusal to provide a broader context in which research is conducted in ORD

After reviewing the materials enclosed, if you would like to bring preliminary comments to the meeting which can be incorporated into the final report, please do so on a 3 5" diskette in any word processing software format.

My colleagues and I look forward to seeing you in Corvallis on Wednesday through Friday, January 29-31. In the interim, Kathy Martin, Purchasing Agent for the Western Ecology Division, will contact the non-Federal reviewers to officially negotiate the procurement of your professional services and reimbursement of expenses. The Western Ecology Division will issue invitational travel orders to Federal reviewers and Purchase Orders to non-Federal reviewers. If you should have any questions, please do not hesitate to call me at 919-541-2973, or in the evening at 919-682-4126.

Addressees. See Attached

APPENDIX 2. PANEL MEMBERS

Address list (attached).

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APPENDIX 3. BRIEFING BOOK

Briefing Book Table of Contents (attached).

WESTERN ECOLOGY DIVISION REVIEW

BRIEFING BOOK

January 1997

Table of Contents

In a folder accompanying this briefing book are reprints of selected publications that represent research conducted under each of these themes (4 to 5 publications per theme).

APPENDIX 4. MEETING AGENDA

Agenda (attached).

BOARD OF SCIENTIFIC COUNSELORS
EFFECTS RESEARCH COMMITTEE
WESTERN ECOLOGY REVIEW TEAM
PUBLIC MEETING
ENVIRONMENTAL PROTECTION AGENCY
WESTERN ECOLOGY DIVISION
CORVALLIS, OREGON
FEBRUARY 19-21, 1997

February 19

9:00 - 10:00 am	Purpose of Review/Procedures for Comments	Coutant/Bond
10:00 - 10:20	Convene/Disclosure/Administrative Items	Bond/Panel
10:20 - 10:45	Welcoming and NHEERL Overview	Reiter/Veith/Bond
10:45 - 11:00	Questions	
11:00 - 11:30	Divisional Overview	Murphy
11:30 - 12:00	Questions	
12:00 - 1:00	Lunch	
1:00 - 1:30	Role of the Rhizosphere	Tingey
1:30 - 2:00	Questions	
2:00 - 2:30	Extrapolation of Plant Response	Hogsett
2:30 - 3:00	Questions	
3:00 - 4:00	Corvallis Facility Tour	Lackey
4:00 - 5:30	Poster Session - Terrestrial Ecology	

February 20

8:15 - 8:40	Pacific NW Program	Baker
8:40 - 9:00	Questions	
9:00 - 9:30	Land/Water Interfaces	Wigington
9:30 - 10:00	Questions	
10:00 - 10:15	Break	

February 20 (cont'd)

10:15 - 10:45	Multi-scale Monitoring	Paulsen
10:45 - 11:15	Questions	
11:15 - 11:45	Indicators of Ecological Condition	Baker
11:45 - 12:15	Questions	
12:15 - 2:00	Lunch/Poster Session - Regional Ecology	
2:00 - 2:20	Newport Facility Description and Visuals	Ferraro
2:20 - 2:40	Pacific NW Estuaries - Cumulative Effects	Lee
2:40 - 3:10	Questions	
3:10 - 4:15	Poster Session - Coastal Ecology	

February 21

9:00 - 11:00	Executive Session/Management Debriefing	Coutant/Bond/Panel

APPENDIX 5. REPRINT LIST OF SELECTED PUBLICATIONS PROVIDED (BY THEME)

Lists of selected reprints by theme (attached).

Reprints of Selected Publications

Role of the Rhizosphere in Ecological Response of Terrestrial Systems

Andersen, C P , and Rygiewicz, P.T · Allocation of carbon in mycorrhizal *Pinus ponderosa* seedlings exposed to ozone. **New Phytology** 131.471-480, 1995.

Porteous, L A., Armstrong, J L , Seidler, R J , and Watrud, L S.. An effective method to extract DNA from environmental samples for polymerase chain reaction amplification and DNA fingerprint analysis. **Current Microbiology** 29 301-307, 1994

Rygiewicz, P T , and Andersen, C P Mycorrhizae alter quality and quantity of carbon allocated below ground **Nature** 369 58-60, 1994

Tingey, D T., McVeety, B D , Waschmann, R , Johnson, M G., Phillips, D L., Rygiewicz, P T., and Olszyk, D M A versatile sun-lit controlled-environment facility for studying plant and soil processes **Journal of Environmental Quality** 25 614-625 1996

Tingey, D T., Johnson, M G., Phillips, D L , Johnson, D W., and Ball, J.T . Effects of elevated CO_2 and nitrogen on the synchrony of shoot and root growth in ponderosa pine **Tree Physiology** 16·905-914, 1996

Reprints of Selected Publications

Extrapolation of Plant Response – from Chambers to Trees

Hogsett, W E , Weber, J F , and Tingey, D T.. An approach for characterizing tropospheric ozone risk to forests **Environmental Management** 20 1-17, 1996

Andersen, C P., and Scagel, C F · Nutrient availability alters below-ground respiration of ozone-exposed ponderosa pine **Tree Physiology** [in press].

Tingey, D T., and Hogsett, W.E.. Water stress reduces ozone injury via a stomatal mechanism **Plant Physiology** 77 944-947, 1985.

Andersen, C P , and Hogsett, W E Ozone decreases spring root growth and root carbohydrate content in ponderosa pine the year following exposure. **Can. J. For. Res.** 21 1288-1291, 1991

Solomon, A M , and Bartlein, P J Past and future climate change Response by mixed deciduous–coniferous forest ecosystems in northern Michigan. **Can. J. For. Res.** 22 1727–1738, 1992

Reprints of Selected Publications

Multi-Scale Monitoring of Ecological Resources

Larsen, D.P., Thornton, K.W., Urquhart, N.S., and Paulsen, S.G.: The role of sample surveys for monitoring the condition of the nation's lakes. **Environmental Monitoring and Assessment** 32:101-134, 1994.

Omernik, J.M. Ecoregions: A spatial framework for environmental management. In W. Davis and T. Simon (Eds.) **Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making**. Boca Raton, FL: Lewis Publishers, 1995.

Larsen, D.P., Urquhart, N.S., and Kugler, D.L. Regional scale trend monitoring of indicators of trophic condition of lakes. **Water Resources Bulletin** 31:117-140, 1995.

Stevens, D.L., Jr. Implementation of a national monitoring program. **Journal of Environmental Management** 42:1-29, 1994.

Young, T.C., and Stoddard, J.L.: The temporally integrated monitoring of ecosystems (TIME) project design 1. Classification of northeast lakes using a combination of geographic, hydrogeochemical, and multivariate techniques. **Water Resources Research** 32(8):2517-2528, 1996.

Reprints of Selected Publications

Ecological Role of Land/Water Interfaces – Riparian Areas and Wetlands

Holland, C C , Honea, J., Gwin, S E , and Kentula, M E. Wetland degradation and loss in the rapidly urbanizing area of Portland, Oregon **Wetlands** 15(4):336-345, 1995

Kentula, M E , Brooks, R.P., Gwin, S E , Holland, C C , Sherman, A.D , and Sifneos, J.C.. **Wetlands: An Approach to Improving Decision Making in Wetland Restoration and Creation** A.J Hairston (Ed) Washington, DC. Island Press, and Boca Raton, FL: C K. Smoley, Inc (CRC Press, Inc), 1993

Kusler, J A , and Kentula, M.E (Eds.). **Wetland Creation and Restoration: The Status of the Science** Washington, DC Island Press, 1990

Abbruzzese, B , and Leibowitz, S G A synoptic approach for assessing cumulative impacts to wetlands **Environmental Management** 21 1-19, 1997

Reprints of Selected Publications

Cumulative Effects of Stressors on Pacific Northwest Estuaries

Ferraro, S P , Swartz, R C., Cole, F A , and Schults, D W. Temporal changes in the benthos along a pollution gradient Discriminating the effects of natural phenomena from sewage–industrial wastewater effects **Estuarine, Coastal and Shelf Science** 33 383-407, 1991

Swartz, R C , Schults, D W., Ozretich, R J , Lamberson, J O , Cole, F A , DeWitt, T H., Redmond, M S , and Ferraro, S.P.. ∑PAH· A model to predict the toxicity of polynuclear aromatic hydrocarbon mixtures in field-collected sediments. **Environmental Toxicology and Chemistry** 14(11)·1977-1987, 1995

Behrenfeld, M J , Lee II, H , and Small, L F Interactions between nutritional status and long-term responses to ultraviolet-B radiation stress in a marine diatom **Marine Biology** 118 523-530, 1994

Landrum P.F., Lee II, H , and Lydy, M J . Toxicokinetics in aquatic systems Model comparisons and use in hazard assessment **Environmental Toxicology and Chemistry** 11.1709-1725, 1992

Reprints of Selected Publications

Indicators of Condition of Ecological Resources

Stemberger, R S , Herlihy, A T., Kugler, D L , and Paulsen, S.G Climatic forcing on zooplankton richness in lakes of the northeastern United States **Limnology and Oceanography** 41(5) 1093-1101, 1996.

Whittier, T.R , Halliwell, D.B , and Paulsen, S.G.. Cyprinid distributions in northeast USA lakes Evidence of regional-scale minnow biodiversity losses **Canadian Journal of Fisheries and Aquatic Sciences** [in press]

Larsen, D P., Stevens, D.L , Selle, A R , and Paulsen, S G · Environmental Monitoring and Assessment Program, EMAP–Surface Waters A northeast lakes pilot **Lake and Reservoir Management** 7(1).1-11,-1991

Andersen, C P , and Rygiewicz, P T . Stress interactions and mycorrhizal plant response Understanding carbon allocation priorities **Environmental Pollution** 73.217-244, 1991

Widmer, F , Seidler, R J., Donegan, K K , and Reed, G L Quantification of transgenic plant marker gene persistence in the field **Molecular Ecology** 5 145-1–145-7, 1996

APPENDIX 6. BIBLIOGRAPHY OF OTHER DOCUMENTS PROVIDED

Anonymous. 1996. Hatfield Marine Science Center, Oregon State University, Newport, Oregon. (brochure).

U.S. Environmental Protection Agency. 1996. ORD's Strategic Plan. Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.

Western Ecology Division. 1996. Important Scientific Issues. Pages 73-79 in NHEERL FY95 Annual Report. Western Ecology Division, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon.

United States Environmental Protection Agency
National Health and Environmental Effects Research Laboratory
Western Ecology Division
200 SW 35th Street
Corvallis, Oregon 97333

June 18, 1998

MEMORANDUM

SUBJECT: Response to WED Science Peer Review

FROM: Thomas A. Murphy, Director
Western Ecology Division

TO: Gilman D. Veith, Associate Director for Ecology
National Health and Environmental Effects Research Laboratory

This memorandum provides a formal response to the observations and recommendations from the 1997 science peer review of the Western Ecology Division. Twelve independent scientists from across North America were commissioned by NHEERL (Randy Bond), in late 1996 to provide Division and Laboratory management with an analysis of Division research programs that would facilitate research planning, implementation, and resource allocation. Each member of the panel was initially provided with detailed background information on the research activities and scientific staff of the Western Ecology Division. Following review of the material, the Panel convened in Corvallis on February 19-20, 1997, to conduct an on-site review. The Panel provided a written report to NHEERL on March 31, 1998. This memorandum is a response to observations and recommendations included in the report from the panel.

Summary Conclusion of the Panel

"In general, the panelists felt that the Division was a premier research facility with unique capabilities which not only serve EPA's needs, but are truly advancing the 'state-of-the-art' in environmental science. The past record of the Corvallis laboratory is outstanding in terrestrial and regional-scale ecology not restricted to the U.S. West. The marine science laboratory at Newport also has a fine history in areas of effects of marine and estuarine contaminants and toxicology.

However, there was a general feeling that reorientation of the Division towards a Western U.S. regional focus of research for environmental risk assessment is diluting extant collaborations, lessening opportunities for synthesis, and introducing unaccustomed efforts at ecology transfer. The predominantly *national focus of the Corvallis laboratory in selected areas of strong expertise had been its strong point. There was a feeling that this is being diminished as the Division is reshaped into a regional focus more broadly geared to ecological research to estimated ecological risks. The review appeared to take place in an awkward period of mission transition, with accompanying uncertainty among staff and a certain disconnect between the Division's traditional mission and that of EPA headquarters and NHEERL. Although disturbing, this transition may be temporary."*

WED Response

Considering that the peer review took place at a time (15 months ago) of major transition for ORD in general and WED in particular, the Panel offered a number of useful observations and suggestions The Panel was diligent, working far into the night to review and discuss materials provided by WED. Every Panel member came to the meeting with a written report on his or her assigned section of the Division. Specific observations from the Panel and our responses follow.

Division-wide Specific Observations

1. **Observation:** *"Although risk assessment is a nominal objective for use of research by the Division, there was little evidence that it was being used as a common framework in designing or rationalizing the work."*

Response: The recent publication of the EPA guidelines for ecological risk assessment will help standardize some of the terminology and general approaches being used in ecological risk assessment Various WED scientists have been involved in developing and reviewing these guidelines and the precursor documents In our research we have been moving toward innovative modifications of risk assessment (such as the alternative futures research and ecological indicators) that should provide EPA regions and others with useful approaches for assessing the consequences of alternative decisions

2. **Observation:** *"There is ambiguity in the separation of research at the Division from risk assessment carried out by others"*

Response: WED scientists conduct research that will be useful to those in EPA (and elsewhere) who do risk assessment, but WED scientists themselves do not *do* risk assessment.

3. **Observation:** *"Understanding of 'risk assessment' differed throughout the briefing materials and staff contacts, suggesting the need for further conceptual refinement before research ['risk science'] can be readily focused."*

Response: We agree that there are a wide range of views and opinions about ecological risk assessment. The recently issued NCEA guidelines on ecological risk assessment are a step in standardizing terminology that should help resolve some of the confusion and disagreements. In addition, NHEERL has formed a committee (Martha Moore, chair) to investigate the best way to raise the understanding of risk assessment in the various Divisions. We support this effort and look forward to providing such training for WED scientists.

4. **Observation:** *"The health effects model for risk assessment may not be the best model for ecological risk assessment. It is understandable and laudable that EPA should seek a common ground for its enforcement-related research mission, and the Panel felt that the general concept of risk assessment serves that function quite well However, the direct application of the health effects risk assessment model to ecological systems has much uncertainty both conceptually and in practice. The Division, along with the general field of ecological risk assessment, will need to further refine the application of risk assessment concepts to ecosystem assessment and management."*

   Response: See response to observation 3.

5. **Observation:** *"There seems to be less emphasis on characterizing environmental stressors than on defining ecological effects."*

   Response: This is correct. When ORD was reorganized along the risk assessment paradigm, the "stressor" box was organizationally separated from the "effects" box. Therefore, the mission of WED falls into the ecological "effects" box rather than into other or additional aspects of ecology. WED scientists have been working with NERL scientists A current example is the development and implementation of the DISPRO sites.

6. **Observation:** *"Outside interaction based on the previous national scientific role may diminish as the Division becomes more regional, and scientists may need to be aggressive in maintaining them."*

   Response: We share this concern. Some of our previous national scientific visibility was because we had the financial resources to be national players across a range of topical areas. With reduced resources we have concentrated our efforts on fewer scientific problems and explored opportunities to address national problems through collaborative arrangements such as our work on establishing EMAP index sites Our national reputation will rest also on the reputation and productivity of our Principal Investigators. To help build and maintain the national reputation, we have been encouraging all Principal Investigators to publish in the peer reviewed scientific literature. We are also encouraging WED scientists to maintain active roles in professional and scientific societies

7. **Observation:** *"The Division does not have an impressive array of regional linkages."*

   Response: As the Panel points out, Division scientists are moving from a "project management" role to a "project execution" role. WED management will continue to strongly encourage Principal Investigators to develop research contacts and scientific networks. To help encourage these scientific linkages, we have reinvigorated the Individual Development Plans for Principal Investigators to include a specific course of action to achieve promotion under the Research Evaluation Guidelines. Some of those Guidelines involve demonstrating scientific peer interaction. We expect that strong regional linkages will become more apparent as regionally focused research becomes more widely known through publications and the active scientific involvement of the Principal Investigators. We are also encouraging Principal Investigators to take full advantage of the professional and scientific resources available within Corvallis and Newport (Oregon State University, U.S. Forest Service, U.S. Geologic Survey, U.S. Agricultural Research Service, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and Oregon Department of Fish and Wildlife.

8. **Observation:** *"The Division will need to keep, recruit, and use 'good thinkers' who will forge the new mission's programs."*

Response: We agree. Recruitment of bright, energetic scientists with potential for growth is always a concern and priority. We have discussed in some detail identifying the barriers that might keep us from recruiting the "best and brightest." We recognize that there is often pressure to recruit scientists for near term (2 - 5 years) specialized needs when recruiting individuals ("good thinkers") for a multiple decade research career would be better.

9. **Observation:** *"The Division can exploit its unique capabilities and special expertise to maintain a critical mass for the future."*

Response: Recent scientific staff recruitments have been targeted to strengthen existing research programs rather than expand into new ones.

10. **Observation:** *"Geographic scope of Division work is confusing and disorganized."*

Response: With the redirection of the extramural program to the EPA grants program, the Division has been shifting to a research program that is much more in-house oriented and has a more regional focus We continue to provide greater research focus through changes in the team structure (see the responses to several observations in the "Land/Water Interface" theme below).

11. **Observation:** *"The Division's ability to do research related to risk assessment seems to go beyond the U.S West in some of its programs more than others."*

Response: This is correct but resources are limited and we, as with all organizations, focus our efforts on the most critical priorities. Most of our work does have application outside the western United States.

12. **Observation:** *"The effectiveness of the various research themes appeared to vary from high potential to currently inadequate."*

Response: The review took place during a period of major transition. Subsequently, we have changed the structure of the themes and research teams. In part, these changes were driven by the summary comments from the Panel given during their exit interview. For example, three of the six research teams have been totally restructured. Responses to some of the Panel's specific observations are covered below

13. Observation: *"Overall productivity of the Division in terms of products for funds expended seemed low compared to other research institutions."*

Response: We are puzzled by this observation because we contend that WED research productivity, even in light of low productivity from scientists in the midst of research transitions, is relatively high Specifically, the productivity of WED Principal Investigators is most easily and appropriately measured in terms of publication in journals and symposia proceedings, as well as books and chapters in books. For the entire Division, the annual number of journal articles, symposium articles, and book chapters was 72 in 1995, 112 in 1996, and 74 in 1997 for an annual productivity rate of between 2 and 3 for each Principal Investigator. We continue to strive for higher productivity from our Principal Investigators, but in our experience these numbers are within the range of professors at Category I Research Universities such as Oregon State University and the University of Washington.

14. Observation: *"There was a 'caste' structure between EPA employees and contractors that was seen as counterproductive and contrary to effective team integration. Frankly, this system was offensive to the reviewers"*

Response: The use of contractor support is circumscribed by various Government and EPA rules and regulations These rules and regulations are a reality that WED must recognize and follow We had hoped that the ORD "contractor conversion" efforts of a few years ago might be continued and allow for overcoming some of the most egregious contractor inefficiencies at WED. The fact that the Review Panel noted this caste structure is an indication that management efforts to avoid the appearance of a "one workforce" situation have been having an effect.

15. Observation: *"Internal collaboration seems lacking in some areas and could be improved."*

Response: The Panel is probably concerned about getting scientists from the Coastal Ecology Branch meshed with scientists in the other two branches. In addition to the geographic separation of the Coastal Ecology Branch in Newport, there are some real discipline differences. We will continue to work on improving this Since the time of the peer review, we have implemented a major shift in research direction (toward a more ecological orientation rather than toxicological) at the Coastal Ecology Branch. This shift brings the research direction more in line with the other two branches and should facilitate scientist-to-scientist collaboration.

16. Observation: *"The Newport facility and staff could be better integrated into the culture and work of the Division, for the staff seemed isolated both geographically and intellectually."*

Response: We agree with this observation, and we will work to strengthen the integration of Principal Investigators from the Coastal Ecology Branch. Since the time of the peer review, we have two joint assignments (Dr. Kentula and Denis White) between the Coastal Ecology Branch and the Regional Ecology Branch. In addition, we now have cross-branch mentors for all newly hired scientists.

17. Observation: *"There are many environmental issues in the U.S. West that are pertinent to EPA's role but are not now being pursued or apparently considered for Division activity, but which might be included."*

Response: We agree with this observation; however, we will continue to focus our limited financial and scientific staff on a few major issues in which research can make a difference.

18. Observation: *"Linkage to the EPA grants program is unclear under the present role compared to the previous role of the Corvallis facility as contract administrator and scientific investigator."*

Response: Since the time of the review, guidance has been issued from ORD that clarifies acceptable interaction between EPA Principal Investigators and Grant Principal Investigators. We believe that some EPA Principal Investigators will be interacting with the colleagues who have been awarded grants. Also since the peer review, WED hosted the "Watershed Grantee" meeting which included all the recipients of EPA grants dealing with watersheds.

19. Observation: "There may be too much staffing from local universities to provide the breadth of capabilities needed for the future "

Response: We share the concern with intellectual inbreeding occurring at major ecological research locations such as Corvallis and Newport. However, we have been sensitive to hiring Principal Investigators with PhDs from across the nation rather than making the "easy choice" of someone with a PhD from Oregon State University. At the present time, four (Boese, Kentula, Larsen, and Olsen) of approximately 40 Principal Investigators have their PhDs from Oregon State It appears likely that the Panel might have confused the hiring patterns of the on-site technical support contractors with those of WED.

Observations on Rhizosphere Research

1. Observation: *"The work on 'above ground carbon assimilation and allocation' on the other hand was not seen as especially unique on it own, and gains most of its value from its linkage with the work on below-ground processes. This linkage, however, did not seem to be as strong as one might have hoped. It is also suggested that perhaps the overall scope of the project was too large to allow a well-defined direction and central focus."*

Response: We agree that research on above ground carbon assimilation and allocation is not unique. Because there are a number of research groups focusing on above ground carbon assimilation, we decided to allocate limited WED resources to below ground research where we can make a bigger impact. The principal linkage we hoped to establish with the above ground studies was to understand the rate and amount of carbon and nitrogen moved into the rhizosphere and how that would influence rhizosphere processes. To this end we feel that the linkage is sufficient and well defined.

2. Observation: *"... the scientists need to take care to restrict their extrapolations to the available data. For example, it is unclear that they have adequately investigated whether or not 'forest management practices that leave organic residues ... will have less impact ...' That assessment does not seem to be either the focus of the research or even a direct derivation."*

Response: At the time of the review, there had been only limited studies of soil organic matter (SOM) by the EPA research team. To strengthen this area of research an EPA soil scientist has been recruited an is now actively developing SOM research. His proposed research was recently peer reviewed as part of the WED Forest Indicator Project and approved. We fully understand the importance of restricting our extrapolations to the available data and will continue to conduct sound research using available data appropriately

3. Observation: *"A weakness of the proposed work is the reliance on a specific model (the MBL/GEM) that may not be the best for their purposes. While a model is required to address questions over long time periods and large areas, the reliance on one particular mode, with no effort to evaluate it, seems inappropriate."*

Response: There are a number of biogeochemical models that could be used to study C and N cycling in an ecosystem, which is a goal of the research. To insure that an appropriate model was selected, we have conducted an evaluation of various biogeochemical models. Based on that evaluation, we found that the MBL/GEM model is suitable for its intended purpose. A key part of model use is a consideration of model "validation". There are several approaches to model validation that we propose to use, including comparison of model results with results from other biogeochemical models We have also taken specific steps to evaluate the selected model The model is currently being parameterized and tested using data from Cascade Elevational Field Sites. To evaluate the parameterized model, independent data from Mark Harmon and Steve Acker's Long-term Biomass Plots in Oregon will be used Also a second set of data is being collected in the Olympic National Park as part of EPA's DISPro activity that will also be used to evaluate the model

4. Observation: *"It is unclear why forest ecologists are looking at the effect of elevated CO2 on the fine roots of the Mojave desert (with funds from NSF-TECO?). One wonders how the effects of CO2 on deserts would be important relative to its effect on forests, which seem to be the Division's main mission."*

Response: The researchers involved in this project include a plant ecologist (whose Ph.D. study was conducted on desert species), a soil scientist, and plant physiologist. The research is on rhizosphere processes which is not limited to forest ecosystems. Previous studies (by EPA scientists), in areas with sufficient water, had established that elevated CO2 increased fine root life span. The desert research is an attempt to develop a more general principle (i.e., we wanted to know if the same phenomenon would occur in a water limited system). The Mojave desert FACE facility seemed the best location to test this hypothesis at minimal cost, as the University of Nevada system was already operating the facility. A key action of any research is the development of general principles that can be applied across a number of different ecosystems and to this end we feel that the research is very relevant to EPA because we must conduct assessments across a number of ecosystems.

5. **Observation:** *"The panel understands why the development of ecological indicators of forest integrity and sustainability is important, and such development seems a worthwhile EPA goal. However, the briefing offered only vague ideas of what such indicators might be, and how they might be related to the Rhizosphere. This approach may take more thought."*

Response: At the time of the Division peer review, the ecological indicators of forest integrity and sustainability were under development. Consequently, the rhizosphere indicators were poorly developed However, since the Division review we have made a major effort to develop a detailed research plan to guide the development of ecological indicators or forest integrity and sustainability. This was culminated by external peer review of the Forest Indicator Project in February, 1998. The peer review panel was very pleased with the proposed Forest Indicator Research as evidenced by a summary quotation from their report, "The Review Committee had high regard for the objectives of the proposed research and great enthusiasm for the development and potential utility of 'indicators' of forest health The proposal clearly and persuasively articulated appropriate criteria for identifying potential indicators, and the suite of processes and variable presented as having potential utility as indicators was inclusive and well justified. Many of the proposed indicators of forest health focus on carbon and nitrogen dynamics. Given the centrality of C and N dynamics to organismal and ecosystem function, this orientation is defensible and appropriate "

6. **Observation:** *"However, there is no indication of how these findings [effect of elevated CO2, temperature, ozone, etc. on features such as root growth and respiration] are integrated into an assessment or monitoring plan to use them and what the linkages are to other of the EPA's offices. It is unclear that there has ben progress toward the NHEERL goal of transferring research results to the risk assessment community."*

Response: The findings on the effect of elevated CO2, temperature, ozone, etc. on features such as root growth and respiration provide key data for the "Forest Ecosystem Indicators Project". These data provide the ability to test model responses and specific indicator responses against stressors of interest to EPA Without the results from these stressor studies, the indicator work would be limited to testing the effects of climatic and edaphic conditions. Because of their integration into the Forest Indicator research, these data will be integrated into the an assessment and/or monitoring plan as part of the Forest Ecosystem Indicators Project.

7. **Observation:** *"There are a few areas in this theme that seem to be of questionable relevance to the rest of the work. It is not clear why the Cascade Elevational Field Sites were started in addition to the terracosms and the mycocosms already in place."*

Response: The Cascade Elevational Field Sites were established as part of the TERA study on the effects of elevated CO2 and temperature on a Douglas-fir ecosystem. The plan to establish the plots was endorsed by an extramural peer review in the summer of 1992 and re-endorsed in 1994. The sites were initially established to test for possible chamber effects of the terracosms on plant and soil responses. Subsequently, they were used to parameterize models for use in extrapolating the results from the TERA study on the effects of elevated CO2 and temperature on a Douglas-fir ecosystem over time and space They now serve as intensive research sits in support of the Forest Ecosystem Indicators Project

Observations on Multi-Scale Monitoring Research

1. Observation: *"Individual scientists are strong, but in some cases should publish more vigorously. a summary volume or symposium would be desirable."*

Response: We are sensitive to the need for WED principal investigators to publish in the peer reviewed scientific literature We have recently added an explicit discussion of specific publication plans to the annual performance review (specifically the Individual Development Plan) The Chief of the Regional Ecology Branch has made increased publication by each Principal Investigator an overall branch priority In addition, the Branch Chief has been encouraging Principal Investigators to take the lead on organizing national symposia (and resulting publications) that highlight WED and related research

2. Observation: *"Regarding future directions, collaboration with groups in diverse regions of the country is a strength. The scope is now largely regional and should move to the national scale. Also, a strong emphasis should be placed on running waters. Finally, it would be advisable to see more evidence of collaboration between this group and the PNW estuaries group."*

Response: Most of the past emphasis of this program has been on lakes in the Northeast, and, more recently, on wadeable streams in the mid-Atlantic. As this work winds down, there will be substantially more publication in the formal scientific literature. A western regional program is planned beginning in 1999 which may include both an estuarine and freshwater component, so the program soon will have a multi-regional focus.

Observations on Extrapolation of Plant Response Research

1. Observation: *"In addition to better integration of scientists on the team, we recommend that greater effort be placed on process-level studies at the whole (adult) tree and local ecosystem levels, and that organisms in addition to tree species be considered in their response to stressors given the difficulties in working with large, long-lived individuals. This approach is more in line with ecosystem science."*

Response: We appreciate the comment and do indeed plan on process-level studies. Studies are on-going this season addressing N allocation in whole trees of varying ages on cascade forest sites with varying soil N level to test the hypothesis that N availability is influential on N retranslocation in trees and testing the role of age and size in N retranslocation. The research will contribute to local ecosystem N budgets as well. We do not plan to limit ourselves to tree species, if questions of nutrient utilization or other processes are best addressed in perennial forbes or annuals.

2. **Observation:** *"Given constraints that exist in terms of funding, we recommend that team members focusing on whole (adult) tree response to stressors consider collaborating with other scientists in the region who have already invested considerably in experimental setups (e.g., bole and canopy access towers) designed to measure responses in such individuals, and who in turn could benefit from the state-of-the-art equipment (such as terracosms) available at the Corvallis Lab to measure seedling responses."*

Response: We are currently collaborating with Oregon State University investigators on studying gas exchange and water movement in ponderosa pine of varying size and age, and in large canopies of Douglas fir at the Wind River Canopy Crane site. Other collaborations are being explored with investigators in the USFS and OSU at sites in the Metolius Natural Area, taking advantage of existing tree access and eddy correlation studies for deposition.

3. **Observation:** *"Moreover, we suggest that the project consider hiring a scientist with expertise in local ecosystem dynamics, preferable with some knowledge of both plants and animals as well as the physical environment, to complement the existing expertise on the team. The addition of a soil scientist would also be highly desirable, as would a remote sensing expert"*

Response: We have hired a soil scientist and are currently interviewing for a forest ecologist position which requires knowledge of local ecosystem dynamics We are advertising for an ecophysiologist with experience in resource (nutrient) utilization and/or canopy gas exchange to lead the project scaling physiological processes in seedlings to large trees and developing a model-based approach for accomplishing scaling of plant response to stresses as a result of size and/or age.

4. **Observation:** *"However, other ecosystems, such as deserts and grasslands, are also quite extensive in North America and elsewhere, so that the EPA should encourage collaborative research with other scientists on stressors in these systems through their grant program."*

Response: Within the WED staff we have encouraged collaboration with other scientists At present, we have on-going research with University of Nevada at Reno on desert ecosystems looking at the role of enhanced CO_2 and root growth in desert plants. We also, through cooperative agreements and IAGs in the Index Site Program are collaborating on studies of N dynamics and availability in desert perennials in Canyonland National Park, and watershed studies in Denali National Park We also have investigators collaborating on grassland ecosystem studies using MBL-GEM at the Konza National Grassland

5. **Observation:** *"Finally, it seems that hypothesis testing has been used only sparingly to date by the team. Given the robustness of this approach to solving problems of an ecological nature, we encourage its use more in the future."*

Response: We appreciate the comment, and do use this approach extensively within our ecosystem and tree-level studies (see earlier response). In the presentation of extrapolation research, the emphasis was on general areas to be addressed, but all research would be testing stated hypotheses.

6. **Observation:** *"What is needed is greater integration of efforts by team members across levels of biological organization and an expansion of this effort to encompass a greater number of attributes and processes inherent in forest ecosystems at various scales."*

Response: We are accomplishing this in a number of WED projects. The Forest Indicators Project is a good example. Within this project there are studies addressing the Cascade forest system as a whole parameterizing the GEM for these forest and at the same time ecophsyiolgoical studies being accomplished on individual trees within the plots studying N and C allocation and partitioning in aboveground and below ground components. On these same plots, microbial ecology studies are addressing the effects on N and C dynamics of the soil food web including bacteria, fungal and invertebrate communities. Other efforts are joining physiologists, ecologists, a soil scientist, tree and stand models, and geographic information systems to develop a means to predict air pollutant effects on trees and stands with the varying spatial nutrient and water availability.

Observations on Indicators of Ecological Condition Research

1. **Observation:** *"As a general guideline it might be preferable to use more transparent indices with less reliance on context-specific prior knowledge and with more widely comparable results."*

Response: We are not clear what the reviewers mean by *"transparent indices"* and *"context-specific prior knowledge"* Our approach is to follow several lines in our research. In particular, for the biological response indicators, we will continue to develop multimetric indices as a way of consolidating information about biological condition, without losing track of the character of the biological assemblages We will also use what are often called multivariate approaches, and an approach developed by British and Australian scientists, and make comparisons among all three, with an eye toward responses to human activities, and expressing that information to both scientific and management audiences. One of the major challenges we face is how we describe a "reference condition" against which we compare existing condition By necessity, the reference condition must be "context specific." A national standard or reference condition would not be scientifically defensible for biological condition.

2. **Observation:** *"While there are a number of references given, it appears that relative to the overall effort, there is a shortage of open literature publications resulting from this research. . . . Application of indicators in the Mid-Atlantic Highlands Area show some interesting results, but again indicate a lack of peer reviewed publications."*

Response: We agree with the desirability of publishing in journals the results of our work on EMAP-Surface Waters, and have made this a top Division priority. In 1997-98, WED scientists working with EMAP-Surface Waters have published, or formally submitted for publication, 78 peer-reviewed papers. We expect more to be submitted during the remainder of 1998 In addition, the Branch Chief has developed a publication plan that sets priorities for journal articles over the next several years

3. **Observation:** *"Of particular concern [with forest indicators] is the development of metabolic profiles of rhizosphere organisms, what will this research tell us if we cannot identify over 99% of soil bacteria, there are over 2,000 potential ectomycorrhizae in the PNW, and populations change drastically in response to wetting and drying? There is a need to not just check the numbers of organisms, but to link it with the ecosystem processes that they control."*

Response: Because of the vast numbers of species present in the rhizosphere, indicators based on taxonomic criteria or morphotypes would be hopelessly complex. On the other hand processes defined by metabolic criteria are relatively few and, it is hypothesized, can be directly related to ecosystem endpoints via mechanistic models.

4. **Observation:** *"It seems that more emphasis on ecosystem-level phenomena than was apparent in the report on the surface water theme description would now be timely."*

Response: We agree. We will begin addressing this issue, especially as we move toward development of the Western Regional Survey

Observations on Land/Water Interfaces Research

1. **Observation:** *"The riparian zone research addresses important needs to understand the function of riparian zones in agriculture landscapes in the region, but deals with too few sites and may not produce information on mass flux. Design of the studies should be considered with the following principles in mind: (1) sites must be sufficiently numerous to provide a basis for generalization; (2) results must be available in the form of mass flux, which is the best means for comparing sites; and (3) interpretation should be made at the watershed level."*

Response: We generally agree with the principles stated by the reviewers. We also believe that our current research addresses these principles to the extent possible given available resources. The research does involve a small sample size (3), but there are only a small number of comparably instrumented sites in the U.S. and no others in the Pacific Northwest. The cost and complexity of the study makes a large sample size prohibitively expensive. Also, the current sites bound the hydrologic conditions expected in poorly drained agricultural landscapes of western Oregon and Washington. Mass flux information would be desirable, and we are using groundwater modeling approaches to provide gross mass flux estimates for groundwater movement. However, it is not possible to obtain rigorous surface water mass balance without physically altering the hydrology of the sites through the construction of weirs or flumes. We believe this would alter the biogeochemistry of the sites. Furthermore, rigorous mass balance measurements have been obtained for few, if any, riparian water quality studies. As we interpret the data, we will seek to place the results in the context of hydrologic process at the watershed scale The first major papers from this study will be submitted to journals this year.

2. **Observation:** *"This program [riparian research] will require broadening and reorientation in order to be most effective. Perhaps it should include rangelands as well as croplands."*

Response: We agree Shortly after this review, the branch incorporated riparian research into a larger group of scientists dealing with ecological effects of landscape change. As part of this new, expanded team, a wider scope of riparian research is included and it is focusing on improving our ability to deal with the response of riparian zones in the larger context of the regional landscape.

3. **Observation:** *"This program [wetlands] has made important contributions but does not appear to have settled in its new role regarding wetlands research across NHEERL divisions and its areas of future emphasis on research on wetlands functions."*

Response: We agree. With the reduction in extramural resources, the wetlands research effort had to be drastically reduced The remaining work (done be EPA Principal Investigators) was incorporated into a larger research team dealing with ecological effects of landscape change.

Observations on Coastal Ecosystems Research

1. **Observation:** *"The justification for the choice of Willapa Bay as "typical" is not clear, and the claim that it is relatively pristine seems to be belied by the current use of a biocide and a herbicide, and land use changes with their consequences of increased nutrient and sediment inputs and other disturbances."*

Response: Since the time of the peer review, there have been major changes in the research of the Coastal Ecology Branch. The Willapa Bay site is now but one of several research locations being studied by branch scientists Emphasis is not on defining a typical estuary, but on comparative studies among estuaries to increase general understanding of ecological systems.

2. **Observation:** *"The complexity of the issues of multiple stressors in estuarine ecosystems, however, means that the WED [CEB] team cannot do it alone, but should develop integrated, collaborative links with the research consortium and state partners."*

Response: Because the research of the Coastal Ecology Branch has changed so much since the review, this comment is no longer directly applicable. We do fully support the idea of collaborative research efforts and are developing such linkages with the current research activities.

3. **Observations:** *"The focus on a population response of a single species as representative, sensitive, or integrative is risky at best and is probably doomed to failure in meeting the broader objectives of the theme."*

Response: We concur with this observation and it is one reason why the branch changed its research approach since the peer review took place The current research of the branch focuses broadly on habitat and community levels, with some supporting research being conducted at the population level.

4. Observation: *"Before proceeding rapidly on the highly risky single-species strategy, the WED should convene a focused workshop to examine various approaches to access watershed-estuary interactions and changes at the ecosystem level in Willapa Bay."*

Response: We agree. The research activities of the branch have changed substantially since the peer review Research plans have been written and are now being subjected to independent scientific peer review Proposed research focuses on broader levels of ecological organization.

5. Observation: *"A senior scientific leader with experience in estuarine ecosystem studies should be recruited to the Newport staff and the other vacant positions should be filled in a very strategic way to build and enhance the team."*

Response: Since the review, Dr Walter Nelson has been hired as Branch Chief. Drs. DeWitt, Power, and Robbins have been hired as scientists. In addition, there are several PhD-level recruitment actions underway in the Coastal Ecology Branch.

6. Observation: *"Opportunities for 're-training' of the ecotoxicology-oriented staff should be provided, perhaps including visiting scientists or short-term assignment of Newport staff to other experienced research centers."*

Response: We agree that retraining the ecotoxicology oriented staff is important and deserves additional management attention We have emphasized having CEB scientists attend estuarine and other ecologically oriented scientific meetings. The Branch Chief will be discussing other opportunities to facilitate transition with each scientists during mid-year and annual performance reviews

7. Observation: *"WED contributions to estuarine ecosystem studies should build on WED strengths, including the excellent experimental and analytical facilities at Newport and the survey design, integration, and spatial analysis capabilities at Corvallis."*

Response: The proposed research (much revised since the peer review) of the Coastal Ecology Branch focuses on estuarine benthic systems, which is where the current branch scientists have primary expertise Liaison relationships, including shared staff members, have been built in the areas of statistical sampling design and landscape ecology with the Regional Ecology Branch in Corvallis Additional collaboration with the Terrestrial Ecology Branch (Corvallis) in the area of nutrient cycling and watershed research will be explored in the coming year. With the additional hiring planned for the Coastal Ecology Branch, we expect to substantially strengthen the overall ecological research capability

8. Observation: *"Truer collaboration with partners in the PNW consortium and state agencies should be*

developed."

Response: We agree that developing regional research partnerships are important. Various scientists within the branch have developed collaborative research efforts with the Pacific Northwest Coastal Ecosystem Research Study (PNCERS) research program, Oregon Sea Grant research, the National Oceanic and Atmospheric Administration Estuarine Research Reserve Program in Oregon, other research linkages with NOAA units co-located at the Marine Science Center in Newport, the Oregon Department of Fish and Wildlife, among others. We have also encouraged individual CEB scientists to take advantage of the co-location of Oregon State University at the Marine Science Center to develop scientists-to-scientist linkages with counterpart professors at Oregon State University.

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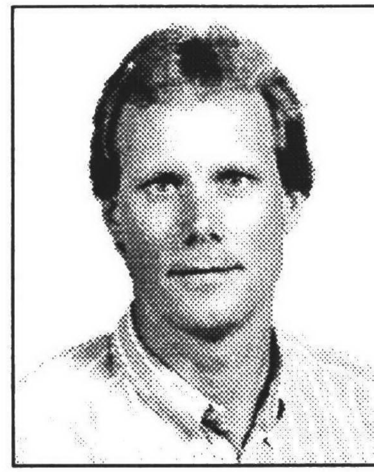

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B.S., Slippery Rock State University, Slippery Rock, PA; Biology, *cum laude*, 1980
M.S., Purdue University, West Lafayette, IN; Forest Biology, 1983
Ph.D., University of Minnesota, St. Paul, MN; Plant Physiology, 1987

Previous Positions:
1987-1988: Postdoctoral Research Associate, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN
1986-1987: Acting Project Leader, Department of Forest Research, University of Minnesota

Research Interests and Skills:
Whole-plant carbon allocation, with special emphasis on root metabolism. Effects of tropospheric ozone on carbon allocation to roots and free-living soil organisms.

Professional Societies:
Soil Ecology Society
Sigma Xi Scientific Research Society

Appointments / Honors:
Assistant professor (courtesy) Forest Science, Oregon State University, 1991-present
Associate Editor, J. of Environmental Quality, 1999- 2001
Board of Editorial Advisors, New Phytologist, 1998- 2003
Editorial Review Board, Tree Physiology, 1991, 1999
Panel member, 1998 USDA NRICGP Competitive Grants Program
Deputy coordinator, IUFRO Section 7.04.02 "Mechanisms of Actions and Indicator Development."
Reviewer: Tree Physiology, Environmental Pollution, Canadian Journal of Forest Research, Wetlands Ecology and Management, Journal of Environmental Quality, Forest Science, New Phytologist, Water Air and Soil Pollution.
EPA Scientific and Technological Achievement Awards, Level II, 1992, 1994, 1996
T. Schantz-Hansen Memorial Research Fellowship, 1983-85
President, Lambda Chapter, Beta Beta Beta National Biology Honorary, 1979-80

Selected Publications:
Andersen, C.P. W.E. Hogsett, M. Plocher, K. Rodecap, and E. Henry Lee, 2001. Blue wild-rye grass competition increases the effect of ozone on ponderosa pine seedlings. Tree Physiol. 21:319-327.
Grulke, N.E., C.P. Andersen, and W.E. Hogsett. 2001. Seasonal changes in above- and belowground carbohydrate concentrations of ponderosa pine along a pollution gradient. Tree Physiol. 21:1-9.
Andersen, C.P. 2000. Ozone stress and changes below-ground: Linking root and soil process. Phyton 40:7-12.
McCrady, J.K. and C.P. Andersen. 2000. The effect of ozone on below-ground carbon allocation in wheat. Environmental Pollution 107(3):465-472.

Andersen, C P , and P T Rygiewicz 1999 Understanding plant-soil relationships using controlled environment facilities Advances in Space Research 24 (3)309-318

Grulke, N E , C P Andersen, M E Fenn, and P R Miller 1998 Ozone and nitrogen deposition lowers root biomass of Ponderosa pine in the San Bernardino Mountains, California Envron Pollut 103 63-73

Scagel, C F , and C P Andersen 1997 Seasonal changes in root and soil respiration of ozone exposed ponderosa pine grown in different substrates New Phytologist 136 627-643

Andersen, C P , R Wessling,, M Plocher, and W E Hogsett 1997 Carry-over effects of ozone on ponderosa pine root growth and carbohydrate concentrations Tree Physiol 17 805-811

Andersen, C P , and C F Scagel 1997 Nutrient availability alters below-ground respiration of ozone-exposed ponderosa pine Tree Physiol 17 377-387

Andersen, C P , and P T Rygiewicz 1995 Effects of ozone on temporal allocation of carbon in mycorrhizal *Pinus ponderosa* seedlings New Phytol 131 471-480

Taylor, G E , D W Johnson, and C P Andersen 1994 Air pollution and forest ecosystems A regional to global perspective Ecological Applications 4 662-689

Rygiewicz, P T , and C P Andersen 1994 Mycorrhizae alter the quality and quantity of carbon allocated below ground Nature 369 58-60

Andersen, C P , and P T Rygiewicz 1991 Stress-response interactions and mycorrhizal plant growth Understanding carbon allocation priorities Invited paper. Environ Poll 73 217-244

Andersen, C P , W E Hogsett, R Wessling., and M Plocher 1991 Ozone decreases spring root growth and root carbohydrate content in ponderosa pine the year following exposure Can J For Res 21 1288-1291

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M.S., Univ. of Wisconsin, Madison; Water Resources Management, 1974
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Ph.D., Cornell Univ., Ithaca, NY; Natural Resources (Fisheries, Aquatic Ecology), 1981

Previous Positions:
1990-1992: Principal, Western Aquatics, Inc., Durham, NC
1985-1989: Director and Senior Scientist, Ecological Services Division, Kilkelly Environmental Associates, Raleigh, NC
1982-1985: Visiting Asst. Professor, N. Carolina State Univ., Raleigh, NC; Atmospheric Deposition Program, School of Forestry
1980-1982: Asst. Professor, Duke Univ., Durham, NC, School of Forestry and Environmental Studies
1974-1976: Research Associate, Oak Ridge National Laboratory, Oak Ridge, TN

Research Interests and Skills:
Effects of landscape change on aquatic ecosystems
Large-scale (watershed, regional) ecological processes and integrative analysis
Effects of acidic deposition on fish communities

Keywords:
Disciplines: Biology-Aquatic, Fisheries Ecology, Aquatic Ecosystems Fisheries, Freshwater Landscape, Watershed
Stressors: Biological-Exotic/Introduced Species, Loss of Species, Physical Habitat Modification, Human Activities/Demographics/Land use
Methods: Field Observation, Indicator Development, Modeling, Ecological Monitoring and Assessment, Environmental Integrated Assessment

Professional Societies:
Ecological Society of America
American Fisheries Society
Phi Beta Kappa

Appointments/Honors:
Secretary-Treasurer for the Oregon Chapter of the American Fisheries Society, 2000-2002
Technical Lead, National Acid Precipitation Assessment Program, Workgroup on effects on aquatic biota 1986-1991

Selected Publications:

Baker, J P , J Van Sickle, C J Gagen, D R DeWalle, W E Sharpe, R F Carline, B P Baldigo, P S Murdoch, D W Bath, W A Kretser, H A Simonin, and P J Wigington, Jr 1996 Episodic acidification of small streams in the northeastern United States Effects on fish populations Ecological Applications 5 422-437

Van Sickle, J , J P Baker, H A Simonin, B P Baldigo, W A Kretser, and W E Sharpe 1996 Episodic acidification of small streams in the northeastern United States Fish mortality in field bioassays Ecological Applications 5 408-421

Baker, J P , W J Warren-Hicks, J Gallagher, and S W Christensen 1993 Fish population losses from Adirondack lakes The role of surface water acidity and acidification Water Resources Research 29(4) 861-874

Turner, R S , P F Ryan, D R Marmorek, K W Thornton, T J Sullivan, J P Baker, S W Christensen, and M J Sale 1992 Sensitivity to change for low-ANC eastern US lakes and streams and brook trout populations under alternative sulfate deposition scenarios Environmental Pollution 77 269-277

Baker, J P , D P Bernard, S W Christensen, M J Sale, J Freda, K Heltcher, D Marmorek, L Rowe, P Scanlon, G Suter, W Warren-Hicks, and P Welbourne, 1991 Biological Effects of Changes in Surface Water Acid-Base Chemistry State of Science/Technology Report 13, National Acid Precipitation Assessment Program, Washington, D C

Baker, J P , and S W Christensen 1991 Effects of acidification on biological communities in aquatic ecosystems In Acidic Deposition and Aquatic Ecosystems Regional Case Studies Springer-Verlag, New York

Haines, T A , and J P Baker 1986 Evidence of fish population response to acidification in the eastern United States Water, Air, and Soil Pollution 31 605-629

Baker, J P , and C L Schofield 1982 Aluminum toxicity to fish in acidic waters Water, Air, and Soil Pollution 18 289-309

Driscoll, C , J Baker, J Bisogni, and C Schofield 1980 Effect of aluminum speciation on fish in dilute acidified lakes Nature 284 161-163

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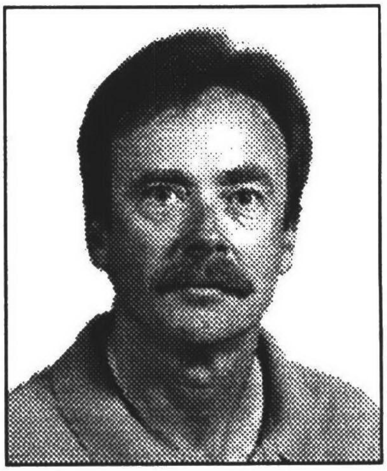

Education:
B.A., Hiram College, Hiram, OH; Biology, 1973
Ph.D., Utah State University, Logan, UT: Biology, 1979
M.B.A., University of Washington, Seattle; Marketing, 1986

Previous Positions:
1999: Director (acting) Western Ecology Division
1988-1990: Leader of the Global Systems Team, US EPA, ERL, Corvallis
1980-1988: Research scientist, Battelle Pacific Northwest Laboratories, Richland, WA

Research Interests and Skills:
Plant community ecology: ecosystem monitoring and effects determination
Application of remote sensing technology to ecological research and assessment

Professional Societies, Honors:
Ecological Society
Phi Beta Kappa
US Patent. Sauer, R.H., and P.A. Beedlow. Electric Dendrometer. US Patent No. 4549355, 1985

Selected Publications:
Lewis, J.D., R.B. McKane, D.T. Tingey, and P.A. Beedlow. 2000. Vertical gradients in photosynthetic light response within an old-growth Douglas-fir and western hemlock canopy. Tree Physiology 20:447-456.

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Beedlow, P.A., D.S. Daly, and M.E. Thiede. 1986. A new device for measuring fluctuations in plant stem diameter: implications for monitoring plant responses. Environmental Monitoring and Assessment 6:277-282.

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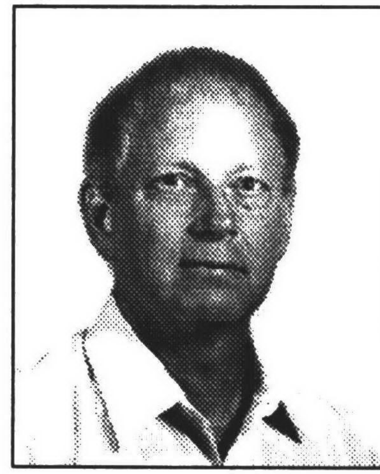

Education:
B.S., University of Illinois , Urbana, IL, 1964
M.F., Yale University, New Haven, CT, 1965
Ph.D., North Carolina State Univ., Raleigh, NC; 1970

Previous Positions:
1990-2000: Regional Ecology Branch Chief, USEPA-ORD, NHEERL, Corvallis, OR
1989-1990: Terrestrial Branch Chief, USEPA-ORD, ERL, Corvallis, OR
1987-1989: Research Ecologist/Acid Rain Team Leader USEPA-ORD, ERL, Corvallis, OR
1986-1987: Forest Team Leader, National Council of Pulp & Paper Industry, Corvallis, OR
1975-1986: Director, Forestry Research, Potlatch Corporation, Lewiston, ID
1974-1975: Senior Research Forester, International Paper Co., Bainbridge, GA

Professional Societies:
Society of American Foresters

Appointments/Honors:
Affiliate Professor of Forest Science. Oregon State University, 1989-present
Inland Empire Tree Improvement Cooperative. Secretary, 1977-1986
Institute of Paper Chemistry. Forest Biology Research Advisory Committee, 1978-1982, 1984-1986; chairman 1981-1982
Affiliate Professor of Forest Management. University of Idaho, 1979-1986
USDA Western Regional Council. Research Planning Group, 1979-1986
Idaho Forest Industries Council. Chairman of the Research Advisory Committee to the University of Idaho, 1982-1986
National Council on Air and Stream Improvement of the Pulp and Paper Industry. Task Group on Air Quality/Forest Health, 1984-1986
National Forest Products Association. Forest Research Committee, 1985-1986
Affiliate Assistant Professor of Forest Management. NC State University, 1970-1975

Selected publications:
Lackey, R.T., and R.L. Blair 1997. Science, policy, and acid rain. Renewable Resources Journal 15(1):9-13.
Zobel, B.J., and R.L. Blair. 1976. Wood and pulp properties of juvenile wood and topwood of the southern pines. Appl. Polymer Symp. 28:421-433.
Blair, R.L., B.J. Zobel, R.G. Hitchings, and J.B. Jett. 1976. Pulp yield and physical properties of young loblolly pine with high density juvenile wood. Appl. Polymer Symp. 28:435-444.
Blair, R.L., B.J. Zobel,, and J.A. Barker. 1975. Predictions in pulp yield and tear strength in young loblolly pine. Tappi 58(1):89-91.
Blair, R.L. 1975. Exploiting natural variation through genetic selection. Pages 35-45 in B.A. Thielges, editor, Forest Tree Improvement - The Third Decade. Louisiana State Univ., Div. Contin. Educ., Baton Rouge.

Blair, R L , B J Zobel, E C Franklin,, A C Djerf, and J M Mendel 1974 The effect of tree form and rust infection on wood and pulp properties of loblolly pine Tappi 57(7) 46-50
Blair, R L , and E B 1974 Cowling Effects of fertilization, site and vertical position on the susceptibility of loblolly pine seedlings to fusiform rust Phytopathology 64(5) 761-762
Stonecypher, R W , B J Zobel, and R L Blair 1973 Inheritance of patterns of loblolly pine from a nonselected population N C Ag Experiment Station Tech Bull No 220
Blair, R L , and B J Zobel 1971 Predictions of expected gains in resistance to fusiform rust in loblolly pine Pages 52-57 in Proc , Eleventh South Forest Tree Impr Conf , Atlanta, Ga
Blair, R L 1970 Quantitative inheritance of resistance to fusiform rust in loblolly pine Ph D thesis, North Carolina State Univ , Raleigh, NC

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Education:
B.S., Southern Oregon College, Ashland; Biology, 1970
M.S., Oregon State University, Corvallis; Oceanography, 1975
Ph.D., Oregon State University, Corvallis; Zoology, 1979

Previous Positions:
1980-1998: Biological Oceanographer, USEPA
1978-1980: Senior Scientist, Northrop Services, Corvallis, OR

Research Interests and Skills:
Seagrass
Cumulative effects of multiple stressors on aquatic organisms
Environmental toxicology/bioaccumulation

Professional Societies:
Pacific Estuarine Research Society

Appointments/Honors:
USEPA Achievement Award for Performance, 1983, 1997
American Fisheries Society/USEPA Science Achievement Award in Biology/Ecology
1995 USEPA Science and Technology Award, Hon. Ment. 1991

Selected Publications:
Boese, B.L. (Submitted). Simulated effects of recreational clam harvesting on eelgrass (*Zostera marina*). Aquat. Bot.

Hecht, S. and B.L. Boese. (Submitted). The sensitivity of an infaunal amphipod, *Eohasutoris estuarius*, to 96-hour static water-borne exposures of 4-nonylphenol (NP). Environ. Tox. Chem.

Robbins, B.D. and B.L. Boese (Submitted). Macroalgae volume: A surrogate for biomass. Aquat. Bot.

Boese, B.L., R.J. Ozretich, J.O. Lamberson, F.A. Cole and R.C. Swartz. 2000. Phototoxic evaluation of marine sediments collected from a PAH contaminated site. 38:274-282

Cole, F.A., B.L. Boese, R.C. Swartz, J.O. Lamberson and T.DeWitt 2000. Storage duration and the toxicity of spike sediment to Rhepoxynius abronius. Environ. Contam. Toxicol. 19:744-748

Boese B.L., R.J. Ozretich, J.O. Lamberson, R.C. Swartz, F.A, Cole, J. Pelletier, and J. Jones. 1999. Toxicity and phototoxicity of mixtures of highly lipophilic PAH compounds in marine sediment: Can the ΣPAH Model be Extrapolated? Arch. Environ. Contam. Toxicol. 36:270-280.

Boese, B.L., J.O. Lamberson, R.C. Swartz, R. Ozretich, and F. Cole. 1998. Photoinduced toxicity of PAHs and alkylated PAHs to the marine infaunal amphipod (*Rhepoxynius abronius*). Archives of Environmental Contamination and Toxicology 34:235-240.

Boese, B.L., H. Lee II,, and S. Echols. 1997. Evaluation of a first-order model for the prediction of the bioaccumulation of PCBs and DDTs from sediment into the marine deposit-feeding clam, *Macoma nasuta*. Environ. Toxicol. Chem. 16(7):1545-1553.

Boese, B.L., J.O. Lamberson, R.C. Swartz, and R.J. Ozretich. 1997. Photoinduced toxicity of fluoranthene to seven marine benthic crustaceans. Arch. Environ. Contam. Toxicol. 32:389-393.

Boese, B L 1996 Standard Guide for the Determination of the Bioaccumulation of Sediment-Associated Contaminants by Benthic Invertebrates Pages 1110-1159 in Annual Book of ASTM Standards 11 05 Philadelphia

Boese, B L , H Lee II, D T Specht, J Pelletier, and K Randall 1996 Evaluation of PCB and hexachlorobenzene biota-sediment accumulation factors based on ingested sediment in a deposit-feeding clam Environ Toxicol Chem 15(9) 1584-1589

Boese, B L , M Winsor, H Lee II, S Echols, J Pelletier, and R Randall 1995 PCB congeners and hexachlorobenzene biota-sediment accumulation factors for *Macoma nasuta* exposed to sediments different total organic carbon contents Environ Toxicol Chem 14 303-310

Lee II, H , B Boese, R Randall, and J Pelletier 1990 Method to determine the gut uptake efficiencies for hydrophobic pollutants in a deposit-feeding clam Environ Toxicol Chem 9 215-219

Boese, B L , M Winsor, H Lee II, D Specht, and K Rukavina 1990 Depuration kinetics of hexachlorobenzene in the clam, *Macoma nasuta* Comp Biochem Physiol 96C 327-331

Boese, B , H Lee II, D Specht, R Randall, and M Winsor 1990 Comparison of aqueous and solid phase uptake for hexachlorobenzene in the tellinid clam, *Macoma nasuta* (Conrad) A mass balance approach Environmental Toxicology and Chemistry 9 221-231

Boese, B 1988 Hypoxia-induced respiratory changes in English sole (*Parophrys vetulus*) Comp Biochem Physiol 89A 257-260

Boese, B , H Lee II, and D Specht 1988 Efficiency of uptake of hexachlorobenzene from water by the tellinid clam, *Macoma nasuta* Aquatic Toxicology 12 345-356

Boese, B 1984 Uptake efficiency of the gills of English sole (*Parophrys vetulus*) for four phthalate esters Can J Fish Aquat Sci 41 1713-1718

Boese, B , V Johnson,, D Chapman, and J Ridlington 1982 Effects of petroleum refinery wastewater exposure on gill ATPase and selected blood parameters in the Pacific staghorn sculpin (*Leptocottus armatus*) Comp Biochem Physiol 71C 63-67

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M.S., Univ. of Washington, Seattle, Tree Physiology, 1987
Ph.D., Univ. of Washington, Seattle, Tree Physiology, 1993

Previous Positions:
1996-1999 Assistant Professor, University of South Florida, Department of Biology
1993-1996 Postdoctoral Research Associate, University of Utah, Department of Biology

Research Interests and Skills:
Whole plant ecology
Forest biology; structure and function of forest canopies
Carbon dioxide dynamics in forest ecosystems

Professional Societies:
Ecological Society of America

Appointments/Honors:
Professor (courtesy) Dept. of Biology Univ. of South Florida, Tampa, 1999-Present
Professor (courtesy) Dept. of Forest Science, Oregon State University, Corvallis, 1999-Present
Reviewer for *Tree Physiology, Canadian J. of Forest Research, Oecologia, Trees, Annals of Forest Science*
NSF Advisory Panel for Instrument Development for Biological Research, 1999-2000

Selected Publications:
Brooks, J.R., L.B. Flanagan, and J.R. Ehleringer. 1998. Responses of boreal conifers to climate fluctuations: indications from tree-ring widths and carbon isotope analyses. Can. J. For. Res. 28:524-533.
Buchmann, N., J.R. Brooks, L.B. Flanagan, and J.R. Ehleringer. 1998. Carbon isotope discrimination of terrestrial ecosystems. Pages 203-221 in H. Griffiths, D. Robinson and P. Van Gardingen, editors, Stable Isotopes and the Integration of Biological, Ecological and Geochemical Processes. BIOS Scientific Publishers Ltd., Oxford.
Hinckley, T.M., D.G. Sprugel, J.R. Brooks, K.J. Brown, T.A. Martin, D.A. Roberts, W. Schaap, and D. Wang. 1998. Scaling and integration in trees. Pages 309-337 in D.L. Peterson and V. T. Parker editors. Ecological Scale: Theory and Applications. Columbia Univ. Press, New York.
Brooks, J.R., L. Flanagan, N. Buchman, and J.R. Ehleringer. 1997. Carbon isotope composition of boreal plants; functional grouping of life forms. Oecologia 110:301-311.
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Flanagan, L.B., J.R. Brooks, and J.R. Ehleringer. 1997. Photosynthesis and carbon isotope discrimination in boreal forest ecosystems: a comparison of functional characteristics in plants from three mature forest types. Journal of Geophysical Research 102: 28861-28869.

Flanagan, L B , J R Brooks, G T Varney, and J R Ehleringer 1997 Discrimination against $C^{18}O^{16}O$ during photosynthesis and the oxygen ratio of respired CO_2 in boreal forest ecosystems Global Biogeochem Cycles 11 83-98

Flanagan, L B , J R Brooks, G T Varney, S C Berry, and J R Ehleringer 1996 Carbon isotope discrimination during photosynthesis and the isotopic ratio of respired CO_2 in boreal forest ecosystems Global Biogeochem Cycles 10 629-640

Brooks, J R , T M Hinckley, and D G Sprugel 1996 The effects of light acclimation during and after foliage expansion on photosynthesis of *Abies amabilis* within the canopy Oecologia 107 21-32

Buchmann, N , J R Brooks, K D Rapp, and J R Ehleringer 1996 Carbon isotope composition of C4 grasses is influenced by light and water supply Plant, Cell and Environment 19 392-402

Kuuluvainen, T , D G Sprugel, and J R Brooks 1996 Hydraulic architecture and structure of *Abies lasiocarpa* seedlings in three subalpine meadows of different moisture status in the eastern Olympic Mountains, Washington, USA Arctic and Alpine Res 28 60-64

Sprugel, D G , J R Brooks, and T M Hinckley 1996 Effect of light on shoot and needle morphology in *Abies amabilis* Tree Physiol 16 91-98

Sprugel, D G , M G Ryan, J R Brooks, Vogt. K , and T Martin 1995 Respiration from the organ level to the stand Pages 255-299 in W K Smith and T M Hinckley editors Resource Physiology of Conifers Academic Press, San Diego

Brooks, J R , T M Hinckley, and D G Sprugel 1994 Acclimation responses of mature *Abies amabilis* sun foliage to shading Oecologia 100 316-324

Hinckley, T M , J R Brooks, J Cermak, R Ceulemans, J Kucera, F C Meinzer, and D A Roberts 1994 Water flux in a hybrid poplar stand Tree Physiol 14 1005-1018

Brooks, J R , T M Hinckley, E D Ford, and D G Sprugel 1991 Foliage dark respiration in *Abies amabilis* (Dougl) Forbes variation within the canopy Tree Physiol 9 325-338

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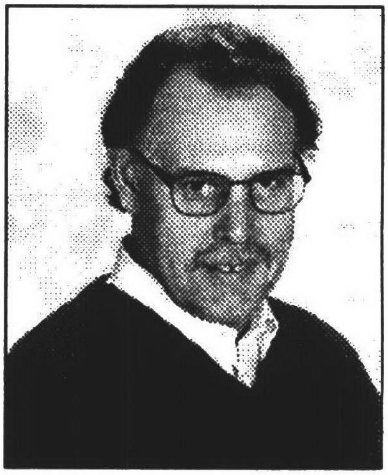

Education:
B.A., San Jose State University, San Jose, CA; Zoology, 1974
M.S., Oregon State University, Corvallis, Fisheries, 1980
B.S., Western Oregon University, Monmouth, Public Policy and Administration, 1989

Previous Positions:
1994-96: Research Biologist, Global Carbon Cycle Project, WED, Corvallis
1989-93: Project Leader, Forest Systems Project, Global Change Research Program, WED, Corvallis
1985-89: Biologist, Wildlife Toxicology Research Team, WED, Corvallis
1981-85: Biologist, Sediment Toxicity Team, WED, Corvallis
1976-81: Biologist, Western Fish Toxicology Station, WED, Corvallis
1974-76: Biological Aid, National Eutrophication Survey, WED, Corvallis

Research Interests and Skills:
Nitrogen biochemistry; terrestrial carbon cycling; forest ecosystem indicators; global change research; water quality; research project management; public policy

Professional Societies:
Ecological Society of America, American Geophysical Union, Northwest Forest Soils Council, American Institute of Biological Sciences, International Society of Tropical Foresters, Mensa

Appointments/Honors:
Office of Environmental Processes and Effects Research long-term training grant, 1988
EPA award for continued superior performance
Cash awards for outstanding job performance (approximately 15)
Gold Medal for Exceptional Service; ERL-C best scientific paper award

Selected Publications:
Cairns, M.A., P.K. Haggerty, R. Alvarez, B.H.J. De Jong, and I. Olmsted. 2000. Tropical Mexico's recent land-use change: a region's contribution to the global carbon cycle. Ecological Applications 10(5):1426-1441.

DeJong, B.H.J., M.A. Cairns, N. Ramírez-Marcial, S. Ochoa-Gaona, J. Mendoza-Vega, P.K. Haggerty, M. González-Espinosa, and I. March-Mifsut. 1999. Land-use change and carbon flux between the 1970s and 1990s in the central highlands of Chiapas, Mexico. Environmental Management 23(3):373-385.

Schuft, M.J., J.R. Barker, and M.A. Cairns. 1998. Spatial distribution of carbon stocks in southeast Mexican forests. Geocarto International 13:77-86.

Turner D.P., J.K. Winjum, T.P. Kolchugina, T.S. Vinson, P.E. Schroeder, D.L. Phillips, and M.A. Cairns. 1998. Estimating the terrestrial-C pools of the former Soviet Union, conterminous U.S., and Brazil. Climate Research 9:183-196.

Cairns, M A , J K Winjum, D P Phillips, T P Kolchugina, and T S Vinson 1997 Biogenic carbon flux Case studies in the former Soviet Union, the conterminous United States, Mexico and Brazil Mitigation and Adaptation Strategies for Global Change 1 363-383

Cairns, M A , S Brown, E H Helmer, and G A Baumgardner 1997 Root biomass allocation in the world's upland forests Oecologia 111 1-11

Turner, D P , J K Winjum, T P Kolchugina, and M A Cairns 1997 Accounting for biological and anthropogenic factors in national land-base carbon budgets Ambio 26 220-226

Schuytema, G S , A V Nebeker, and M A Cairns 1996 Comparison of recirculating, static, and elutriate aquatic sediment bioassay procedures Bull Environ Contam Toxicol 56 742-749

Cairns, M A , J R Barker, R W Shea, and P K Haggerty 1996 Carbon dynamics of Mexican tropical evergreen forests Influence of forest management options and refinement of carbon-flux estimates Interciencia 21 216-223

Cairns, M A , R Dirzo, and F Zadroga 1995 Forests of Mexico A declining resource? Journal of Forestry 93 21-24

Barker, J R , P E Schroeder, and M A Cairns 1994 A risk assessment framework for evaluating forest adaptation to climate change Pages 274-294 in A R Maarouf, N N Barthakur, and W O Haufe, editors, Proceedings of the 13th International Congress of Biometeorology Environment Canada, Downsview, Ontario

Cairns, M A , and R A Meganck 1994 Carbon sequestration, biological diversity, and sustainable development integrated forest management Environmental Management 18 13-22

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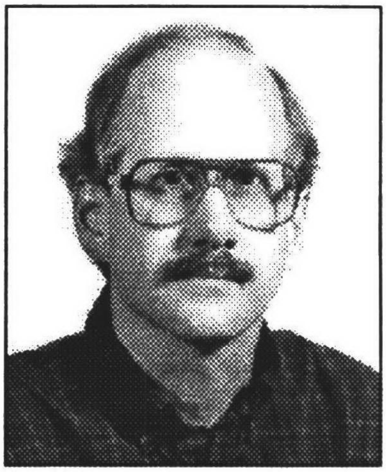


Education:
B.A., University of Virginia, Charlottesville; Chemistry, 1971
Ph.D., Univ. of Virginia, Charlottesville; Environmental Sciences, 1980

Previous Positions:
1982-1983: Environmental Scientist, USEPA/NC State. University Acid Precipitation Research Program, Corvallis, OR
1980-1982: Postdoctoral Fellowship, Department of Environmental Sciences, University of Virginia
1979: Instructor in Aquatic Ecology, Department of Environmental Sciences, University of Virginia
1977-1978: Research Limnologist, Waterways Experiment Station, U.S. Army Engineers, Vicksburg, MS

Research Interests and Skills:
Effects of acidic deposition on surface water chemistry; runoff mapping

Keywords:
Scientific Disciplines: Hydrochemistry, Watershed Modeling, Watershed Biogeochemistry, Watershed Nutrient Cycling, Biogeochemistry, Runoff Mapping, Regional Hydrology, Hydrology
Forest Hydrology, Chemical Limnology, Water Quality Modeling
Stressors: Acidic Deposition, Atmospheric Nitrogen Deposition, Nutrients
Methods: Process Modeling, Empirical Modeling, Time Trend Analysis

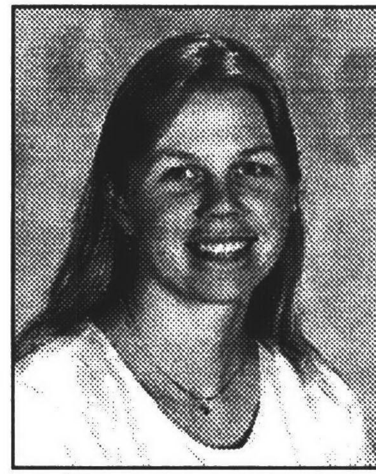
Professional Societies:
American Geophysical Union, Water Quality Committee, 1986-2000; Meetings Comm. (ex officio)1999-2001
Society of the Sigma Xi, University of Virginia 1973; Oregon State University, 2000
American Society of Limnology and Oceanography

Appointments/Honors:
Citationist for George M. Hornberger, Recipient–American Geophysical Union Excellence in Geophysical Education Award, 1999
Chapman Conference Chair, American Geophysical Union, 1999-2002
Professor (courtesy) Department of Geosciences, Oregon State University, 1998-present
Scientific and Technological Achievement Awards, USEPA, Level III 1993, 1996; Level I, 1997; Level II, 1999
Originated and chaired American Geophysical Union Chapman Conferences, 1989, 1996
Editors' Citation for Excellence in Refereeing for Water Resources Research, 1993
Originated and chaired continuing Gordon Research Conference, 1991
Technical Contribution Awards, USEPA, 1985, 1986, 1987, 1989, 1990
Best Quarterly Scientific Paper Award, Environmental Research Laboratory, Corvallis USEPA, 1st Quarter 1989
Special Achievement or Act Awards, USEPA, 1987, 1996
Bronze Medal for Commendable Service, USEPA, 1985

American Chemical Society Undergraduate Award in Analytical Chemistry, University of Virginia, 1971
Chaired 14 symposia for national meetings of AGU, AIH, ISEM, and NALMS
Reviewer for Annales Geophysicae, Biogeochemistry, Can J Fish & Aquat Sci ,Chapman & Hall Publishers, Env Manage , EOS, ES&T, J Amer Wat Resour Assoc , J Env Eng Div - ASCE J Hydrologic Eng , ASCE J Irr & Drain Eng , ASCE J Hydrology, Limnology & Oceanography, Nature, Science, Soil Science Society American Journal, Sci Tot Environ , Water, Air & Soil Pollution, Water Resources Research
Reviewer for USDA, USDOE, USDI, EPRI, Florida DEP, Maryland DNR, IH-UK, Univ of Nevada EPSCoR
Mentor for students MentorNet (The National Electronic Industrial Mentoring Network for Women in Engineering and Science)
Listed in American Men and Women of Science and Who's Who in Science and Engineering, Premier ed

Selected Publications:

Church, M R , and J Van Sickle 1999 Potential relative future effects of sulfur and nitrogen deposition on lake chemistry in the Adirondack Mountains, United States Water Resour Research 35 2199-2211
Driscoll, C T , G E Likens, and M R Church 1998 Recovery of surface waters in the Northeastern U S from decreases in atmospheric deposition of sulfur Water, Air, & Soil Pollut 105 319-329
Bishop, G D , M R Church, and C Daly 1998 Effects of improved precipitation estimates on automated runoff mapping Eastern United States J Am Water Resources Assn 34(1) 159-166 NHEERL-COR-2109J
Church, M R 1998 Acidic deposition acidification of surface waters Pages 34-36 in R W Herschy and R W Fairbridge, editors, Encyclopedia of Hydrology and Water Resources. Encyclopedia of Earth Sciences Series Kluwer Academic Publishers, Boston
Bishop, G D and M R Church 1998 Hydrologic Mapping Pages 371-374 in R W Herschy and R W Fairbridge. editors, Encyclopedia of Hydrology and Water Resources, Encyclopedia of Earth Sciences Series Kluwer Academic Publishers, Boston
Church. M R , and C T Driscoll 1997 Nitrogen cycling in forested catchments A Chapman Conference Global Biogeochemical Cycles 11 613-616
Church, M R 1997 Hydrochemistry of forested catchments Annual Review of Earth and Planetary Sciences 25 23-59
Church, M R , G D Bishop, and D L Cassell 1995 Maps of regional evapotranspiration and runoff/precipitation ratios in the Northeast United States J Hydrol 168 283-298
Herlihy, A T , P R Kaufman, M R Church, P J Wigington, R Webb, and M J Sale. 1993 The effects of acidic deposition on streams in the Appalachian Mountain and Piedmont Region of the Mid-Atlantic United States Wat Resour Research 29 2687-2703
Church, M R , Shaffer, P W , Eshleman, K N . and Rochelle, B P 1990 Potential future effects of current levels of sulfur deposition on surface water chemistry in the Southern Blue Ridge Mountains, U S Water , Air, & Soil Pollut 50 39-48
Church, M R , et al 1989 Direct/Delayed Response Project Future Effects of Long-Term Sulfur Deposition on Surface Water Chemistry in the Northeast and Southern Blue Ridge Province USEPA. EPA/600/3-89/061 887 pp Washington, D C
Sullivan, T J , J M Eilers, M R Church, D J Blick, K N Eshleman, D H Landers, and M D DeHaan 1988 Atmospheric wet sulphate deposition and lakewater chemistry Nature 331 607-609
Galloway, J N , S A Norton and M R Church 1983 Freshwater acidification from atmospheric deposition of sulfuric acid A conceptual model Environ Sci and Tech 17 541A-545A



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Education:
B.S., Earlham College, Richmond, Ind., Biology -Chemistry, 1988
M.S., University of Washington, Seattle, Forest Ecosystem Analysis, 1990
Ph.D., University of Washington, Seattle, Forest Biogeochemistry, 1994

Previous Positions:
1996-1999: Assistant Professor of Forest Biogeochemistry, University of Rhode Island, Kingston
1994-1996: Post-doctoral researcher, Harvard Forest, Harvard University, Petersham, Mass.
1988-1994: Research Assistant, University of Washington, Seattle
1991: Intern at the Oak Ridge National Laboratory, Oak Ridge, Tenn.

Research Interests and Skills:
Biogeochemistry; soil microbial processes; impacts of present and past land use on nutrient and organic matter dynamics; role of plant species in soil processes

Professional Societies:
Ecological Society of America
Soil Science Society of America - Forest and Range Soils
Soil Ecology Society
Association for Women in Science

Appointments/Honors:
Associate Editor for the *Soil Science Society of America Journal*, 2001-present
Editor's Citation for Excellence in Manuscript Review, Soil Science Society of America, 1999
Professor (adjunct), Dept. Natural Resources Science, University of Rhode Island, Kingston, 1999-present
Professor (adjunct), Dept. Forest Science, Oregon State University, Corvallis 1999-present
Reviewer for *Soil Science Society of America Journal, Canadian Journal of Forest Research, EcoScience, Ecology, Journal of Environmental Quality, Oecologia, Biogeochemistry*

Selected Publications:
Compton, J.E. and Cole, D.W. 2001. Fate and effects of phosphorus additions in soils under N2-fixing red alder. Biogeochemistry 53: 225-247.
Canary, J.D., R.B. Harrison, J.E. Compton and H.N. Chappell. 2000. Additional carbon sequestration following repeated urea fertilization of second-growth Douglas-fir stands in western Washington. Forest Ecology and Management 138:225-232.
Compton, J.E., and R.D. Boone. 2000. Long-term impacts of agriculture on organic matter pools and nitrogen transformations in central New England forests. Ecology 81:2314-2330.
Compton, J.E., R.D. Boone, G. Motzkin, and D.R. Foster. 1998. Soil carbon and nitrogen in a pine-oak sand plain in central Massachusetts: Role of vegetation and land-use history. Oecologia 116:536-542.
Compton, J.E, and D.W. Cole. 1998. Phosphorus cycling and soil P fractions in Douglas-fir and red alder stands. Forest Ecology and Management 110:101-112.

Compton, J E , D W Cole, and P S Homann 1997 Leaf element concentrations and soil properties in successive rotations of red alder (*Alnus rubra*) Canadian Journal of Forest Research 27 662-666

Harrison, R B , S P Gessel, D Zabowski, C L Henry, D Xue, D W Cole, and J E Compton 1996 Mechanisms of negative impacts of three forest treatments on nutrient availability Soil Science Society of America Journal 60 1622-1628

Cole, D W , J Compton, P S Homann, R L Edmonds, and H Van Miegroet 1995 Carbon accumulation in Douglas-fir and red alder forests Pages 527-546 in W W McFee and M J Kelly, editors Carbon forms and functions in forest soils, Proceedings of the 8th North American Forest Soils Conference Soil Science Society of America Journal

Homann, P S , D W Cole, H Van Miegroet, and J E Compton 1994 Cation-nitrate relationships in soil solutions from undisturbed and harvested red alder stands Canadian Journal of Forest Research 24 1646-1652

Cole, D W , J E Compton, H Van Miegroet, and P S Homann 1991 Changes in soil properties and site productivity caused by red alder Water Air and Soil Pollution 54 231-246

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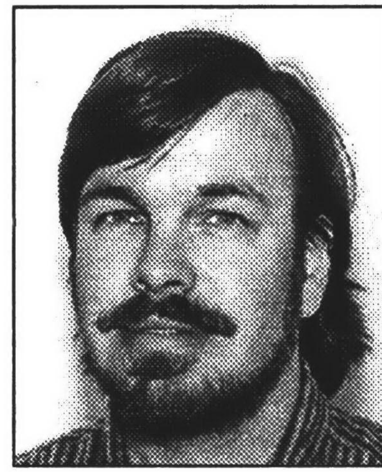

Education:
B.A., New College of the University of South Florida, Sarasota, FL; Biology, 1976
Ph.D., State University of New York, Stony Brook, NY; Ecology and Evolution, 1985
Postdoctoral Fellow, Hatfield Marine Science Center, Oregon State University, Newport, OR, 1985-1987
Postdoctoral Fellow, Smithsonian Environmental Research Center, Edgewater, MD, 1987-1988

Previous Positions:
1994-1997: Senior Scientist, Battelle Marine Sciences Laboratory, Pacific Northwest National Laboratory, Sequim, WA
1993-1994: Senior Research Associate, National Research Council, USEPA, ERL, Newport, OR
1992-1993: Marine Ecologist, AScI Corp., Hatfield Marine Science Center, Newport, OR
1987-1992: Research Associate, Oregon State University, Dept. of Zoology and Hatfield Marine Science Center, Newport, OR

Research Interests and Skills:
Ecology of marine and estuarine benthic invertebrates
Population dynamics of marine organisms
Bioturbation of sediments, with particular interest in effects on benthic communities and flux of chemicals and materials
Integration of effects of anthropogenic stressors within coastal ecosystems
Ecotoxicology and geochemistry of chemical contaminants in sediments

Professional Societies:
Society of Environmental Toxicology and Chemistry (Board of Directors, Pacific Northwest Chapter, 1990-1995)
American Association for the Advancement of Science
Appointments/Honors:
Distinguished Visiting Scientist, National Institute of Water and Atmospheric Research, Hamilton, New Zealand, 1993, 1996
Co-chair, Ecological Effects Committee, Pellston Conference on Sediment Risk Assessment, Society of Environmental Toxicology and Chemistry, Pacific Grove, CA, 1995
Organizing Committee, Second World Congress of the Society of Environmental Toxicology and Chemistry, Vancouver, BC, Canada, 1995.
President, Pacific Northwest Chapter, Society of Environmental Toxicology and Chemistry, 1994
Senior Research Associate, National Research Council, 1993

Selected Publications:
DeWitt, T.H., C.W. Hickey, D.J. Morrisey, R.B. Williamson, L. Van Dam, E.K. Williams, M.G. Nipper, and D.S. Roper. 1999. Do amphipods have the same concentration-response to contaminated sediment *in situ* versus *in vitro?* Environmental Toxicology and Chemistry 18(5):1026-1037.

Morrissey, D J , T H DeWitt, D S Roper, and R B Williamson 1999 Variation in the depth and morphology of burrows of the mud crab *Helice crassa* among different types of intertidal sediment in New Zealand Marine Ecology Progress Series 182 231-242

DeWitt, T H , L A Niewolny, S L Nieukirk, B Gruendell, W Gardiner, and A Borde 1996 Support for development of a standard chronic sediment toxicity protocol with the estuarine amphipod. *Leptocheirus plumulosus* Battelle Marine Sciences Laboratory, Richland, WA

DeWitt, T H , D J Morrisey, D S Roper, and M G Nipper 1996 Fact or artifact The need for appropriate controls in ecotoxicological field experiments Learned Discourses, SETAC News 16 22-23

Burton, G A Jr , C W Hickey, T H DeWitt, D S Roper, D J Morrisey, and M G Nipper 1996 *In situ* toxicity testing Teasing out the environmental stressors Learned Discourses, SETAC News 16 20-22

DeWitt, T H , R C Swartz, D J Hansen, W J Berry, and D McGovern 1996 Bioavailability and chronic toxicity of cadmium in sediment to the estuarine amphipod, *Leptocheirus plumulosus* Environmental Toxicology and Chemistry 15 2095-2101

DeWitt, T H , R J Ozretich, R C Swartz, J O Lamberson, D W Schults, G R Ditsworth, J K P Jones, L Hoselton, and L M Smith 1992 The effects of organic matter quality on the toxicity and partitioning of sediment-associated fluoranthene to the infaunal amphipod, *Rhepoxynius abronius* Environmental Toxicology and Chemistry 11 197-208

DeWitt, T H , R C Swartz, and J O Lamberson 1989 Measuring the acute toxicity of estuarine sediments Environmental Toxicology and Chemistry 8 1035-1048

DeWitt, T H , G R Ditsworth, and R C Swartz 1988 Effects of natural sediment features on the phoxocephalid amphipod, *Rhepoxynius abronius* Implications for sediment toxicity bioassays Marine Environmental Research 25 99-124

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Education:
B.A., Southampton College, Southampton, NY, Biology/Chemistry, 1970
M.S., Long Island University, Brookville, NY, Marine Science, 1976
Ph.D., College of William and Mary, Virginia Institute of Marine Science, Gloucester Pt., VA, Oceanography, 1990

Previous Positions:
1994-1998: Research Associate, Texas A&M University, College Station
1994-1998: Biological Oceanographer, Texas Parks and Wildlife Department, Austin
1993-1994: Associate Research Scientist, Department of Oceanography, Dalhousie University, Halifax, Nova Scotia
1991-1993: Research Associate, Texas A&M University, College Station
1990-1991: Post Doctoral Associate, Texas A&M University, College Station

Research Interests and Skills:
Ecological modeling of estuaries
Stable isotopes as tracers
Nutrient effects modeling
Sediment seagrass interactions

Professional Societies:
The American Society of Limnology and Oceanography
Society of Environmental Toxicology and Chemistry

Appointments/Honors
Lead modeler on the Laguna Madre Seagrass project, Texas A&M University
Lead modeler on Texas Parks and Wildlife freshwater inflow study of Galveston Bay
Modeler for Coastal Biogeochemical Workshop, Texas A&M University

Selected Publications:
Eldridge, P.M., and J.W. Morse, 2000. A diagenetic model for sediment-seagrass interactions. Marine Chemistry 70:89-103.
Cifuentes, L.A., R.B. Coffin, J. Morin, and P.M. Eldridge. 1998. Particulate organic matter in the Gulf of Mexico estuaries -- implications for net heterotrophy. Pages 239-268 in T.S. Bianchi, J.R. Pennock, and R.R. Twilley, editors, Biogeochemistry of Gulf of Mexico Estuaries, John Wiley & Sons.
Roelke, D.L., P.M. Eldridge, and L.A. Cifuentes. 1997. Nutrient and phytoplankton dynamics in a sewage impacted Gulf Coast estuary: A field test of the PEG-model and equilibrium resource competition theory. Estuaries 20:725-742.
Coffin, R.B., L.A. Cifuentes, and P.M Eldridge. 1994. The use of stable isotopes to study microbial processes in estuaries. Pages 222-239 in K. Lajtha and R.H. Michener, editors, Stable Isotopes in Ecology and Environmental Science. Blackwell Scientific Publications, Boston.

Murray, A G , and P M Eldridge 1994 The effects of bacteriophage on bacterial recycling of energy to mesozooplankton production Journal of Plankton Research 16(6) 627-641

Eldridge, P M , W Pulich, J Hensen, and C Loeffer 1994 Freshwater inflow recommendations for Guadalupe Estuary Technical Report submitted to the Texas National Resource Conservation Commission

Eldridge, P M , and G A Jackson 1993 Descriptions of California coastal basin and slope benthic food webs derived from inverse analysis Marine Ecology Progress Series 99 115-135

Eldridge, P M and M E Sieracki 1993 Biological and hydrodynamic regulation of the microbial food web in a periodically mixed estuary Limnology and Oceanography 38 1666-1679

Eldridge, P M , and G A Jackson 1992 Benthic food web flows in the Santa Monica Basin estimated with inverse methodology Pages 255-276 in G T Rowe, and V Pariente, editors, Deep-sea food chains and their relationship to the global carbon cycle

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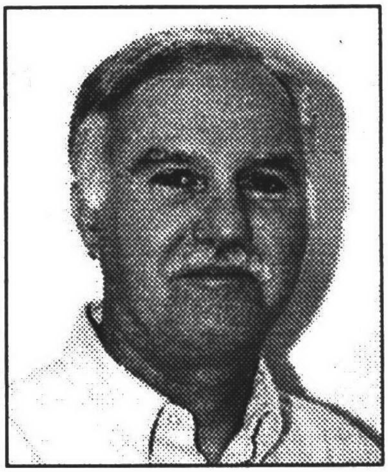

Education:
B.S., State University of New York, Stony Brook, NY; Biology, 1968
Ph.D., State University of New York, Stony Brook, NY; Biology, 1980

Previous Positions:
1982: Biologist, Tippetts, Abbett, McCarthy & Stratton Architects and Planners, New York, NY

Research Interests and Skills:
Marine/estuarine ecology; pollution ecology; environmental statistics

Professional Societies:
American Association for the Advancement of Science
Society of Environmental Toxicology and Chemistry
American Fisheries Society
Estuarine Research Federation

Appointments/Honors:
State of the Environment Report, Marine/Estuary Committee, 1999
USEPA Special Act Award, 1996
USEPA Science Achievement Award in Biology/Ecology, 1995
Member, EPA's Pacific Northwest Regional Marine Research Program, 1994-present
USEPA Scientific and Technological Achievement Awards, 1990, 1991, 1992, 1996
USEPA Scientific and Technological Achievement Awards, Honorable Mention, 1991, 1993
Member, EPA's 301(h) National Task Force, 1982-1986

Selected Publications:
Ozretich, R.J., S.P. Ferraro, J.O. Lamberson, and F.A. Cole. 2000. A test of Σ polycyclic aromatic hydrocarbon model at the creosote-contaminated site, Elliott Bay, Washington, USA. Envir. Toxicol. Chem.19(9):2378-2389.

Kravitz, M.J., J.O. Lamberson, S.P. Ferraro, R.C. Swartz, B.L. Boese, and D.T. Specht. 1999. Avoidance response of the estuarine amphipod *Eohaustorius estuarius* to PAH-contaminated field-collected sediments. Environ. Toxicol. and Chem. 18:1232-1235.

Ferraro, S.P., and F.A. Cole. 1997. Effects of DDT sediment contamination on macrofaunal community structure and composition in San Francisco Bay. Marine Biology 130:323-334.

Rohlf, F.J., H.R. Akcakaya, and S.P. Ferraro. 1996. Optimizing composite sampling protocols. Environ. Science & Technology 30:2899-2905.

Swartz, R.C., D.W. Schults, R.J. Ozretich, J.O Lamberson, F.A. Cole, T.H. DeWitt, M.S. Redmond, and S.P. Ferraro, 1995. ΣPAH: A model to predict the toxicity of polynuclear aromatic hydrocarbon mixtures in field-collected sediments. Environ. Toxicol. and Chem. 14:1977-1987.

Ferraro, S.P., and F.A. Cole. 1995. Taxonomic level sufficient for assessing pollution impacts on the Southern California Bight macrobenthos revisited. Environ. Toxicol. and Chem. 14:1031-1040.

Ferraro, S P , R C Swartz, F A Cole, and W A DeBen 1994 Optimum macrobenthic sampling protocol for detecting pollution impacts in the Southern California Bight Environ Monitoring and Assessment 29 127-153

Swartz, R C , F A Cole, J O Lamberson, S P Ferraro, D W Schults, W A DeBen, H Lee II and R J Ozretich 1994 Sediment toxicity, contamination, and amphipod abundance at a DDT- and dieldrin-contaminated site in San Francisco Bay Environ Toxicol and Chem 13 949-962

Ferraro, S P , and F A Cole 1992 Taxonomic level sufficient for assessing a moderate impact on macrobenthic communities in Puget Sound, Washington, USA Canadian J Fisheries Aquatic Sci 49 1184-1188

Schults, D W , S P Ferraro, L M Smith, F A Roberts, and C K Poindexter 1992 A comparison of methods for collecting interstitial water for trace organic compounds and metals analyses Water Resources 26 989-995

Ferraro, S P , R C Swartz, F A Cole, and D W Schults 1991 Temporal changes in the benthos along a pollution gradient discriminating the effects of natural phenomena from sewage-industrial wastewater effects Estuar Coast Shelf Sci 33 383-407

Ferraro, S P , and F A Cole 1990 Taxonomic level and sample size sufficient for assessing pollution impacts on the Southern California Bight macrobenthos Marine Ecol Prog Ser 67 251-262

Ferraro, S P , H Lee II, R J Ozretich, and D T Specht 1990 Predicting bioaccumulation potential a test of a fugacity-based model Arch Environ Contam 19 386-394

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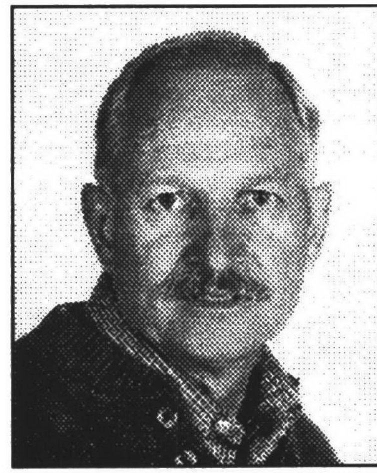

Education:
B.S., Ohio State University, Education, 1960
M.N.S., Arizona State University, 1965
Ph.D., Purdue University, Plant Physiology, 1969

Previous Positions:
1969-Present: Asst., Assoc., and Professor of Botany, University of Oklahoma, Norman
1965-1969: Teaching assistant and research assistant, Purdue University
1964-1965: NSF Fellowship, Arizona State University
1963-1964: High school biology & chemistry teacher, Cleveland, OH.

Professional Societies:
American Society of Plant Physiologists
Society of Environmental Toxicology and Chemistry

Research Interests and Skills:
Phytoremediation, plant metabolism, phytotoxicology, air pollution

Appointments/Honors:
EPA Scientific & Technological Achievement Award, 1998
Organizer and moderator of Phytoremediation/Rhizosphere Workshop at 1998 IBC Conference
Editor, *Journal of Environmental Toxicology and Chemistry*, 1996-1998
EPA Science Advisory Panel for Office of Pesticide Programs, 1993-1998
Organizer and editor of proceedings: Plant Tier Testing/A Workshop to Evaluate Nontarget Plant Testing in Subdivision J Pesticide Guidelines, 1991
Served on EPA Alternative Fuels Research Strategy, 1989
Served on USDA Competitive Grants Review Panel, 1986
O.U. Associates Distinguished Lecturer, 1988, 1986, 1984
Recipient, Univ. of Oklahoma Regents Teaching Award, 1983
Univ. of Oklahoma Danforth Teaching Associate, 1980
Ortenburger Award for Biology Teaching from Phi Sigma, 1977
AMOCO Award for Outstanding Undergraduate Teaching, 1975

Selected Publications:
Gaskin, J. and J.S. Fletcher. 1997. Mineralization of exogenously supplied organic substrates by ponderosa pine roots with and without the ectomycorrhizal fungus *Hebeloma crustuliniforme*. Am. Chem. Soc. Symposium Series 664:152-160.
Fletcher, J.S., T.G. Pfleeger, H.C. Ratsch,, and R. Hayes. 1996. Potential impact of low levels of chlorsulfuron and other herbicidses on nontarget crop yield. Environ. Toxicol. Chem. 15:1189-1196.
Hegde, R.S., and Fletcher, J.S. 1996. Influence of plant growth stage and season on the release of root phenolics by mulberry as related to development of phytoremediation technology. Chemosphere 32:2471-2479.

Fletcher, J S 1995 Influence of Chlorsulfuron, 2,4-D, Altrazine, and glyphosate on the growth and yield of garden pea Physiologia Plantarum 94 261-267

Hegde, R S and J S Fletcher 1995 Release of phenols by perennial plant roots and their potential importance in bioremediation Chemosphere 31 3009-3016

Donnelly, P K , and J S Fletcher 1995 PCB metabolism by mycorrhizal fungi Bull Environ Contam Toxicol 54 507-513

Donnelly, P K , and J S Fletcher 1994 Potential use of mycorrhizal fungi as bioremediation agents Pages 93-99 in T Anderson and J Coats, editors, Bioremediation Through Rhizosphere Technology, American Chemical Society Symposium series 563

Fletcher, J S , J E Nellessen, and T Pfleeger 1994 Literature review and evaluation of the EPA food chain (Kenaga) monogram, an instrument for estimating pesticide residues on plants Environ Toxicol Chem 13 1383-1391

Donnelly, P K , R S Hegde, and J S Fletcher 1994 Growth of PCB-degrading bacteria on compounds from photosynthetic plants Chemosphere 28 981-988

Fletcher, J S , T Pfleeger, and H Ratsch, 1993 Potential environmental risks associated with the new sulfonylurea herbicides Envir Sci and Tech 27 2250-2252

Nellessen, J E , and J S Fletcher 1993 Assessment of published literature pertaining to the uptake/ accumulation, translocation, adhesion, and biotransformation of organic chemicals by vascular plants Chemosphere 12 2045-2052

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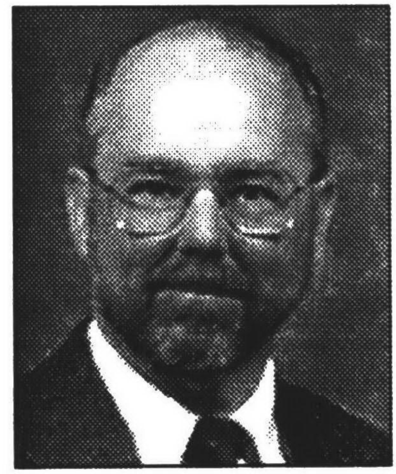

Education:
B.A. University of Mississippi, Biology, 1972
M.S. University of Florida, Environmental Biology, Environmental Engineering Sciences, 1974
Ph.D. University of Florida, Systems Ecology, Environmental Engineering Sciences, 1978

Previous Positions:
1999-2001, Director, Environmental Monitoring and Assessment Division, South Florida Water Management District (SFWMD)
1992-1999, Director, Everglades Systems Research Division, SFWMD
1988-1989, Program Leader, Coordinated Ecosystem Research, NOAA-Great Lakes Environmental Research Laboratory (GLERL)
1984-1988, Group Head, Environmental Systems Studies Group, NOAA-GLERL
1982-1983, Assistant Ecologist, University of Georgia Faculty, Savannah River Ecology Laboratory
1979-1982, Research Associate, University of Georgia Faculty, Savannah River Ecology Laboratory
1972-1979, Graduate Research Assistant, Environmental Engineering Sciences Department, University of Florida

Research Interests and Skills:
Systems ecology and modeling, research program development and communication; Nutrient and contaminant fate, transport, and effects modeling; Uncertainty, risk, and optimization analyses; TMDL process; Monitoring network design; Natural and constructed wetland processes

Professional Societies:
AAAS, Ecological Society of America, Estuarine Research Federation

Appointments / Honors:
Member of Governor's Commission for a Sustainable South Florida Scientific Advisory Panel
National Audubon-American Association of Engineering Societies Palladium Medal (team award for r of Comprehensive Everglades Restoration Plan, May 2000
Invited and contributing speaker at numerous scientific meetings.
Invited panelist at numerous EPA, NOAA, IJC, USFWS, USGS, and NRC workshops on wetland restoration, national nutrient assessment, water quality, Great Lakes, and fisheries issues.
Chair, Modeling Committee, EPA contaminant mass balance studies in the Upper Great Lakes Connecting Channels.

Selected Publications: *(Author or co-author of over 35 scientific publications in peer-reviewed journals)*
McCormick, P., S. Newman, S. Miao, R. Reddy, D. Gawlik, C. Fitz, T. Fontaine, and D. Marley. (In press). Ecological needs of the Everglades. In Porter & Porter, editors. Linkages Between Everglades Watersheds. CRC press.
McCormick, P.V., S. Newman, G. Payne, S. Miao, and T.D. Fontaine. 2000. Ecological effects of phosphorus enrichment in the Everglades. Chapter 3 in Everglades Consolidated Report. (A peer reviewed publication of the SFWMD available at http://www.sfwmd.gov/org/wre/eir/index.html)

Rudnick, D T , Z Chen, D L Childers, and T D Fontaine 1999 Phosphorus and nitrogen inputs to Florida Bay the importance of the Everglades watershed Estuaries 22 398-416

Moustafa, M Z , S Newman, T D Fontaine, J J Chimney, and T C Kosier 1999 Phosphorus retention by the Everglades Nutrient Removal Project an Everglades Stormwater Treatment Area In K R Reddy, G A O'Conner, and C L Schelske, editors Phosphorus Biogeochemistry in Subtropical Ecosystems, Lewis Publishers, Boca Raton

Newman, S , J Schuette, J B Grace, K Rutchey, T Fontaine, K R Reddy, and M Pietrucha 1998 Factors influencing cattail abundance in the northern Everglades Aquat Bot 60 265-280

Moustafa, M Z , T D Fontaine, M Guardo, and R T James 1998 The response of a freshwater wetland to long-term "low level" nutrient loads Nutrients and water budget Hydrobiologia 364 41-53

Moustafa M , M J Chimney, T Fontaine, G Shih and S Davis 1996 The response of a freshwater wetland to long-term low level nutrient loads -- marsh efficiency Ecological Engineering 7 15-33

Guardo, M , L Fink, T Fontaine, S Newman, M Chimney, R Bearzotti. G Goforth 1995 Large scale constructed wetlands for nutrient removal from stormwater runoff An Everglades restoration project Environ Mgt 19 879-889

Fontaine, T D , and D J Stewart 1992 Exploring the effects of multiple management objectives and exotic species on Great Lakes food webs and contaminant dynamics Environ Mgt 16 225-229

Landrum, P F , T D Fontaine, W R Faust. B J Eadie, and G A Lang 1992 Modeling the accumulation of polycyclic aromatic hydrocarbons by the amphipod Diporeia (sp) In F A Gobas. and J A McCorquodale, editors Chemical Dynamics in Fresh Water Ecosystems Lewis Publishers. Boca Raton

Lesht, B M , T D Fontaine, and D M Dolan 1991 Great Lakes total phosphorus model post audit and regionalized sensitivity analysis J Great Lakes Res 1 3-17

Clites, A , T D Fontaine, and J Wells 1991 The distributed costs of environmental contamination Ecological Economics 3 215-229

Lang, G A and T D , Fontaine 1990 Modeling the fate and transport of contaminants in Lake St Clair J Great Lakes Res 16 216-232

Lang, G A , J A Morton, and T D Fontaine 1988 Total phosphorus budget for Lake St Clair 1975-1980 J Great Lakes Res 14 257-266

Fontaine. T D , and B M Lesht 1987 Contaminant management strategies for the Great Lakes Optimal solutions under uncertain conditions J Great Lakes Res 13 178-192

Fontaine, T D 1984 A non-equilibrium approach to modeling toxic metal speciation in acid. aquatic systems Ecological Modelling 22 85 100

Fontaine, T D , III 1984 Application of risk and uncertainty analysis techniques to a heavy metal speciation model Ecological Modelling 22 101-108

Fontaine, T D 1984 A non-equilibrium approach to modeling metal speciation in acid, aquatic systems Theory and process equations Ecological Modelling 21 287-313

Fontaine, T D 1983 Characteristics of Aufwuchs on natural and artificial submersed lotic plants Substrate effects Archiv fur Hydrobiologie 96 293-301

Fontaine, T D , and S M Bartell, editors 1983 Dynamics of Lotic Ecosystems 494 pp Ann Arbor Science, Ann Arbor

Ewel, K C and T D Fontaine 1983 Structure and function of a lower latitude lake Ecological Modelling 19 139-161

Ewel, K D and T D Fontaine 1982 Effects of white amur (*Ctenopharyngodon idella*) on a Florida lake ecosystem A model Ecological Modelling 16 251-273

Fontaine, T D 1981 A self-designing model for testing hypotheses of ecosystem development In D M DuBois, editor Progress in Ecological Engineering and Management by Mathematical Modelling

Fontaine, T D , and K C Ewel 1981 Metabolism of a Florida lake ecosystem Limnol Oceanogr 26 754-763

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Education:
B.S., University of Utah, Salt Lake City; Biology, 1988
M.S., University of Utah, Salt Lake City; Biology, 1991
Ph.D., Cornell University, Ithaca, NY; Biology, 1998

Previous Positions:
1991-1998: Teaching Assistant, Cornell University, Ithaca, NY.
1987-1991: Teaching Assistant, University of Utah, Salt Lake City.
1988: Smithsonian Tropical Research Institute Short-Term Fellow, Barro Colorado Island, Panama.
1987-1988: Field Assistant, Tropical Ecology, Smithsonian Tropical Research Institute.
1987-1988: Laboratory Technician, Plant physiological ecology, University of Utah
1986: Field Assistant, Desert Ecology, University of Utah

Research Interests and Skills:
Plant physiological ecology.
Effects of multiple environmental changes on plant growth and physiology.
Stable isotopic applications to the effect of anthropogenic stresses on forest ecosystems.

Professional Societies:
Ecological Society of America

Appointments/Honors:
Mellon Foundation Fellowship, Cornell University, 1995
Edna Bailey Sussman Fund for Environmental Internships, 1993 and 1994
New York State Heritage Fellowship, 1993
Sigma Xi Fellowship, 1993
Center for the Environment Fellowship, Cornell University, 1992
Institute of Ecosystem Studies Research Grant, 1992 and 1993

Selected Publications:
Phillips, D.L. and J.W. Gregg. 2001. Uncertainty in source partitioning using stable isotopes. Oecologia 127:171-179.

Gregg, J.G., C.G. Jones, and T.E. Dawson. 1997. Plant growth along an urban-rural gradient: the relative impacts of elevated temperature, CO_2 and ozone. Bulletin of the Ecological Society of America 78(4):98.

Pimentel, D., M. Herdendorf, S. Eisenfeld, L. Olander, M. Carroquino, C. Corson, J. McDade, Y. Chung, W. Cannon, J. Roberts, L. Bluman, and J.Gregg. 1994. Achieving a secure energy future: environmental and economic issues. Ecological Economics 9:201-219.

Gregg, J.G. and J.R. Ehleringer. 1991. Mistletoe presence is dependent on host quality. Bulletin of the Ecological Society of America 72(2):128.

William E. Hogsett
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Education:
B.S., Texas Christian University, Fort Worth, TX; Biology, 1966
Ph.D., Baylor College of Medicine, Houston, TX; Bio-chemistry, 1972

Previous Positions:
1978-1980: Technical Supervisor, Northrop Services, Inc., Corvallis, OR
1976-1977: Senior Research Fellow, Dept. Microbiology and Immunology, University of Washington, Seattle, WA
1972-1976: Research Associate/NIH Postdoctoral Fellow, Dept. Botany and Plant Pathology, Oregon State University, Corvallis

Research Interests and Skills:
Carbon and nitrogen allocation in above- and below ground systems of annual and perennial plants, in response to tropospheric ozone exposure, relevant environmental factors, and components of exposure

Professional Societies:
American Society of Plant Physiologists
Sigma XI

Appointments/Honors:
Graduate Faculty (courtesy), Environmental Sciences, Oregon State University
Technical Advisor/Contributor, EPA Air Quality Criteria for Ozone and Related Photochemical Oxidants. Chapter 5. Environmental Effects, 1986; 1992 Supplement; 1997
Co-Director, PRIMENet (NPS/EPA co-sponsored research & monitoring program), 1996-present.
Member, Effects Work Group, UN ECE Convention on Long-Range Transboundary Air Pollution: Critical Levels for Ozone, 1992-present
Member, Scientific Liaison Committee, North American Research Strategy for Tropospheric Ozone (NARSTO), 1992-present
Member, Federal Land Managers Air Quality related Values Workgroup (FLAG). 1996-Present
Member, Risk and Exposure Assessment Group, EPA/Office of Air and Radiation,1995-present
Peer Review Panel, Swedish Environmental Research Institute, Effects of Tropospheric Ozone on Forest Trees. Gothenburg, Sweden, 1995, 1997, 1999
Peer Review Panel, Air Quality Research Programs, Air Quality Division, National Park Service. 1989 - 1992
Peer Reviewer Panel, U.S. Forest Service Global Change Programs, Pacific Southwest and Southeast. 1995, 1998, 1999
Peer Reviewer, USDA Competitive Grants 1995, 1996, 1998, 1999, 2000
Participant, Canadian Council Ministers of the Environment, Development of a Management Plan for Control of NOx and VOC: Vegetation Effects Work Group. Toronto Canada, 1989 Participant, Trans-Pacific Air Pollution Project. Tokyo, Japan, 1998; Nagoya, Japan, 1999
Participant, Air Quality Related Values for Class I Wilderness US Forest Service, Pacific Southwest and Pacific Northwest, 1990

EPA Bronze Medal of Commendation - 1988, 1992, 1997
EPA/ORD Scientific and Technological Achievement Award - 1986, 1991, 1998

Selected Publications:

Andersen, C P , W E Hogsett, M Plocher and E H Lee 2001 Blue wild-rye grass competition increases the effect of ozone on ponderosa pine seedlings Tree Physiol 21 319-327

Grulke, N E , C P Andersen and W E Hogsett 2001 Seasonal changes in above-and belowground carbohydrate concentrations of ponderosa pine along a pollution gradient Tree Physiol 21 1-9

Laurence, J A , W A Retzlaff, J S Kern, E H Lee, D A Weinstien and W E Hogsett 2001 Predicting the regional impcat of ozone and precipitation on the growth of loblolly pine and yellow-poplar using linked TREGRO and ZELIG models Forest Ecology and Management 146 251-267

Lee, E H , and W E Hogsett 1999 Role of concentration and time of day in developing ozone exposure indices used in modeling crop loss J of Air & Waste Management Association 49 669-681

Hogsett, W E , and C P Andersen 1998 Ecological effects of tropospheric ozone a U S perspective -- past, present, and future Pages 419-437 in T Schneider, editor, Air Pollution in the 21st Century, Priority Issues and Policy Studies in Environmental Science Elsevier Publishers

Hogsett, W E , A A Herstrom, J A Laurence, E H Lee, J E Weber, and D T Tingey 1997 An approach for characterizing tropospheric ozone risk to forests Environmental Management 20 1-17

Weber, J A , C S Clark, and W E Hogsett 1993 Analysis of the relationships among O_3 uptake, conductance, and photosynthesis in needles of *Pinus ponderosa* Tree Physiology 13 157-172

Andersen, C , W E Hogsett, R Wessling, and M Plocher 1991 Ozone decreases spring root growth and root carbohydrate content in ponderosa pine the year following exposure Canadian J Forest Research 21 1288-1291

Tingey, D T , W E Hogsett, and S Henderson 1990 Definition of adverse effects for the purpose of establishing secondary national ambient air quality standards J Environ Quality 19 635-639

Hogsett, W E , D T Tingey, C Hendricks, and D Rossi 1989 Sensitivity of important western conifer species to SO_2 and seasonal interaction of acid fog and ozone Pages 469-491 in R K Olson and A S Lefohn, editors Effects of Air Pollution on Western Forests, APCA Transaction Series Air and Waste Management Association, Pittsburgh

Hogsett, W E , D T Tingey, and E H Lee 1988 Ozone exposure indices Concepts for development and evaluation of their use Pages 107-138 in W W Heck, O C Taylor, and D T Tingey, editors Assessment of crop loss from air pollutants Proceedings of the International Conference, Raleigh, North Carolina, USA Elsevier, Applied Science, London

Hogsett, W E , D T Tingey, and S R Holman 1985 A programmable exposure control system for determination of the effects of exposure regimes on plant growth Atmos Environ 19 1135-1140

Hogsett, W E , M C Plocher, V Wildman, D T Tingey and J P Bennett 1985 Growth response of two varieties of slash pine to chronic ozone exposure Can J Bot 63 2369-2376

Tingey, D T and W E Hogsett 1985 Water stress reduces ozone injury via a stomatal mechanism Plant Physiology 77 944-947

Hogsett, W E , R M Raba and D T Tingey 1981 Biosynthesis of stress ethylene in soybean seedlings Similarities to endogenous ethylene biosynthesis Physiol Plant 53 307-314

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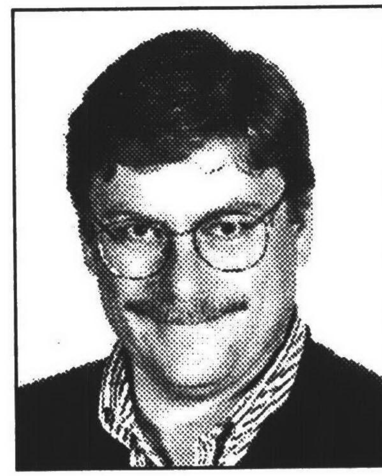

Education:
B.S., Kansas State University, Manhattan, KS; Agronomy, 1979
M.S., Kansas State University, Manhattan, KS; Soil Chemistry and Plant Nutrition, 1981
Ph.D., Cornell University, Ithaca, NY; Soil Chemistry, 1986

Previous Positions:
1993-1997: Principal Investigator, ManTech Environmental Services/Dynamac Corp.
1988-1993: Project Scientist, NSI Technology Services/ManTech
1985-1988: Senior Scientist, NSI Technology Services

Research Interests and Skills:
Effects of natural and anthropogenic stresses on roots, soil and soil processes
Biogeochemistry of forested systems

Appointments/Honors:
Team Honor Award for Advancing Environmental Science, USEPA Western Ecology Division, April, 1999
Director's Technical Contribution Award, USEPA, Corvallis Environmental Research Laboratory, December 1989
Technical Achievement Award, USEPA, Corvallis Environmental Research Laboratory, October 1987
Director's Technical Contribution Award, USEPA, Corvallis Environmental Research Laboratory, July 1987
Courtesy Faculty Appointment, Assistant Professor of Soil Science, Department of Crop and Soil Science, Oregon State University, Corvallis, OR, 1987-present

Selected Publications:
Johnson, M.G., D.T. Tingey, D.L. Phillips, and M.J. Storm. 2001. Advancing fine root research with minirhizotrons. Environ. Exp. Botany 45:263-289.
Lin, G., P.T. Rygiewicz, J.R. Ehleringer, M.G. Johnson, and D.T. Tingey. 2001. Time-dependent responses of soil CO_2 efflux components to elevated atmospheric [CO_2] and temperature in experimental forest mesocosms. Plant and Soil 229:259-270.
Phillips, D.L., M.G. Johnson, D.T. Tingey, C. Biggart, R.S. Novak, and J. Newsome. 2000. Minirhizotron installation in sandy, rocky soils with minimal soil disturbance. Soil Sci Soc of Am. J. 64:761-764.
Tingey, D.T., D.L. Phillips, and M.G. Johnson. 2000. Elevated CO_2 and conifer roots: Effects on growth, life span and turnover. New Phytologist 147:87-103.
Johnson, M.G., D.L. Phillips, D.T. Tingey, and M.J. Storm. 2000. Effects of elevated CO_2, N-fertilization and season on survival of ponderosa pine fine roots. Can. J. For. Res. 30(2):220-228.
Lin, G., J.R. Ehleringer, P.T. Rygiewicz, M.G. Johnson, and D.T. Tingey 1999. Elevated CO_2 and temperature impacts on different components of soil CO_2 efflux in douglas-fir terracosms. Global Change Biology 5:157-168.
Johnson, M.G., and P. Meyer. 1998. Mechanical advancing handle that simplifies minirhizotron camera

registration and image collection J Environ Qual 27(3) 710-714

Johnson, M G , D T Tingey, M J Storm, L M Ganio, and D L Phillips 1997 Effects of elevated CO_2 and N fertilization on the lifespan of *Pinus ponderosa* fine roots Pages 370-373 in H E Flores, J P Lynch, and D Eissenstat, editors Radical Biology Advances and Perspectives on the Function of Plant Roots Vol 18 Current Topics in Plant Physiology series American Society of Plant Physiologists

Rygiewicz, P T , M G Johnson, L M Ganio, D T Tingey, and M J Storm 1997 Lifetime and temporal occurrence of ectomycorrhizae on ponderosa pine (*Pinus ponderosa* Laws) seedlings grown under varied atmospheric CO_2 and nitrogen levels Plant and Soil 189 275-287

Tingey, D T , D L Phillips, M G Johnson, M J Storm, and J T Ball 1997 Effects of elevated CO_2 and N-fertilization on fine root dynamics and fungal growth in seedling *Pinus ponderosa* Environ Exp Botany 37 73-83

Vose, J M , K J Elliot, D W Johnson, D T Tingey, and M G Johnson 1997 Soil respiration response to two years of elevated CO_2 and N in ponderosa pine (*Pinus ponderosa* Doug ex Laws) Plant and Soil 190 19-28

Tingey, D T , M G Johnson, D L Phillips, D W Johnson, and J T Ball 1996 Effects of elevated CO_2 and nitrogen on the synchrony of shoot and root growth in ponderosa pine Tree Physiology 16 905-914

Tingey, D T , M G Johnson, D L Phillips, and M J Storm 1996 Effects of elevated CO_2 and nitrogen on ponderosa pine fine roots and associated fungal components Journal of Biogeography 22-281-287

Tingey, D T , B D McVeety, R Washmann, M G Johnson, D L Phillips, P T Rygiewicz, and D M Olszyk 1996 A versatile sun-lit controlled-environment facility for studying plant and soil processes J Environ Qual 25-614-625

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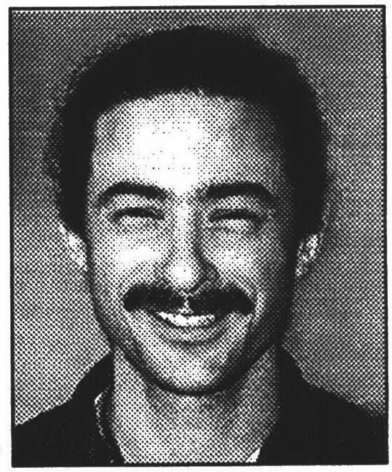

Education:
B.S., Long Island Univ.-Southampton, Marine Science/Biology, 1989
M.S., Univ. of New Hampshire, Plant Biology, 1992
Ph.D.,Univ. of Texas-Austin, Marine Science, 1997

Previous Positions:
1998-2000 Post-doctoral Researcher, Texas A&M Univ., Oceanography Dept.
1996-1997 Research Assistant, Marine Science Institute, Univ. of Texas
1993-1994 Research Assistant, Marine Science Institute, Univ. of Texas

Research Interests and Skills:
Ecology, physiology and reproduction in seagrasses and marine algae
Use of stable isotopes in estuarine ecology
Use of models to address process oriented questions in estuarine ecology
Influence of stressors on estuarine/marine macrophyte communities

Professional Societies:
Estuarine Research Federation
Gulf Estuarine Research Society
Tri-Beta National Biological Honors Society
Sigma Xi
American Society of Limnology and Oceanography

Appointments/Honors:
1997 Summer Tuition Fellowship
1994-1996 E.J. Lund Scholarship in Marine Science
1987 Provost Citizenship Award, LIU-Southampton

Selected Publications:
Kaldy, J.E. and K.H. Dunton. 2000. Above- and below-ground production, biomass and reproductive ecology of *Thalassia testudinum* (Turtle grass) in a subtropical coastal lagoon. Marine Ecology Progress Series 193:271-283.
Kaldy, J.E. and K.H. Dunton. 1999. Ontogenetic photosynthetic changes, dispersal and survival of *Thalassia testudinum* Banks ex König seedlings in a subtropical lagoon. J. Exp. Marine Biology & Ecol. 240:193-212.
Kaldy, J.E. N. Fowler and K.H. Dunton.1999. Critical Assessment of *Thalassia testudinum* (Turtle Grass) Aging: Implications for Demographic Methods. Marine Ecology Progress Series 181:279-288.
Kaldy, J.E. 1996. Range extension of *Halimeda incrassata* (Chlorophyta, Bryopsidales): Occurrence in the lower Laguna Madre of Texas. Southwestern Naturalist 41:419-423.
Kaldy, J.E., K.H. Dunton and A.B. Czerny. 1995. Variation in macroalgal species composition and abundance on a rock jetty in the northwest Gulf of Mexico. Botanica Marina 38:518-527.

Short, F T , D M Burdick and J E Kaldy 1995 Mesocosms quantify the effect of eutrophication on eelgrass, *Zostera marina* L Limnology & Oceanography 40 740-749

Tettleback, S T , C F Smith, J E Kaldy, T W Arroll and M R Denson 1990 Burial of transplanted bay scallops *Argopecten irradians irradians* (Lamark, 1819) in winter J Shellfish Research 9 127-134

Kaldy, J E 1990 An attempt to establish an eelgrass (*Zostera marina* L) bed ecosystem in a microcosm Bios 60 2-11

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Education:
B.S., Gonzaga University, Biology, 1971
M.S., Wash. State U., Environmental Science-Limnology, 1977
Ph.D., Oregon State U., Forest Hydrology, 1987

Previous Positions:
1991-1998 Research Associate Prof., Dept. Fisheries & Wildlife, Oregon State Univ.
1990-1991 Research Associate Professor, Utah Water Research Lab, Utah State Univ.
1986-1990 Research Assistant Professor, Utah Water Research Lab, Utah State Univ.
1981-1986 Graduate Research Assistant, Dept. Forest Engr/Hydrology, Oregon State Univ.
1977-1981 Environ. Scientist/Project Manager, M.A. Kennedy Consulting Engrs., Spokane, WA.

Research Interests and Skills:
Stream channel morphology and hydraulics.
Design/testing field methods for quantifying aquatic habitat and biota.
Natural and anthropogenic controls on aquatic habitat and biota at large regional scales.
Acidic deposition effects on aquatic ecosystems.

Professional Societies:
American Geophysical Union; North American Benthological Society; American Fisheries Society

Appointments/Honors:
Associate Professor (courtesy), Oregon State Univ., Dept. Fisheries & Wildlife, 1999-Present
Associate Professor (courtesy), Utah State Univ., Water Research Lab, 1991-1997
Certificate of Appreciation for participation on Mid-Atlantic Highlands Assessment Team, USEPA, Region III, 2000
Special Act Award ($1,000) for exemplary accomplishments in leading completion of habitat manual–USEPA, NHEERL-WED, 1999
Technical Director, NAPAP/EPA National Stream Survey 1987-1990
USEPA Environmental Research Lab award for best technical report, 1988 and 1991
Letter of Commendation from USEPA Administrator for contribution to design, implementation, and interpretation of EPA's National Surface Water Survey, 1988
USEPA Environmental Research Laboratory, award for best published journal article, Q2-1988
USEPA Environmental Research Lab Director's Award for scientific achievement, 1987

Selected Publications:
Li, J., A. Herlihy, W. Gerth, P.R. Kaufmann, S. Gregory, S. Urquhart, and D.P. Larsen. 2001. Variability in stream macroinvertebrates at multiple spatial scales. Freshwater Biology 46:87-97.
Hill, B.H., R.J. Sevenson, Y. Pan, A.T. Herlihy, P.R. Kaufmann, and C.B. Johnson. 2001. Comparison of correlations between environmental characteristics and stream diatom assemblages characterized at genus and species levels. J. N. Am. Benthol. Soc. 20(2):299-310.
Griffith, M.B., P.R. Kaufmann, A. Herlihy, and B. Hill. 2001. Analysis of macroinvertebrate assemblages in relation to environmental gradients in Rocky Mountain streams. Ecological Applic. 11(2):489-505.

Hill, B H , A T Herlihy, P R Kaufmann, R J Stevenson, F H McCormick, and C B Johnson 2000 The use of periphyton assemblage data as an index of biotic integrity J N Am Benthol Soc 19(1) 50-67

Kaufmann, P R , P Levine, E G Robison, C Seeliger, and D V Peck 1999 Quantifying Physical Habitat in Wadeable Streams EPA 620/R-99/003 U S EPA, Washington, DC

Allen, A , T Whittier, P R Kaufmann, D P Larsen, R O'Conner, R Hughes, R Stemberger, S Dixit, R Brinkhurst, A T Herlihy, and S G Paulsen 1999 Concordance of taxonomic richness patterns across multiple assemblages in lakes of the northeastern United States Can J Fish Aquat Sci 56 739-747

Pan, Y , R Stevenson, B Hill, P R Kaufmann, and A Herlihy 1999 Spatial patterns and ecological determinants of benthic algal assemblages in Mid-Atlantic streams, U S A J Phycology 35 460-468

Bryce, S , D P Larsen, R M Hughes, and P R Kaufmann 1999 Assessing relative risks to aquatic ecosystems a Mid-Appalachian case study J Am Water Resource Assoc 35(1) 23-36

Kaufmann, P R 1998 Stream Discharge Pages 67-76 in J M Lazorchak, D J Klemm and D V Peck, editors EMAP - Surface Waters Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams EPA/620/R-94/004F Office of Research and Develop , U S EPA, Washington, D C

Hughes, R M , T M Kincaid, P R Kaufmann, A T Herlihy, L Reynolds, and D P Larsen 1998 A process for developing and evaluating indices of fish assemblage integrity Can J Fish Aquat Sci 55 1618-1631

Hill, B H , A T Herlihy, P R Kaufmann, and R L Sinsabaugh 1998 Sediment microbial respiration in a synoptic survey of mid-Atlantic region streams Freshwater Bio 39 493-501

Kaufmann, P R and T R Whittier 1997 Habitat Assessment Pages 5-1 to 5-26 in J R Baker, D V Peck, and D W Sutton editors EMAP-Surface Waters Field Operations Manual for Lakes EPA/620/R-97/001 U S EPA, Washington, D C

Herlihy, A T , P R Kaufmann, L Reynolds, J Li, and E G Robison 1997 Developing indicators of Ecological Condition in the Willamette Basin Pages 275-282 in River Quality Dynamics and Restoration Lewis Publishers Boca Raton, FL

Robison, E G and P R Kaufmann 1994 Evaluating two objective techniques to define pools in small streams Pages 659-668 in R A Marston and V R Hasfurther editors Effects of Human-Induced Changes on Hydrologic Systems, Proc symposium, Jackson Hole, Wyoming, June 26-29, 1994 American Water Resources Association, Bethesda MD

Herlihy, A T , P R Kaufmann, M R Church, P J Wigington, Jr , J R Webb, and M J Sale 1993 The effects of acidic deposition on streams in the Appalachian Mountain and Piedmont region of the mid-Atlantic United States Water Resources Research 29 2687-2703

Kaufmann, P R , A T Herlihy, and L A Baker 1992 Sources of acidity in lakes and streams of the United States Environmental Pollution 77 115-122

Kaufmann, P R , A T Herlihy, M E Mitch, J J Messer, and W S Overton 1991 Chemical characteristics of streams in the eastern United States I Synoptic Survey Design, Acid Base Status, and Regional Patterns Water Resources Res 27 611-627

Herlihy, A , P R Kaufmann, and M Mitch 1991 Chemical characteristics of streams in the eastern United States II Sources of Acidity in Acidic and Low ANC Streams Water Resources Res 27 629-642

Baker, L A , A T Herlihy, P R Kaufmann, and J M Eilers 1991 Acidic lakes and streams in the United States the role of acidic deposition Science 252 1151-1154

Elwood, J W , M J Sale, P R Kaufmann, and G F Cada 1991 Southern Blue Ridge Province effects of acid deposition on streams, lakes, and reservoirs Chapter 11 in D F Charles editor Acid Deposition and Aquatic Ecosystems Regional Case Studies Springer-Verlag, New York

Herlihy, A T , P R Kaufmann, M E Mitch, and D D Brown 1990 Regional estimates of acid mine drainage impact on streams in the Mid-Atlantic and southeastern United States Water, Air, and Soil Pollut 50 91-107

Eshleman, K N and P R Kaufmann 1987 Assessing the regional effects of sulfur deposition on surface water chemistry the Southern Blue Ridge Environ Sci & Tech 22 685-690

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Education:
B.S., St. Francis College, Loretto, PA; Biology, 1971
M.S., Oregon State Univ., Corvallis; Biology, 1973
Ph.D., Oregon State Univ., Corvallis; Botany and Aquatic Ecology, 1983
Postdoctoral Fellow, Department of Biology, San Diego State Univ., San Diego, CA,1984-1985

Previous Positions:
1985-1990: Technical Supervisor II, Wetlands Research Program, NSI Technology Services, Corp, USEPA ERL, Corvallis, OR
1984-1985: Lecturer, Department of Biology, San Diego State University, San Diego, CA
1982-1984: Assistant Professor (non-tenure track), General Science Dept., Oregon State University, Corvallis
1981-1982: Instructor, Department of Botany and Plant Pathology, Oregon State University, Corvallis

Research Interests and Skills:
Restoration ecology, especially as it applies to wetlands
Use of autecological and synecological theory to solve resource management problems involving aquatic and wetland systems

Professional Societies:
Association of State Wetland Managers (Science Advisory Board, 1995-present)
Ecological Society of America (Corporate Award Subcommittee, 1992-1995; Reviewer for *Ecological Applications*)
Estuarine Research Federation (Reviewer for Estuaries)
Society of Wetland Scientists (Treasurer, 1997-present; Reviewer for Wetlands)
Society for Ecological Restoration (Editorial Board of Restoration Ecology, 1993-present; Board of Directors, 1989-1993; Committee on Standards and Monitoring, 1989-1992)

Appointments/Honors:
USEPA Science Achievement Award in Biology/Ecology for achievements in wetland ecology, 1998
Member, US Delegation, Fifth Meeting of the Conference of the Contracting Parties of the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (also known as the Ramsar Convention), 1993
Bronze Medal, ORD, USEPA, 1991
National Wetlands Technical Council, invited workshop participant, Pacific Regional Wetland Functions, 1985
International Waterfowl and Wetland Research Bureau, Specialist Group on Wetland Restoration
National Oceanic and Atmospheric Administration, Estuarine Habitat Program Technical Advisory Committee
National Research Council, Transportation Research Board, Project Advisory Committees for Project 25-3, Guidelines for the Development of Wetland Replacement Areas

Selected Publications:

Kentula, M E 2000 Perspectives on setting success criteria for wetland restoration Ecological Engineering 15(3-4) 199-209

Shaffer, P W , C A Cole, M E Kentula, and R P Brooks 2000 Effects of measurement frequency on water level summary statistics Wetlands 20(1) 148-161

Kentula, M E and T K Magee 1999 Foreword to Special Section Wetlands in an Urbanizing Landscape Wetlands 19(3) 475-6

Gwin, S E , M E Kentula, and P W Shaffer 1999 Evaluating the effects of wetland management through hydrogeomorphic classification and landscape profiles Wetlands 19(3) 477-489

Shaffer, P W M E Kentula, and S E Gwin 1999 Characterization of wetland hydrology using hydrogeomorphic classification Wetlands 19(3) 490-504

Magee, T K , T L Ernst, M E Kentula, and K A Dwire 1999 Floristic comparison of freshwater wetlands in an urbanizing environment Wetlands 19(3) 517-534

Kentula, M E 1997 A comparison of approaches to prioritizing sites for riparian restoration Restoration Ecology 5(4S) 69-74

Holland, C C , J Honea, S E Gwin, and M E Kentula 1995 Wetland degradation and loss in the rapidly urbanizing area of Portland, Oregon Wetlands 15(4) 336-345

Kentula, M E , R P Brooks, S E Gwin, C C Holland, A Sherman, and J C Sifneos, 1993 An Approach to Improving Decision Making in Wetland Restoration and Creation Island Press, Washington, D C

Holland, C and M E Kentula 1992 Impacts of Section 404 permits requiring compensatory mitigation on wetlands in California (USA) Wetlands Ecology and Management 2(3) 157-169

Kentula, M E , J C Sifneos, J W Good, M Rylko, and K Kunz 1992 Trends and patterns in Section 404 permitting requiring compensatory mitigation in Oregon and Washington Environmental Management 16(1) 109-119

Sifneos, J C , E W Cake, Jr , and M E Kentula 1992 Impacts of Section 404 permitting on freshwater wetlands in Louisiana, Alabama, and Mississippi Wetlands 12(1) 28-36

Kusler, J A , and M E Kentula, editors 1990 Wetland Creation and Restoration The Status of the Science Island Press, Washington, D C

Kentula, M E , and C D McIntire 1986 The autecology and production dynamics of eelgrass (*Zostera marina* L) in Netarts Bay, Oregon Estuaries 9 188-199

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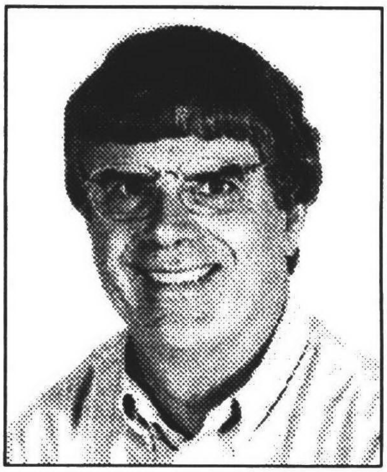

Education:
B.S., Washington State Univ., Pullman, Biology, Forestry 1964
M.S., Oregon State Univ., Corvallis, OR, Fisheries 1966
Ph.D. University of London, Zoology (Limnology) 1969

Previous Positions:
1995-1998 Senior Scientist, Global Climate Observing System, Geneva, Switzerland
1991-1995 Associate Director/Inland Aquatics, USEPA, EMAP, Corvallis
1979-1991 Chief Ecotoxicology Branch, USEPA, ERL, Corvallis
1975-1979 Biologist, USEPA, ERL Corvallis
1972-1975 Biologist, USEPA, ORD, Washington DC
1970-1972 Assistant Professor of Biology, State University of New York, Brockport, NY

Professional Societies:
Freshwater Biological Association UK

Appointments/Honors:
NRC Postdoctoral Fellowship
EPA Bronze Medal 1990 and 1992

Selected Publications:
Gallagher, J.L., H.V. Kibby, and K.W. Skirvin. 1984. Detritus processing and marsh cycling in seagrass (*zosters*) litter in an Oregon salt marsh. Aquatic Botany 20:97-108.
Gallagher, J.L., H.V. Kibby, and K.W. Skirvin. 1984. Community respiration of decomposing plants in Oregon estuarine marshes. Estuarine and Coastal Shelf Science 18:421-431.
Gallagher, J.L., and H.V. Kibby. 1981. The streamside effect in a *Carex lyngyei* estuarine marsh. Estuarine and Coastal Shelf Science 15:451-460.
Kibby, H.V., J.L. Gallagher, and W.S. Sanville. 1980. Field guide to evaluate net primary production of wetlands. Corvallis Environmental Research Laboratory. EPA/600/8-80/037 ERL-COR-167.
Gallagher, J.L., and H.V. Kibby. 1980. Marsh Plants as vectors in trace metal dynamics of Pacific Coast ecosystems. American Journal of Botany 67(7):1065-1074.
Kibby, H.V.: 1979. Effects of Wetlands on Water Quality. Pages 289-298 in R. Johnson and J.F. McCormick, editors. Strategies for protection and management of floodplain wetlands and other riparian ecosystems. USDA Forest Service GTR-WO-12.
Kibby, H.V., and D.H. Hernandez. 1978. Environmental impacts of advanced wastewater treatment at Ely, Minnesota. EPA 600/3-76-092.
Tihansky, D.P., and H.V. Kibby. 1974. A cost risk benefit analysis of toxic substances. Journal of Environmental Systems 4:117-121.
Kibby, H.V., and F.H. Rigler. 1973. Feeding behavior of Limnocalanus in a high arctic lake. Verh. Internat Verein. Limnol. 18:1457-1461.
Kirchner, W.B., and H.V. Kibby. 1972. The Arctic biome. In White and Little, editors. American Reference Encyclopedia of Ecology and Pollution. North American Publishing Co.

Kibby, H V 1972 Metabolism of Animals and effects of pollution In White and Little, editors American Reference Encyclopedia of Ecology and Pollution, North American Publishing Co

Kibby, H V 1971 Effect of temperature on feeding behavior of Daphnia rosea Limnology and Oceanography 15 580-581,

Kibby, H V 1971 Energetics and population dynamics in Diaptomus gracilis Ecological Monographs 41 311-327

Kibby, H V , J R Donaldson, and C E Bond 1968 Temperature and current observations in Crater Lake, Oregon Limnology and Oceanography 13 363-366

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Education:
B.S., Humboldt State Univ., Arcata, CA; Fisheries Science (with high honor), 1967
M.S., Univ.of Maine, Orono; Zoology (Statistics Minor), 1968
Ph.D., Colorado State U., Ft. Collins; Fisheries and Wildlife Science (Statistics Minor), 1971

Previous Positions:
1995-2000: Associate Director for Science, USEPA, WED, Corvallis
1989-1995: Deputy Director: USEPA, ERL, Corvallis
1987-1989: Chief, Terrestrial Branch, USEPA, ERL, Corvallis
1984-1987: Associate Chief, Air Branch, USEPA, ERL, Corvallis
1981-1984: Senior Ecologist, USEPA, ERL, Corvallis
1979-1981: Leader, National Water Resources Analysis Group, US Fish and Wildlife Service, Leetown, WV
1971-1979: Assistant/Associate Professor, Virginia Polytechnic Institute and State University, Blacksburg, VA (promoted and tenured 1974)

Research Interests and Skills:
Salmon Science and Policy
Fisheries Management
Natural Resource Ecology
Ecosystem Management

Professional Societies:
American Fisheries Society (Certified Fisheries Scientist)
American Institute of Fishery Research Biologists (Fellow)
International Association for Ecology
Ecological Society of America
Pacific Fishery Biologists

Appointments/Honors:
Professor (courtesy), Fisheries, Oregon State University, 1982-present
Professor (adjunct), Political Science, Oregon State University, 1995-present
Honor Alumnus, College of Natural Resources, Colorado State University, 2001
Fulbright Scholar, University of Northern British Columbia, 1999-2000
Graduate Faculty, Oregon Water Resources Research Institute, Oregon State University, 1982-present
Associate Science Editor, *Fisheries*, American Fisheries Society, 2000-present
Associate Director, Center for Analysis of Environmental Change, Oregon State University, 1991-1997
Consulting Editor, *Journal of Aquatic Ecosystem Stress and Recovery,* 1997-present
Editorial Board, *Human and Ecological Risk Assessment*, 1995-present
Senior Advisor, National Biological Service, USDI, Washington, D.C., Oct. 1993-Jan. 1994
Elected Fellow, American Institute of Fishery Research Biologists, 1990

ORD Management Excellence Award, EPA Office of Research and Development, 1987
Distinguished Alumnus, Humboldt State University, 1986
Program Coordinator, Environmental Protection Program, U S Fish and Wildlife Service, Washington, DC, 1976-77 (sabbatical year)
Visiting Professor, George Mason University Fairfax, VA, Spring Semester, 1977
Visiting Distinguished Professor, School of Natural Resources, University of Michigan, Winter, 1977

Selected Publications:

Lackey, R T (In press) Restoring wild salmon to the Pacific Northwest framing the risk question Human and Ecological Risk Assessment

Lackey, R T 2001 Defending reality Fisheries 26(6) 26-27

Lackey, R T 2001 Policy conundrum restoring wild salmon to the Pacific Northwest In Proceedings of the Biennial Conference of the International Institute of Fisheries Economics and Trade, July 2000, Corvallis, Oregon

Lackey, R T 2001 Values, policy and ecosystem health BioScience 51(6) 437-443

Lackey, R T 2000 Restoring wild salmon to the Pacific Northwest chasing an illusion? In P Koss and M Katz, editors What We Don't Know about Pacific Northwest Fish Runs--An Inquiry into Decision-Making Portland State University, Portland, pp 91-143

Lackey, R T 2000 Managing place scale problems ecosystem management Pages 16 11-16 20 in J H Lehr, editor The Standard Handbook of Environmental Science, Health, and Technology McGraw-Hill, New York, pp

Lackey, R T 1999 Salmon policy science, society, restoration, and reality Renewable Resources J 17(2) 6-16

Clark, J R , K L Dickson, J P Giesy, R T Lackey, E M Mihaich, R G Stahl, and M G Zeeman 1999 Using reproductive and developmental effects data in ecological risk assessment for oviparous vertebrates exposed to contaminants Pages 363-401 in R T Di Giulio and D E Tillitt, editors Reproductive and Developmental Effects of Contaminants in Oviparous Vertebrates SETAC Press, Pensacola, FL

Lackey, R T 1999 Radically contested assertions in ecosystem management J Sustainable Forestry 9(1-2) 21-34

Lackey, R T 1999 The savvy salmon technocrat life's little rules Environmental Practice 1(3) 156-161

Lackey, R T 1998 Seven pillars of ecosystem management Landscape and Urban Planning 40(1/3) 21-30

Lackey, R T 1998 Fisheries management integrating societal preference, decision analysis, and ecological risk assessment Environmental Science and Policy 1(4) 329-335

Lackey, R T 1997 Is ecological risk assessment useful for resolving complex ecological problems? Pages 525-540 in D J Stouder, P A Bisson, and R J Naiman, editors
Pacific Salmon and Their Ecosystems Status and Future Options Chapman and Hall, Publishers

Lackey, R T 1996 Pacific salmon, ecological health, and public policy Ecosystem Health 2(1) 61-68

Hlohowskyj, Ihor, Michael S Brody, and R T Lackey 1996 Methods for assessing the vulnerability of African fisheries resources to climate change Climate Research 6(2) 97-106

Lackey, R T 1996 Pacific salmon and the Endangered Species Act Northwest Science 70(3) 281-284

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M.S., College of William and Mary, Williamsburg, VA., Marine Biology, 1973

Previous Positions:
1984-1992: Aquatic Biologist, USEPA, Newport, OR
1981-1984: Biological Laboratory Technician, USEPA, Newport, OR

Research Interests and Skills:
Benthic ecology of Pacific Northwest estuaries
Sediment toxicology
Tropical ecology

Professional Societies:
Society of Environmental Toxicology and Chemistry
American Society for Testing and Materials
Estuarine Research Federation
Western Society of Naturalists

Appointments/Honors:
USEPA Scientific and Technical Award, 1996
American Fisheries Society/EPA Science Achievement
Award in Biology/Ecology, 1995
USEPA Award for the Advancement of Human Resources, 1993
USEPA Special Acts Award, 1991
USEPA Scientific and Technological Achievement Award, Honorable Mention, 1991
USEPA Scientific and Technological Achievement Award, 1989
USEPA Scientific and Technological Achievement Award, 1987

Selected Publications:
Ozretich, R.J., S.P. Ferraro, J.O. Lamberson, and F.A. Cole. 2000. A test of Σ polycyclic aromatic hydrocarbon model at the creosote-contaminated site, Elliott Bay, Washington, USA. Envir. Toxicol. Chem. 19(9)2378-2389.
Boese, B.L., R.J. Ozretich, J.O. Lamberson, F.A. Cole, and R.C. Swartz. 2000. Phototoxic evaluation of marine sediments collected from a PAH contaminated site. Arch. Environ. Contam. Toxicol. 38:274-282.
Cole, F.A., B.L. Boese, R.C. Schwartz, J. O. Lamberson and T.H. DeWitt. 1999. Effect of sediment storage on the toxicity of sediments spiked with fluorathene to the amphipod *Rhepoxynius abronius*. Environ. Toxicol. Chem. 19(3):744-748.
Kravitz, M. J., J.O. Lamberson, S.P. Ferraro, R.C. Swartz, B.L. Boese and D.T. Specht. 1999. Avoidance response of the estuarine amphipod *Eohaustorius estuarius* to PAH-contaminated field-collected sediments. Environ. Toxicol. Chem. 18:(6)1232-1235.

Boese, B L , R J Ozretich, J O Lamberson, R C Swartz, F A Cole, J Pelletier, and J Jones 1999 Toxicity and phototoxicity of mixtures of highly lipophilic PAH compounds in marine sediment can the Σ PAH model be extrapolated? Arch Environ Contam Toxicol 36 270-280

Swartz, R C , S P Ferraro, J O Lamberson, F A Cole, R J Ozretich, B L Boese, D W Schultz, M Behrenfeld, and G T Ankley 1997 Photoactivation and toxicity of polycyclic aromatic hydrocarbon compounds in marine sediment Environ Toxicol Chem 16(10) 2151-2157

Boese, B L , J O Lamberson, R C Swartz, and R J Ozretich 1997 Photoinduced toxicity of fluoranthene to seven marine benthic crustaceans Arch Environ Contam Toxicol 32 389-393

Swartz, R C , D W Schults, R J Ozretich, J O Lamberson, F A Cole, T H DeWitt, M S Redmond, and S P Ferraro 1995 ΣPAH A model to predict the toxicity of field-collected marine sediment contaminated by polynuclear aromatic hydrocarbons Environ Toxicol Chem 14 1977-1987

Swartz, R C , F A Cole, J O Lamberson, S P Ferraro, D W Schultz, W A DeBen, H Lee II, and R J Ozretich 1994 Sediment toxicity, contamination and amphipod abundance at the DDT- and Dieldrine-contaminated site in San Francisco Bay Environ Toxicol Chem 13(6)949-962

Lamberson, J O , T H DeWitt, and R C Swartz 1992 Assessment of sediment toxicity to marine benthos Pages 183-211 in G A Burton, editor Sediment Toxicity Assessment Lewis Publisher, Inc . Chelsea, MI

DeWitt, T H , R J Ozretich, R C Swartz, J O Lamberson, D W Schults, G R Ditsworth, J K P Jones, L Hoselton, and L M Smith 1992 The influence of organic matter quality on the toxicity and partitioning of sediment-associated fluoranthene Environ Toxicol Chem 11 197-208

Swartz, R C , D W Schults, J O Lamberson, R J Ozretich, and J K Stull 1991 Vertical profiles of toxicity, organic carbon, and chemical contaminants in sediment cores from the Palos Verdes Shelf and Santa Monica Bay, California Marine Environmental Research 31 215-225

Lamberson, J O , T H DeWitt, M S Redmond, D J Reish, and R C Swartz 1991 ASTM E-1367-90 Standard guide for conducting 10-day static sediment toxicity tests with marine and estuarine amphipods ASTM Standard Methods Series, Vol 11 04 The American Society of Testing and Materials, Philadelphia

Lamberson, J O , and R C Swartz 1989 Spiked-sediment toxicity test approach In Sediment Classification Methods Compendium USEPA, Criteria and Standards Division, Washington, D C

Lamberson, J O and R C Swartz 1988 Use of bioassays in determining the toxicity of sediment to benthic organisms Pages 257-279 in M S Evans, editor Toxicology Contamination and Ecosystem Health, A Great Lakes Focus. John Wiley and Sons, New York

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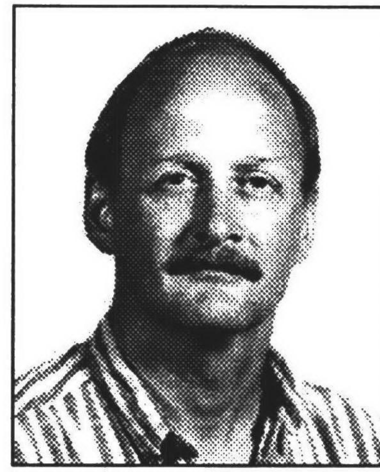

Education:
B.S., Kansas State University; Zoology, 1969
M.A.T., Indiana University; Biology, 1974
Ph.D., Indiana University; Zoology (Limnology), 1979

Previous Positions:
1990-1994: Leader, Aquatic Monitoring Program/Director, Arctic Contaminants Research Program, ERL, Corvallis, OR
1989-1990: Aquatic Team Leader/ Director, Aquatic Effects Research Prog. and Chairman, Interagency Aquatic Effects Task Group for NAPAP, USEPA, ERL, Corvallis, OR
1984-1989: Aquatic Team Leader/Research Director, National Lake Survey, SUNY (3yrs), USEPA (2 yrs)
1982-1984: Asst. Director/Research Associate/ Environ-mental Chemist, State University Research Center at SUNY, Oswego, NY
1981-1983: Aquatic Ecology Consultant, Dept. of the Interior, National Park Service, Everglades National Park, FL

Research Interests and Skills:
Regional limnology and freshwater/landscape interaction
Application of interdisciplinary approaches to develop environmental management options

Professional Societies:
American Society of Limnology and Oceanography
International Limnological Society

Appointments/Honors:
Appointed as a member of the National Research Council Review Panel for the Young Investigator Program on Ecological Concerns in the Development of the Arctic and Far Northern Regions (with Russia), 1993
Invited to serve as a member of the Dahlem Conference Steering Committee for the Conference on Acidification in Freshwater Ecosystems; Selected as Rapporteur for working group, 1992
National Acid Precipitation Assessment Award for Outstanding Contributions as Task Group Leader, 1990
EPA Silver Medal for Superior Service, 1988
EPA Bronze Medal for Commendable Service, 1987
Chancellor's Award from State University of New York for Outstanding Performance as scientific leader for the design and implementation of the Eastern Lake Survey, 1986
Associate Professor (courtesy), Department of Fisheries and Wildlife, Oregon State University

Selected Publications:
Fernald, A.G., P.J. Wigington, Jr., and D.H. Landers. 2001. Transient storage and hyporheic flow along the Willamette River, Oregon: field measurements and model estimates. Water Resources Res 37:1681-1694
Landers, D.H., P.K. Haggerty, S. Cline, W. Carson, and F. Faure. 2000. The role of regionalization in large river restoration. Verh. Int. Verein. Limnol. 27:344-351.

Landers, D H , C Gubala, M Verta, M Lucotte, K Johansson, and W L Lockhart 1998 Using lake sediment mercury flux ratios to evaluate regional and continental dimensions of mercury deposition in arctic and boreal ecosystems Atmospheric Environment 32(5) 919-928

Landers, D H , R M Hughes, S G Paulsen, D P Larsen, and J M Omernik 1998 How can regionalization and survey sampling make limnological research more relevant? Verh Int Verein Limnol 26 2428-2436

Landers, D H , C Gubala, J Ford, M Monetti, B K Lasora, and S Allen-Gil 1995 Mercury in terrestrial and freshwater arctic ecosystems Water, Air and Soil Pollution 80 591-601

Allen-Gil, Susan M , C P Gubala, R Wilson, D H Landers, T L Wade, J L Sericano, and L R Curtis 1997 Organochlorine pesticides and polychlorinated biphenyls (PCBs) in sediments and biota from four U S Arctic lakes Arch Environ Contam Toxicol 33 378-387

Allen-Gil, Susan M , C P Gubala, D H Landers, B K Lasorsa, E A Crecelius, and L R Curtis 1997 Heavy metal accumulation in sediment and freshwater fish in US Arctic lakes Environ Toxicol Chem 16(4) 733-741

Landers, D H 1997 Riparian restoration current status and the reach to the future Restoration Ecology 5(4S) 113-121

Landers, D H (Guest editor) 1995 Special Issue of the Science of the Total Environment 80 research papers from The International Symposium on the Ecological Effects of Arctic Airborne Contaminants Vol 160-161

Landers, D H , J M Eilers, D F Brakke, and P E Kellar 1988 Characteristics of acid lakes in the eastern United States Verh Int Verein Limnol 23 152-162

Landers, D H , and M J Mitchell 1988 Seasonality of sulfur incorporation and transformation in three New York lakes Hydrobiologia 160 85-95

Landers, D H , W S Overton, R A Linthurst, D F Brakke, and J M Eilers 1988 Eastern Lake Survey Regional Estimates of Lake Chemistry (feature article) Environ Sci Technol 22 128-135

Linthurst, R A , D H Landers, J M Eilers, P E Kellar, D F Brakke, W S Overton, R Crowe, E P Meier, P Kanciruk, and D S Jefferies 1986 Regional Chemical Characteristics of Lakes in North America Part II Eastern United States Water, Air & Soil Pollution 31 577-591

Landers, D H 1982 Effects of naturally senescing aquatic macrophytes on nutrient chemistry and chlorophyll of surrounding waters Limnol and Oceanogr 27 438-439

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Education:
B.S., Sonoma State University, California; Botany, 1987
M.S., Humboldt State U., California; Biological Sciences, 1991
Ph.D., Univ. of Hawaii, Manoa; Zoology (Ecology, Evolution and Conservation Biology), 1997

Previous Positions:
1997-1998: Postdoctoral Fellow, National Science Foundation, University of Hawaii

Research Interests and Skills:
Ecosystem-level effects non-native aquatic species
Nutrient dynamics in aquatic ecosystems
Primary productivity and organic matter in streams
Ecological and physiological effects of flow and turbulence

Professional Societies:
American Society of Limnology and Oceanography
Ecological Society of America
North American Benthological Society

Selected Publications:
Larned, S.T., R. A. Kinzie, A. P. Covich and C. T. Chong. (In review). Leaf litter processing by endemic and non-native Hawaii stream invertebrates: a microcosm study of species-specific effects. Oikos.

Larned, S.T. (In press). Detrital fruit as a food resource in a tropical stream ecosystem. Biotropica.

Stimson, J., S.T. Larned and E. Conklin. 2001. Effects of herbivory, nutrient levels and introduced algae on the distribution and abundance of the invasive macroalga *Dictyosphaeria cavernosa* in Kaneohe Bay, Hawaii. Coral Reefs 19:343-357

Larned, S.T., and S.R. Santos. 2000. Light- and nutrient-limited periphyton in low order streams of Oahu, Hawaii. Hydrobiologia 432:101-111.

Larned, S.T. 2000. Dynamics of riparian detritus in a Hawaiian stream ecosystem: a comparison of drought and post-drought conditions. J. N. Am. Benthological Soc. 19(2):215-234.

Stimson, J., and S.T. Larned. 2000. Nitrogen efflux from the sediments of a subtropical bay and the potential contribution of macroalgal nutrient requirements. J. Exp. Marine Biology & Ecol. 252:159-180.

Larned, Scott T. 1998. Nitrogen- versus phosphorus-limited growth and sources of nutrients for coral reef macroalgae. Marine Biology 132:409-421.

Larned, Scott T. and M.J. Atkinson. 1997. Effects of water velocity on NH_4 and PO_4 uptake and nutrient-limited growth in the macroalga *Dictyosphaeria cavernosa*. Marine Ecology Progress Series 1517:295-302.

Larned, Scott T. and J. Stimson. 1996. Nitrogen-limited growth in the coral reef chlorophyte, *Dictyosphaeria cavernosa*, and the effect of exposure to sediment-derived nitrogen on growth. Marine Ecology Progress Series 143:95-108.

Stimson, J , S T Larned, and K McDermid 1996 Seasonal growth of the coral reef chlorophyte, *Dictyosphaeria cavernosa*, and the effects of nutrient availability, temperature, and herbivore on growth rate Journal of Experimental Marine Biology and Ecology 196 53-77

Larned, Scott T 1995 Effects of ultraviolet radiation and nitrogen enrichment on growth in the coral reef chlorophyte *Dictyosphaeria cavernosa*, and *Dictyosphaeria versluysii* Pages 181-191 in P Jokiel, editor Ultraviolet Radiation and Coral Reefs Sea Grant

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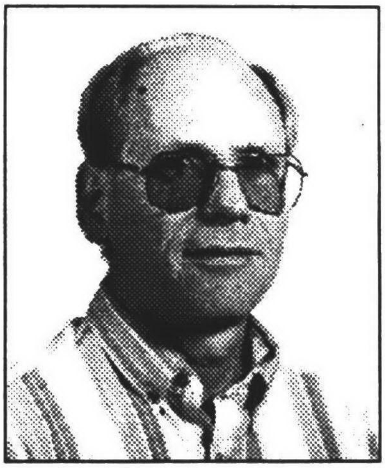

Education:
B.A., Pomona College, Claremont, CA; Zoology, 1964
Ph.D., Oregon State University, Corvallis, OR; Biological Oceanography, 1975

Previous Positions:
1981-1989: Team leader, Environmental Assessment Team, USEPA, ERL, Corvallis, OR
1980-1981: Team leader, Microcosm Toxicology Team, USEPA, ERL, Corvallis, OR
1972-1980: Research Aquatic Biologist, USEPA, ERL, Corvallis, OR

Research Interests and Skills:
Effects of human disturbances on aquatic ecosystems; indicator development; sampling designs

Professional Societies:
American Association for the Advancement of Science

Appointments/Honors:
EPA Bronze Medal for research in support of EMAP-Surface Waters, 1993
EPA ORD Scientific and Technological Achievement Award, 1987
Reviewer for *Canadian Journal of Fisheries and Aquatic Sciences; Transactions of American Fisheries Society; Environmental Management; Ecological Applications*

Selected Publications:
Cao, Y., D.D. Williams, and D.P. Larsen. (Accepted). Comparison of ecological communities: the problem of sample representativeness. Ecology.
Larsen, D.P., T.M. Kincaid, S.E. Jacobs, and N.S. Urquhart. (Accepted). Evaluating local and regional scale temporal trends. BioScience.
Cao, Y, D.P. Larsen, and R. St.-J. Thorne. 2001. Rare species in multivariate analysis for bioassessment: some considerations. J. North American Benthological Society. 20:144-153
McCormick, F.H., D.V. Peck, and D.P. Larsen. 2000. Comparison of geographic classification schemes for Mid-Atlantic stream fish assemblages. Journal of the North American Benthological Society. 19(3):385-404.
Waite, I.R., A.T. Herlihy, D.P. Larsen, and D.J. Klemm. 2000. Comparing strengths of geographic and nongeographic classifications of stream benthic macroinvertebrates in the Mid-Atlantic Highlands, USA. Journal of the North American Benthological Society. 19(3): 429-441
Herlihy, A.T., D.P. Larsen, S.G. Paulsen, N.S. Urquhart, and B.J. Rosenbaum. 2000. Designing a spatially balanced, randomized site selection process for regional stream surveys: The EMAP Mid-Atlantic Pilot Study. Environ. Monit. Assess. 63:95-113.
Bryce, S.A., D.P. Larsen, R.M. Hughes, and P.R. Kaufmann. 1999. Assessing relative risks to aquatic ecosystems: a mid-Appalachian case study. J. Am. Water Resources Assn. 35(1):1-14.
Larsen, D.P., and A.T. Herlihy. 1998. The dilemma of sampling streams for macroinvertebrate richness. J. N. Am. Benthological Soc. 17:359-366.

Paulsen, S G , R M Hughes, and D P Larsen 1998 Critical elements in describing and understanding our nation's aquatic resources J Am Water Resources Assn 34 995-1005

Urquhart, N S , S G Paulsen, and D P Larsen 1998 Monitoring for policy-relevant regional trends over time Ecological Applications 8 246-257

Larsen, D P 1997 Sample survey design issues for bioassessment of inland aquatic ecosystems Hum & Ecol Risk Assess 3(6) 979-991

Larsen, D P , N S Urquhart, and D L Kugler 1995 Regional scale trend monitoring of indicators of trophic condition of lakes Water Resources Bulletin 31 117-140

Larsen, D P 1994 The role of ecological sample surveys in the implementation of biocriteria Pages 287-300 in W S Davis and T P Simon, editors Biological Assessment and Criteria Tools for Water Resource Planning and Decision Making Lewis Publishers, Boca Raton

Larsen, D P , K W Thornton, N S Urquhart, and S G Paulsen 1994 The role of sample surveys for monitoring the condition of the nation's lakes Environ Monit Assess 32 101-134

Nelson, R L , W S Platts, D P Larsen, and S E Jensen 1992 Trout distribution and habitat in relation to geology and geomorphology in the North Fork Humbolt River Drainage, Northeastern Nevada Trans Amer Fish Soc 121 405-426

Hughes, R M , T R Whittier, C M Rohm, and D P Larsen 1990 A regional framework for establishing recovery criteria Environmental Management 14 673-683

Hughes, R M , and D P Larsen 1988 Ecoregions an approach to surface water protection J Water Pollut Control Fed 60 486-493

Larsen, D P , D R Dudley, and R M Hughes 1988 A regional approach to assess attainable water quality an Ohio case study J Soil Water Conserv 43 171-176

Whittier, T R , R M Hughes, and D P Larsen 1987 The correspondence between aquatic ecoregions and spatial patterns in stream ecosystems in Oregon Can J Fish Aquat Sci 45 1264-1278

Larsen, D P , F deNoyelles, Jr , F S Stay, and T Shiroyama 1986 Comparisons of single-species, microcosm, and experimental pond responses to atrazine exposure Environ Toxicol Chem 5 179-190

Larsen, D P , et al 1986 The correspondence between spatial patterns in fish assemblages in Ohio streams and Aquatic ecoregions Environmental Management 10 815-828

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Acting Chief, Ecosystems Characterization Branch
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Education:
B.S., The Pennsylvania State University, University Park, Forest Science, 1971
M.S., Univ. of Minnesota, St. Paul, Plant Pathology, 1973
Ph.D., University of Minnesota, St. Paul, Plant Pathology, 1976

Previous Positions:
1976-present: Plant Pathologist, Boyce Thompson Institute for Plant Research, Ithaca, NY
1991-1998 Program Director, Environmental Biology, Boyce Thompson Institute for Plant Research, Ithaca, NY

Research Interests and Skills:
Habitat response to environmental stress
Modeling tree and forest response to stress
Pathology and physiology of forest ecosystems

Professional Societies:
American Phytopathological Society
International Society of Plant Pathology
Ecological Society of America

Appointments / Honors:
Sigma Xi
Gamma Sigma Delta
Board of Directors and Corporate Secretary, Boyce Thompson Southwestern Arboretum, 1997-present
Adjunct Professor, Cornell University, Ithaca, NY.,1982-present
Professor (courtesy) Botany and Plant Pathology, Oregon State University, 1991-1993
Board of Editorial Advisors, New Phytologist, 1998- present
Editorial Board, Environmental Pollution, 2001-present
Editorial Board, Journal of Phytopathology, 2001-present
Reviewer for scientific journals including Science, Plant Disease, Environmental Pollution, Water, Air, and Soil Pollution, Journal of Environmental Quality, Canadian Journal of Forest Science, Canadian Journal of Botany, Phytopathology, Forest Science, Journal of the Air and Waste Management Association, Plant Cell and Environment, and Trees, Structure and Function, The New Phytologist, American Journal of Botany.
Reviewer of grant proposals for NSF, USDA, the National Acid Precipitation Assessment Program, the National Research Council of Canada, and the USEPA.
Peer Review Committee Appointments: Minnesota Environmental Quality Board (Minnesota Bioindicator Program); USEPA Environmental Monitoring and Assessment Program (EMAP), Agricultural Ecosystems

Selected Publications:
Laurence, J.A., W.A. Retzlaff, J.S, Kern, E.H. Lee, W.E. Hogsett, and D.A. Weinstein. 2001. Predicting the regional impact of ozone and precipitation on the growth of loblolly pine and yellow-poplar using linked TREGRO and ZELIG models. For. Ecol. & Mgmt. 146:247-263.

Tingey, D T , J Laurence, J A Weber, J Greene, W E Hogsett, S Brown, and E H Lee (In press) Effects of Elevated CO_2 and Temperature on the Response of Ponderosa Pine to Ozone A Simulation Analysis Ecological Applications

Laurence, J A and C P Andersen 2001 Ozone and Natural Systems Understanding exposure, response, and risk Presented at *Future Directions in Air Quality Research, Raleigh, NC, February 2001* Accepted for publication in conference proceedings

Madkour, S A and J A Laurence 2001 Egyptian Plant Species as New Bioindicators of Ozone Accepted for Publication Environ Pollut

Laurence, J A , S V Ollinger, and P B Woodbury 2000 Regional impacts of ozone on forest productivity Pages 425-453 in R A Mickler, R Birdsey, and J Hom, editors Responses of Northern Forests to Environmental Change Springer-Verlag Ecological Studies Series

Yun-S-C , E W Park, and J A Laurence 2000 Simulation of one-year old *Populus tremuloides* response to ozone stress at Ithaca, USA and Suwon, Republic of Korea Environ Pollut 112 253-260

Yun, S-C and J A Laurence 1999 The response of clones of Populus tremuloides differing in sensitivity to ozone in the field New Phytologist 141 411-421

Yun, S-C and J A Laurence 1999 The response of sensitive and tolerant clones of Populus tremuloides to dynamic ozone exposure under controlled environmental conditions New Phytologist 143 305-313

Yun, S-C , J A Laurence, and E W Park 1999 Ozone damage assessment of aspen at the five sites in Seoul using a computer simulation model of individual tree growth, TREGRO Plant Path J 15 210-216

Laurence, J A 1998 Ecological Effects of Ozone Integrating exposure and response with ecosystem dynamics and function Environmental Science and Policy 1 179-184

Woodbury, P B , J E Smith, D A Weinstein, and J A Laurence 1998 Assessing potential climate change effects on loblolly pine growth a probabilistic regional modeling approach For Ecol & Mgmt 107 99-116

Laurence, J A , R J Kohut, R G Amundson, and D A Weinstein 1997 Growth and water use of red spruce (*Picea rubens* Sarg) exposed to ozone and simulated acidic precipitation for four growing seasons For Sci 43 355-361

Rubin, G , C E McCulloch, and J A Laurence 1996 A model for estimating daily ozone doses for plants from atmospheric ozone concentration and vapor pressure deficit J Agric Biol Environ Stat 1 1-16

Smith, J E , P B Woodbury, D A Weinstein, and J A Laurence 1996 Synthesizing effects of climate change on Loblolly pine A probabilistic regional modeling approach pp 429-451 In Mickler, R A And S Fox (eds) The Productivity and Sustainability of Southern Forest Ecosystems in a Changing Environment Springer Verlag Ecological Studies Series No 128

Hogsett, W E , J E Weber, D Tingey, A Herstrom, E H Lee, and J A Laurence 1996 An approach for characterizing tropospheric ozone risk to forests Environmental Mgmt 21 105-120

Retzlaff W A , D A Weinstein, J A Laurence, and B Gollands 1996 Simulating the growth of a 160-year-old sugar maple (*Acer saccharum* Marsh) tree with and without ozone exposure using the TREGRO model Can J For Res 27 783-789

Constable, J V H , G E Taylor, Jr , J A Laurence, and J A Weber 1995 Climatic change effects on the physiology and growth of *Pinus ponderosa* Can J For Res 26 1315-1325

Amundson, R G , R J Kohut, and J A Laurence 1995 Influence of foliar N on foliar soluble sugars and starch of red spruce saplings exposed to ambient and elevated ozone Tree Phys 15 167-174

Laurence, J A , R G Amundson, P J Temple, E J Pell, and A L Friend 1994 Allocation of Carbon in Plants Under Stress An analysis of the ROPIS experiments J Environ Qual 23 412-417

Laurence, J A , R J Kohut, and R G Amundson 1993 Use of TREGRO to simulate the effects of ozone on the growth of red spruce seedlings Forest Science 39 453-464

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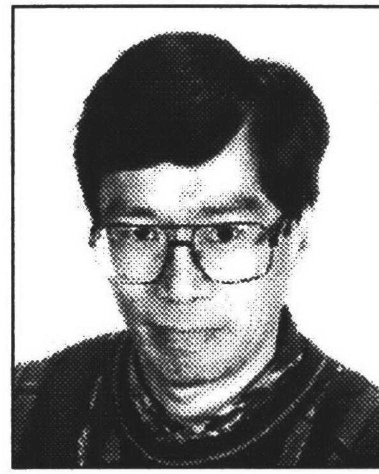

Education:
B.Sc., Univ. of Manitoba, Winnipeg, Manitoba; Statistics, 1976
M.Sc., Univ. of Manitoba, Winnipeg, Manitoba; Statistics, 1977
Ph.D., Iowa State University, Ames, IA; Statistics, 1981

Previous Positions:
1990-Present: Courtesy Faculty, Assistant Professor, Department of Statistics, Oregon State University
1985-1997: Biostatistician, Dynamac International, Inc (1996-1997); Mantech Environmental Research Services Corporation (1989-1996); NSI Technology Services Corporation - Environmental Services (1985-1989), Corvallis, OR
1981-1985: Assistant Professor, Department of Mathematical Sciences, Montana State University
1977-1981: Research Assistant, Statistical Laboratory. Iowa State University

Research Interests and Skills:
Ozone and exposure indices
Exposure-response modeling
Ozone uptake and deposition
Risk assessment of forest oxidant damage

Professional Societies:
American Statistical Association

Appointments/Honors:
President, Oregon Chapter of the American Statistical Association, 1996-1997
Vice-President, Oregon Chapter of the American Statistical Association, 1995-1996
Secretary-Treasurer, Oregon Chapter of the American Statistical Association, 1994-1995
President, Mu Sigma Rho, Iowa State University Chapter, 1980

Selected Publications:
Lee. E.H., and W.E. Hogsett. (Accepted). Interpolation of temperature and non-urban ozone exposure at high spatial resolution over the western United States. Climate Research.
Neufeld, H.S., E.H. Lee, J.R. Renfro, and W.D. Hacker. 2000. Seedling insensitivity to ozone for three conifer species native to Great Smoky Mountains National Park. Environmental Pollution 108:141-151.
Lee, E.H., and W.E. Hogsett. 1999. Role of concentration and time of day in developing ozone exposure indices used in modeling crop loss. J. of Air & Waste Management Association 49:669-681.
Hogsett, W.E., J.E. Weber, D. Tingey, A. Herstrom, E.H. Lee, and J.A. Laurence. 1997. An approach for characterizing tropospheric ozone risk to forests. Environmental Management. 21:105-120.
Lee, E.H., W.E. Hogsett, and D.T. Tingey. 1994. Attainment and effects issues regarding the secondary ozone air quality standard. J. Environ. Qual. 23:1129-1140.
Lee, E.H., D.T. Tingey, and W.E. Hogsett. 1988. Evaluation of ozone exposure indices in exposure-response modeling. J. Environ. Pollut., 53:43-62.

U S Environmental Protection Agency 1996 Air Quality Criteria for Ozone and Other Photochemical Oxidants Chapter 5 Environmental Effects of Ozone and Related Photochemical Oxidants Co-authored Section 5 5 of Document with Dr Allen S Lefohn Research Triangle Park, NC National Center for Environmental Assessment, Office of Research and Development, report no EPA/600/P-93/004bF Available from NTIS, Springfield, VA, PB96-185590INZ

Hogsett, W E , A A Herstrom, J A Laurence, E H, Lee, J W Weber, and D T Tingey 1995 Risk characterization of tropospheric ozone to forests Pages 119-145 in S D Lee and T Scheider, editors. Comparative Risk Analysis and Priority Setting for Air Pollution Issues proceedings of the 4th U S -Dutch international symposium June 1993, Keystone, CO Air & Waste Management Association publication VIP-43, Pittsburgh

Lee, E H , W E Hogsett, and D T Tingey 1994 Alternative attainment criteria for a secondary federal standard for ozone Pages 549-584 in J O Nriagu, and M S Simmons, editors, Environmental Oxidants Advances in Environmental Sciences and Technology Series, v 28, John Wiley & Sons, New York,

Tingey, D T , W E Hogsett, and E H Lee 1993 Effects of ozone on crops Pages 175-206 in D J McKee, editor, Tropospheric Ozone Human Health and Agricultural Impacts Lewis Publishers. Boca Raton, FL

Hogsett, W E , D T Tingey, and E H Lee 1988 Ozone exposure indices concepts for development and evaluation of their use Pages 107-138 in W W Heck, O C Taylor, and D T Tingey. editors, Assessment of Crop Loss from Air Pollutants, Proceedings of an International Conference. October 1987, Raleigh, NC Elsevier Applied Science, New York

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Education:
B.S., Rollins College, FL; 1970
M.S., University of North Carolina, Chapel Hill, NC; Marine Sciences, 1974
Ph.D., University of North Carolina, Chapel Hill, NC; Marine Sciences, 1978

Previous Positions:
1997-1999: ORD Regional Scientist, USEPA Region 9
1979-1980: NRC Postdoctorate: USEPA, Newport, OR
1978: Postdoctorate, University of Maryland, Horn Point

Research Interests and Skills:
Effects of nonindigenous species on aquatic ecosystems; Bioavailability and ecological effects of sediment contaminants; Effects of multiple stressors on near-coastal ecosystems and relationship to watershed management

Professional Societies:
Ecological Society of America

Appointments/Honors:
USEPA Bronze Metal, 1983, 1998, 2001
USEPA Special Achievement Award 1985, 1989, 1992
USEPA Scientific Achievement Award, Honorable Mention, 1991
USEPA Innovative Research Proposals, 1985, 1990
USEPA Science Achievement Award in Biology/Ecology, 1995
Member EPA's 301(h) National Task Force 1982-1986

Selected Publications:
Lee II, H., B. Thompson, and S. Lowe. (2001, submitted). Spatial patterns and associations of nonindigenous benthos in the San Francisco Estuary. Bioinvasions
Lee II, H. and J. Chapman. 2001. A Landscape in Transition: Effects of Invasive Species on Ecosystems, Human Health, and EPA Goals. Vol. 2 of Nonindigenous Species - An Emerging Issue for the EPA. EPA rpt. 54 pages.
EMS and H. Lee II., editors. 2001. Region/ORD Nonindigenous Species Workshop Reports. Vol. 1 of Nonindigenous Species - An Emerging Issue for the EPA. EPA rpt. 111 pages.
Young, D.R., R.J. Ozretich, H. Lee II, S. Echols, and J. Frazier. 2001. Persistence of DDT residues and dieldrin off a pesticide processing plant in San Francisco Bay, California. Chapter 15, pages 204-217 in R.L Lipnick, J.L.M. Hermens, K.C. Jones, and D.C.G. Muir, editors, Persistent Bioaccumulative Toxic Chemicals I: Fate and Exposure, American Chemical Society, Wash. DC.
Landrum, P.F., J. Kukkonen, M.J. Lydy, and H. Lee II.1999. Measuring absorption efficiencies: Some additional considerations. Environmental Toxicology and Chemistry 18:2403-2404.

Young, D R , D T Specht, P J Clinton and Henry Lee II 1998 Use of color infrared aerial photography to map distributions of eelgrass and green macroalgae in a non-urbanized estuary of the Pacific Northwest, U S A Vol II, pages 37-45 in B Petoskey, editor Proceedings of the Fifth International Conference on Remote Sensing for Marine and Coastal Environments, ERIM International, Inc Ann Arbor, MI NHEERL-COR

Boese, B , H Lee II, and S Echols 1997 Evaluation of a first-order model for the prediction of bioaccumulation of PCBs and DDTs from sediment into the marine deposit-feeding clam, Macoma nasuta Environ Toxicol Chem 16 1545-1552

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Behrenfeld, M J , Lean, D S , and Lee, II, H 1995 Ultraviolet-B radiation effects on inorganic nitrogen uptake by natural assemblages of oceanic plankton Journal of Phycology 31 25-36

Behrenfeld, M , H Lee II, and L Small 1994 Interactions between nutritional status and long-term responses to ultraviolet-B radiation stress in a marine diatom Mar Biol 118 523-530

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Landrum, P , H Lee II, and M Lydy 1992 Toxicokinetics in aquatic systems Model comparisons and use in hazard assessment Environ Toxicol Chem 11 1709-1725

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Lee II, H , B Boese, R Randall, and J Pelletier 1990 A method for determining gut uptake efficiencies of hydrophobic pollutants in a deposit-feeding clam Environ Toxicol Chem 9 215-219

Lee II, H , and W Ambrose 1989 Life after competitive exclusion An alternative strategy for a competitive inferior Oikos 56 424-427

Davis, M and Lee, II, H 1983 Recolonization of sediment-associated microalgae and effects of estuarine infauna on microalgal production Marine Ecology Progress Series 11 227-232

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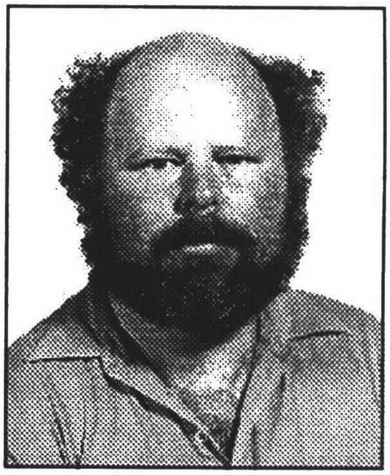

Education:
B.S., Cornell University, Ithaca, NY; Agriculture and Life Sciences, 1978
M.S., University of Florida, Gainesville; Environmental Engineering Sciences, 1980
Ph.D., Louisiana State University, Baton Rouge, LA; Marine Sciences, 1989

Previous Positions:
1981-1987: Research Assoc., Center for Wetland Resources, Louisiana State University, Baton Rouge
1987-1988: Research Associate, Remote Sensing and Image Processing Lab, LA State University, Baton Rouge
1989-1998: Research Ecologist, Wetlands Research Program, NHEERL-WED, Corvallis

Research Interests and Skills:
Landscape ecology and wetland ecology

Keywords:
Discipline: Ecosystem Ecology, Landscape Ecology, Wetland Ecology
Stressor: Biological, Exotic/Introduced Species; Physical, Habitat Modification, Land Use, and Human Activities/Demographics
Methods and Techniques: Ecological Modeling; Monitoring and Assessment, Methods Development; Spatial Analysis, Geographic Information Systems and Statistical; Statistics, Generalized Estimating Equations

Professional Societies:
International Association for Landscape Ecology
Society of Wetland Scientists

Appointments/Honors:
EPA Bronze Medal for Commendable Service, 1992
NASA Group Achievement Award, 1985
Reviewer for Conservation Biology, Ecological Applications, Journal of the American Water Resources Association, and Wetlands

Selected Publications:
Schweiger, E.W., S.G. Leibowitz, J.B. Hyman, W.E. Foster, and M.C. Downing. (In press). Synoptic assessment of wetland function: a planning tool for protection of wetland species biodiversity. Biodiversity and Conservation.
Hyman, J.B., and S.G. Leibowitz. 2001. JSEM: A framework for identifying and evaluating indicators. Environmental Monitoring and Assessment 66(3):207-232.
Leibowitz, S.G., C. Loehle, B.L. Li, and E.M. Preston. 2000. Modeling landscape functions and effects: a network approach. Ecological Modelling 132(1-2):77-94.

McAllister, L S , B E Peniston, S G Leibowitz, B Abbruzzese, and J B Hyman 2000 A synoptic assessment for prioritizing wetland restoration efforts to optimize flood attenuation Wetlands 20(1) 70-83

Hyman, J B , and S G Leibowitz 2000 A general framework for prioritizing land units for ecological protection and restoration Environmental Management 25(1) 23-25

Leibowitz, S G , and J B Hyman 1999 Use of scale invariance in evaluating judgement indicators Environmental Monitoring and Assessment 58 283-303

Abbruzzese, B , and S G Leibowitz 1997 A synoptic approach for assessing cumulative impacts to wetlands Environmental Management 21(3) 457-475

Wigington, P J , Jr , J P Baker, D H Landers, S G Leibowitz, S G Paulsen, S A Peterson, and N E Detenbeck 1994 An overview of selected U S Environmental Protection Agency ecological research in the Prairie Pothole and Pacific Northwest Regions Pages 57-61 in H Herner and J Woled, editors Proceedings of the Fifth Biennial Watershed Management Conference, Ashland, OR Water Resources Center Report No 86, Univ of California Davis

Leibowitz, S G , E M Preston, L Y Arnaut, N E Detenbeck, C A Hagley, M E Kentula, R K Olson, W D Sanville, and R R Sumner 1992 Wetland research plan FY 92-96 An integrated risk-based approach EPA/600/R-92/060, U S Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR

Leibowitz, S G , B Abbruzzese, P R Adamus, L E Hughes, and J T Irish 1992 A synoptic approach to cumulative impact assessment A proposed methodology EPA/600/R-92/167, U S Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR

Leibowitz, S G , and J M Hill 1989 Spatial analysis of Louisiana coastal land loss Pages 331-355 in R E Turner and D R Cahoon, editors Causes of Wetland Loss in the Coastal Central Gulf of Mexico, Volume II Technical Narrative OCS Study MMS 87-0120, Minerals Management Service, U S Department of the Interior, New Orleans

Leibowitz, S G , F H Sklar, and R Costanza 1989 Perspectives on Louisiana land loss modeling Pages 729-753 in R R Sharitz and J W Gibbons, editors Freshwater Wetlands and Wildlife Perspectives on Natural, Managed and Degraded Ecosystems CONF-8603101, DOE Symposium Series No 61, Office of Scientific and Technical Information, U S Department of Energy, Oak Ridge, TN

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Education:
B.S., Univ. of Utah, Salt Lake City, UT; Botany, 1964
M.S., Univ. of Utah, Salt Lake City, UT; Plant Physiology, 1966
Ph.D., Univ. Of California, Riverside; Plant Physiology, 1971

Previous Positions:
1991-1993: EPA, ERL, Corvallis, OR, Project leader, Global program, Terrestrial Branch
1990-1991: Guest scientist, GSF, Munich, Germany
1980-1990: EPA, ERL-C Corvallis, OR Team leader, Plant contamination research
1970-1980: EPA, EMSL-Las Vegas, NV Team Leader, Plant toxicology monitoring research; Branch Chief (acting 2 years)

Professional Societies:
American Society of Horticulture
Society of Environmental Toxicology and Chemistry

Appointments/Honors:
Scientific Steering Committee, Institute for Ecology of Industrial Areas, Katowice, Poland. Committee co-sponsored by US Dept. of Energy, 1995-present
Consultant to the EPA of Kuwait for the development of an oil reclamation and plant contamination research plan, 1992
Science Advisory Committee: Hazardous Substance Research Center, Univ. of Kansas, Manhattan, KS, 1991-present
Science Advisory Committee, CELSS Program, NASA, Kennedy Spacecraft Center, FL, 1985-1990
Editorial boards: SETAC, 1989-1993; ASHS, 1979-1984

Selected Publications (career total of 93 peer-reviewed publications in 36 years):
McFarlane, C. 1997. Lighting, and Special use chambers, Chapters 1 and 11 in R.W. Langhans and T.W. Tibbitts, editors. Growth Chamber Manual: Environmental Control for Plants. SR-99, Iowa Agriculture and Home Economics Experiment Station.
McFarlane, C., and S. Trapp, editors.1995. Plant Contamination: Modeling and Simulation of Organic Chemical Processes., Lewis Publishers, Boca Raton, FL.
Paterson, S., D. Mackay, and C. McFarlane. 1995. A model of organic chemical uptake by plants from soil and the atmosphere. Environ. Sci. Technol. 28:2259-2266.
McFarlane, C. 1994. Anatomy and physiology of plant conductive systems. In S. Trapp and C. McFarlane, editors. Plant Contamination: Modeling and Simulation of Organic Chemical Processes. Lewis Publishers, Boca Raton, FL.
Trapp, S., McFarlane, C., and Matthies, M.: 1994. Model for uptake of xenobiotics into plants: Validation with bromacil experiments. Environ. Toxicol. Chem. 13(3):413-422.
McFarlane, C., J. Fletcher, M. Matthies, S. Bressler, and R. Owens. 1994. Phytotox Interactive Query Program, A User's Manual.

McFarlane, C 1992 Uptake of organic contaminants by plants Pages 151-164 in C C Travis, editor Municipal Waste Incineration Risk Assessment Deposition, Food Chain, Impacts, Uncertainty, and Research Needs Plenum Press New York

Boersma, L , C McFarlane, and T Lindstrom 1991 Mathematical model of plant uptake of organic chemicals Application to experiments J Environ Qual 20 (1)137-146

McFarlane, C , T Pfleeger, and J Fletcher 1990 Nitrobenzene uptake, translocation, and metabolism in several terrestrial plants Environ Toxicol Chem 9 513-520

Fletcher, J S , F L Johnson, and C McFarlane 1990 The influence of greenhouse versus field testing and taxonomic differences on plant sensitivity to chemical treatment Environ Toxicol Chem 9 769-776

McCrady, J K , C McFarlane, and L K Gander 1990 The transport and fate of 2,3,7,8-TCDD in soybean and corn Chemosphere 21(3) 359-376

McFarlane, C , and T Pfleeger 1987 Plant exposure chambers for study of toxic chemical/plant interactions J Environ Qual 16(4) 361-371

McFarlane, C , T Pfleeger, and J Fletcher 1987 Transpiration effect on the uptake and distribution of bromacil, nitrobenzene, and phenol in soybean plants J Environ Qual 16(4) 372-376

McFarlane, C , A Cross, and R D Rogers 1981 Atmospheric benzene depletion by soil microorganisms Environ Monitoring and Assessment 1 75-81

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M.S., Univ. of Washington, Seattle, WA; Forest Soils, 1983
Ph.D., Univ. of Minnesota, St. Paul, MN; Soil Science/Ecosystem Ecology, 1991

Previous Positions:
1995-1997: National Research Council Associate, Western Ecology Division, NHEERL, Corvallis, OR
1990-1995: Research Associate, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA
1987-1989: Research Technician, Dept. of Ecology and Evolutionary Biology, Univ. of Minnesota, Minneapolis
1984-1987: Research Assistant, Dept. of Soil Science, University of Minnesota, St. Paul
1984-1986: Teaching Assistant (Advanced Forest Soils), Dept. of Soil Science, University of Minnesota, St. Paul

Research Interests and Skills:
Ecosystem ecology, Biogeochemistry, Plant Community Ecology, Modeling, Stable Isotope Techniques

Professional Societies:
Ecological Society of America
Soil Science Society of America
Organization for Tropical Studies
American Association for the Advancement of Science

Appointments/Honors:
EPA Special Accomplishment Recognition Awards, 2000, 2001.
Consultant for the Japanese Forestry and Forest Products Research Institute Project, "Carbon budget in forest ecosystem of Japan," 1999
National Research Council Fellowship, 1995 - 1998
Sigma Xi
Reviewer of manuscripts for *Ecology, Oecologia, Soil Science Society of America Journal, Global Change Biology, Annals of Botany,* and *Journal of Environmental Quality*
Reviewer of proposals for NSF Ecosystems and Ecology programs; USDA Forest/Range/Crop Ecosystems, Soil and Soil Biology programs

Selected Publications:
Norris, M., J. Blair, L. Johnson and R. McKane. 2001. Assessing changes in biomass, productivity, and C and N stores following Juniperus virginiana forest expansion into tallgrass prairie. Canadian Journal of Forest Research. *In press.*
Lewis, J.D., R.B. McKane, D.T. Tingey and P.A. Beedlow. 2000. Vertical gradients in photosynthetic light response within an old-growth Douglas-fir and western hemlock canopy. Tree Physiology 20:447-456.
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McKane, R B , E B Rastetter, G R Shaver, K J Nadelhoffer, A E Giblin, J A Laundre, and F S Chapin III 1997 Reconstruction and analysis of historical changes in carbon storage in arctic tundra Ecology 78 1188-1198

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Hobbie J E , B L Kwiatkowski, E B Rastetter, D A Walker, and R B McKane 1998 Carbon cycling in the Kuparuk Basin plant production, carbon storage, and sensitivity to future changes Journal of Geophysical Research Vol 103 D22, pages 29,065-29,073

Nadelhoffer, K , G Shaver, B Fry, A Giblin, L Johnson, and R McKane 1996 ^{15}N natural abundances and N use by tundra plants Oecologia 107 386-394

McKane, R B , E B Rastetter, J M Melillo, G R Shaver, C S Hopkinson, D N Fernandes, D L Skole, and W H Chomentowski 1995 Effects of global change on carbon storage in tropical forests of South America Global Biogeochemical Cycles 9 329-350

Fry, B ,D E Jones, G W Kling, R B McKane, K J Nadelhoffer, and B J Peterson 1995 Adding ^{15}N tracers to ecosystem experiments Pages 171-192 in E Wada, T Yoneyama, M Minagawa, T Ando. and B Fry, editors, Stable Isotopes in the Biosphere Kyoto University Press, Japan

Rastetter, E B , R B McKane, G R Shaver, and J M Melillo 1992 Changes in C storage by terrestrial ecosystems How carbon-nitrogen interactions restrict responses to CO_2 temperature Water, Air, and Soil Pollution 64 327-344

McKane, R B , D F Grigal, and M P Russelle 1990 Spatiotemporal differences in ^{15}N uptake and the organization of an old-field plant community Ecology 71 1126-1132

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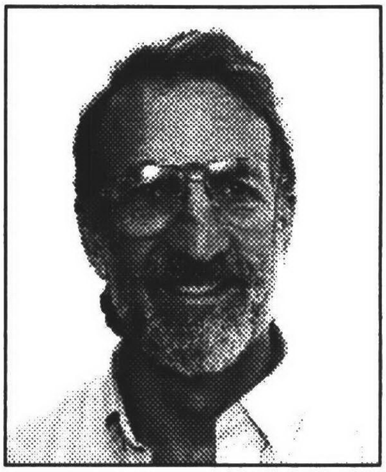

Education:
B.S., University of Washington, Seattle; Marine Fisheries, 1965
Ph.D., University of Washington, Seattle; Fisheries, 1975

Previous Positions:
1991-1994: Deputy Director, USEPA, EMAP, ORD, Corvallis, OR
1989-1991: Associate Director Inland Aquatics, EMAP, ORD, Corvallis, OR
1989-1991: Watershed Branch Chief, USEPA, ERL, Corvallis, OR
1986-1989: Watershed Team Leader, USEPA, ERL, Corvallis, OR
1976-1986: Senior Research Scientist, Ecological Sciences Div., Battelle Northwest Laboratories, Richland, WA

Appointments/Honors:
Interagency Implementation Task Force on Research and Monitoring, Northwest Forest Plan, 1993-1994
Intergovernmental Task Force on Monitoring Water Quality, USEPA and USGS, 1991-1993
Director, Task Group 6: Aquatic Effects Research Program, NAPAP, 1988-1989
Reviewer for NSF, EPRI, Journal of Environmental Management

Selected Publications:
McKenzie, D.H., D.E. Hyatt, and V.J. McDonald, editors. 1992. Ecological Indicators 1,561 pages in two volumes. Elsevier Applied Science, London.
Skalski, J.R., and D.H. McKenzie. 1982. A design for aquatic monitoring programs. Journal of Environmental Management 14(3):237-251.
Thomas, J.M., and D.H. McKenzie. 1979. A procedure for assessing biological effects of power plants on fish. Fisheries, Bulletin of American Fisheries Society 4(6):23-27.
Taub, F.B., and D.H. McKenzie. 1973. Continuous cultures of an alga and its grazer *(Chlamydomonas reinhardi)*, Bulletin of Ecological Research Committee, Swedish National Science Research Council 17:371-377.

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M.S., University of Utah, Salt Lake City, UT; Zoology and Entomology, 1963

Ph.D., University of Utah, Salt Lake City, UT; Water Pollution Biology, 1966

Previous Positions:

1988-1993: Research Biologist, Wildlife Program, ERL, USEPA, Corvallis, OR
1976-1988: Research Aquatic Biologist, ERL, USEPA, Corvallis, OR
1971-1976: Research Aquatic Biologist, NERC, USEPA, Corvallis, OR
1966-1971: Research Aquatic Biologist, National Water Quality Laboratory, FWPCA, USDI, Duluth, MN

Professional Societies:

American Fisheries Society
Entomological Society of America

Appointments/Honors:

Cert. Professional Fisheries Scientist
Cert. Professional Entomologist
EPA Gold Medal for Exceptional Service

Selected Publications

Nebeker, A.V. and R.B. Bury. 2000. Temperature selection by hatchling and yearling Florida red-bellied turtles (*Pseudemys nelsoni*) in thermal gradients. J. Herpetology 34(3):465-469.

Nebeker, A.V. and G.S. Schuytema. 2000. Effects of ammonium sulfate on growth of larval Northwestern salamanders, red-legged frog and Pacific treefrog tadpoles, and juvenile fathead minnows. Bul. Environ. Contam. Toxicol. 64(2):271-278.

Nebeker, A.V. and G.S. Schuytema. 1998. Chronic effects of the herbicide diuron on freshwater cladocerans, amphipods, midges, minnows, worms, and snails. Arch. Environ. Contam. Toxicol. 35:441-446.

Nebeker, A.V., G.S. Schuytema, W.L Griffis, and A. Cataldo. 1998. Impact of guthion on growth of the frog *Pseudacris regilla* and the salamanders *Ambystoma gracile* and *Ambystoma maculatum*. Arch. Environ. Contam. Toxicol. 35:48-51.

Nebeker, A.V., S.T. Onjukka, D.G. Stevens, and G.A. Chapman. 1996. Effect of low dissolved oxygen on aquatic life stages of the caddisfly *Clistoronia magnifica* (Limnephilidae). Arch. Environ. Contam. Toxicol. 31:453-458.

Nebeker, A.V., G.S. Schuytema,, and S.L. Ott. 1995. Effects of cadmium on growth and bioaccumulation in the Northwestern salamander *Ambystoma gracile*. Arch. Environ. Contam. Toxicol. 29:492-499.

Nebeker, A.V., G.S. Schuytema, and S. Ott. 1994. Effects of cadmium on limb regeneration in the salamander *Ambystoma gracile*. Arch. Environ. Contam. Toxicol. 27:318-322.

Nebeker, A V , K D Dunn, W L Griffis, G S Schuytema 1994 Effects of dieldrin in food on growth and bioaccumulation in mallard ducklings Arch Environ Contam Toxicol 26(1) 29-32
Nebeker, A V , W L Griffis, T W Stutzman, G S Schuytema, L A Carey, and S M Scherer 1992 Effects of aqueous and dietary exposure of dieldrin on survival, growth and bioconcentration in mallard ducklings Environ Toxicol Chem 11 687-699
Nebeker, A V , S T Onjukka, D G Stevens, G A Chapman, and S E Dominguez 1992 Effects of low dissolved oxygen on survival, growth and reproduction of *Daphnia, Hyalella*, and *Gammarus* Environ Toxicol Chem 11 373-379
Nebeker, A V , G S Schuytema, W L Griffis, J A Barbitta, and L A Carey 1989 Effect of sediment organic carbon on survival of *Hyalella azteca* exposed to DDT and endrin Environ Toxicol Chem 8 705-718
Nebeker A V , and C E Miller 1988 Use of the amphipod crustacean *Hyalella azteca* in freshwater and estuarine sediment toxicity tests Environ Toxicol Chem 7 1027-1033
Nebeker, A V , C Savonen, and D G Stevens 1985 Sensitivity of rainbow trout early life stages to nickel chloride Environ Toxicol Chem 4 233-239
Nebeker, A V , C Savonen, R J Baker, and J K McCrady 1984 Effects of copper, nickel, and zinc on the life cycle of the caddisfly *Clistoronia magnifica* (Limnephilidae) Environ Toxicol Chem 3 645-649
Nebeker, A V , M A Cairns, J H Gakstatter K W Malueg, G S Schuytema, and D F Krawczyk 1984 Biological methods for determining toxicity of contaminated freshwater sediments to invertebrates Environ Toxicol Chem 3 617-630
Nebeker, A V , M A Cairns, and C M Wise 1984 Relative sensitivity of *Chironomus tentans* life stages to copper Environ Toxicol Chem 3 151-158
Nebeker, A V , C K McAuliffe, R Mshar, and D G Stevens 1983 Toxicity of silver to steelhead and rainbow trout, fathead minnows, and *Daphnia magna* Environ Toxicol Chem 2 95-104
Nebeker, A V , P McKinney, and M A Cairns 1983 Acute and chronic effects of diflubenzuron (dimilin) on freshwater fish and invertebrates Environ Toxicol Chem 2 329-336
Nebeker, A V , J D Andros, J K McCrady, and D G Stevens 1978 Survival of steelhead trout (*Salmo gairdneri*) eggs, embryos, and fry in air-supersaturated water J Fis Res Board Can 35 261-264
Nebeker, A V , and J R Brett 1976 Effects of air- supersaturated water on survival of Pacific salmon and steelhead smolts Trans Amer Fish Soc 105(2) 338-342
Nebeker, A V , A K Hauck, and F D Baker 1979 Temperature and oxygen-nitrogen gas ratios affect fish survival in air-supersaturated water Water Research 13 299-303
Nebeker, A V , D G Stevens, and R K Stroud 1976 Effects of air-supersaturated water on adult sockeye salmon J Fish Res Bd Canada, 33(11) 2629-2633
Nebeker, A V , F A Puglisi, and D L DeFoe 1974 Effect of polychlorinated biphenyl compounds on survival and reproduction of the fathead minnow and flagfish Trans Amer Fish Soc 103(3) 562-568
Nebeker, A V 1973 Temperature requirements and life cycle of the midge *Tanytarsus dissimilis* J Kansas Entom Soc 46(2) 160-165
Nebeker, A V 1972 Effect of low oxygen concentration on survival and emergence of aquatic insects Trans Amer Fish Soc 101 675-679
Nebeker, A V 1971 Effect of temperature at different altitudes on the emergence of aquatic insects from a single stream J Kansas Ent Soc 44(1) 26-35
Nebeker, A V and A E Lemke 1968 Preliminary studies on the tolerance of aquatic insects to heated waters J Kansas Ent Soc 41(3) 413-418
Nebeker, A V and A R Gaufin 1964 Bioassays to determine pesticide toxicity to the amphipod crustacean Gammarus lacustris Utah Academy Proc 41(1) 64-67

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Ph.D., Duke Univ., Durham, NC; Zoology (Oceanography minor), 1978
Postdoctoral Fellow, Harbor Branch Oceanographic Institution, Fort Pierce, FL, 1978-1979
Postdoctoral Fellow, Institute of Marine Biology, University of Bergen, Bergen, Norway, 1979-80

Previous Positions:

1989-1997: Professor, Florida Institute of Technology, Melbourne, FL
1987-1997: Director, Indian River Marine Science Research Center, Florida Institute of Technology, Vero Beach, FL
1985-1987: Assistant Director, IRMSRC, Vero Beach, FL
1984-1989: Associate Professor, Florida Institute of Technology, Melbourne, FL
1981-1984: Assistant Professor, Florida Institute of Technology, Melbourne, FL
1980-1981: Research Associate, National Research Council, USEPA, Newport, OR

Research Interests and Skills:

Marine impacts of anthropogenic stressors, including watershed development, dredging, aquaculture, and sewage discharge
Seagrass community ecology and habitat restoration
Development of impact assessment metrics for marine benthos

Professional Societies:

American Association for the Advancement of Science, Ecological Society of America, Estuarine Research Federation, Sigma Xi

Appointments/Honors:

College of Engineering Excellence Award for University Service, Florida Institute of Technology, 1997
National Research Council Senior Research Fellowship, 1994
Faculty Senate Excellence Award for Research, Florida Institute of Technology, 1994
College of Engineering Excellence Award for Research, Florida Institute of Technology, 1994
Visiting Professor, Akademi University, Turku, Finland, 1991
Fulbright Fellowship, 2 months, Finland, 1988
American Scandinavian Foundation, Carl G. and Rikke Frederiksen Barth Fund, for Study and Research in Finland, 1988

Selected Publications:

Zupo, V., W.G. Nelson and M.C. Gambi. 2001. Measuring invertebrate grazing on seagrasses and epiphytes. In: F. Short and R. Coles, ed. Global Seagrass Research Methods. Elsevier.
Tunberg, B. and W.G. Nelson. 1998. Do climatic oscillations influence cyclical patterns of soft bottom microbenthic communities on the Swedish west coast? Marine Ecology Progress Series 170:85-94.
Vose, F.W. and W.G. Nelson. 1998. An assessment of the use of stabilized oil ash (SOA) for construction of artificial fishing reefs: comparisons of fish colonization on SOA reefs and concrete reefs. Marine Pollution Bulletin 36:980-988.

Swain, G W , W G Nelson, and S Preedeekanit 1998 The influence of biofouling adhesion and biotic disturbance on the development of fouling communities on non-toxic surfaces Biofouling 12 257-269

Heidelbaugh, S E, and W G Nelson 1996 An evaluation of core and quadrat methods for assessing spatial and temporal changes in seagrass cover Aquatic Botany 53 227-233

Bonsdorff, E and W G Nelson 1996 The use of macroalgae in measuring environmental impacts limited utility of blade length measurements of *Fucus vesiculosus* L Botanica Marina 39 129-132

Nelson, W G , and R W Virnstein 1995 Long-term dynamics of seagrass macrobenthos Asynchronous population variability in space and time Pages 185-190 in A Eleftheriou, editor Proceedings of the 28th European Marine Biology Symposium Olsen and Olsen, Fredensborg, Denmark

Nelson, W G 1995 Amphipod crustaceans of the Indian River Lagoon Current status and threats to biodiversity Bulletin of Marine Science 57 143-152

Kensley, B , and W G Nelson, and M Schotte 1995 Marine isopod biodiversity of the Indian River, Florida Bulletin of Marine Science 57 136-142

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Hamilton, K L , W G Nelson, and J L Curley 1993 Toxicological evaluation of the effects of waste-to-energy ash-concrete on two marine species Ecological Toxicology and Chemistry 12 1919-1930

Mojica, R , Jr , and W G Nelson 1993 Environmental effects of a hard clam (*Mercenaria mercenaria*) aquaculture site in the Indian River Lagoon, Florida Aquaculture 113 313-329

Bonsdorff, E and W G Nelson 1992 Some observations on the ecology of the coquina clams *Donax variabilis* Say 1822 and *Donax parvula* Philippi 1849 on the east coast of Florida The Veliger 35 358-365

Nelson, W G 1992 Beach restoration in the south-eastern United States environmental effects and biological monitoring Ocean and Coastal Management 18 1-26

Nelson, W G and L Demetriades 1992 Peracarid crustaceans associated with sabellariid (*Phragmatapoma lapidosa* Kinberg) worm rock at Sebastian Inlet, Florida Journal of Crustacean Biology 12 647-654

Nelson, W G , D Charvat, and T Allenbaugh 1990 Community dynamics of surf zone amphipod assemblages from the central Florida East Coast Journal of Crustacean Biology 10 446-454

Nelson, W G 1990 Prospects for development of an index of biotic integrity for evaluating habitat degradation in estuarine and coastal systems Chemistry and Ecology 4 197-210

Nelson, W G and E Bonsdorff 1990 Fish predation and habitat complexity are complexity thresholds real? Journal of Experimental Marine Biology and Ecology 141 183-194

Nelson, W G and M A Capone 1990 Experimental studies of predation on polychaetes associated with seagrass beds Estuaries 13.51-58

Nelson, W G , P M Navratil, D M Savercool, and F E Vose 1988 Short-term effects of stabilized oil ash reefs on the marine benthos Marine Pollution Bulletin 19 623-627

Lowery, W and W G Nelson 1988 Aspects of the biology of the hermit crab *Clibinarius vittatus* at Sebastian Inlet, Florida Journal of Crustacean Biology 8 548-556

Ronn, C , E Bonsdorff, and W G Nelson 1988 Predation as a mechanism of interference within infauna in shallow brackish water soft-bottoms experiments with an infaunal predator. *Nereis diversicolor* O F Muller Journal of Experimental Marine Biology and Ecology 116 143-157

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Education:
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M.S., University of Wyoming, Laramie; Statistics, 1969
Ph.D., Oregon State Univ., Corvallis; Statistics, 1973

Previous Positions:
1984-1990: Adjunct Associate Professor of Mathematics, Washington State University, Pullman
1979-1985: Mathematics & Statistics Chair, Joint Ctr.for Grad. Study, Washington State Univ., Richland
1974-1990: Research Statistician, Battelle, Pacific Northwest Laboratory, Richland, WA
1972-1974: Mathematical Statistician, Experimental Meteorology Laboratory, NOAA, Coral Gables, FL

Professional Societies:
The International Biometric Society, Western North American Region
American Statistical Association
The International Environmetrics Society
International Statistics Institute (elected member)

Appointments / Honors:
2000 Fellow of the American Statistical Association
1998 Distinguished Statistical Ecologist Award, International Association for Ecology
1994 Distinguished Achievement Medal, Section on Statistics and the Environment, American Statistical Association

Selected Publications:
Handcock, M.S., J. Sedransk, and A.R.Olsen. (In press). Statistical methods for ecological assessment of riverine systems by combining information from multiple sources. In Proceedings Section on Statistics and the Environment. American Statistical Association, Alexandria, VA.

Hall, R.K., A.R. Olsen, D. Stevens, B. Rosenbaum, P. Husby, et al. 2000. EMAP Design and River Reach File 3 (RF3) as an EMAP sample frame in the Central Valley, California. Environmental Monitoring and Assessment, 64: 69-80.

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Dixon, P M , A R Olsen, and B Kahn 1998 Invited Feature Measuring trends in ecological resources Ecological Applications 8 225-7
Goebel, J H Schreuder, C House, T Olsen, and B Williams 1998 Integrating surveys of terrestrial natural resources The Oregon Demonstration Study Rep Inventory and Monitoring Report No 2, U S Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO
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Olsen. A R , and H T Schreuder 1997 Perspectives on large-scale resource surveys when cause-effect is a potential issue Environmental and Ecological Statistics 4(2) 167-180
Carr, D B and A R Olsen, 1996 Simplifying visual appearance by sorting an example using 159 AVHRR classes Statistical Computing & Graphics Newsletter 7 10-6
Sisterson, D L , V C Bowersox, and A R Olsen 1994 A Review of Spatial and Temporal Trends of Precipitation Composition for North America for the Period 1979-1987 Pages 157-201 in J Rose. editor Acid Rain Gordon and Breach Science Publishers
Carr, D B , A R Olsen, and D White 1992 Hexagon mosaic maps for display of univariate and bivariate geographical data Cartography & Geographic Information Systems 19 228-236,271
Davis, W E , A R Olsen, and B T Didier 1989 MLAM Assessment of radionuclide air concentration and deposition for the Chernobyl reactor accident Pages 123-136 in H Van Dop, editor Air Pollution Modelling and Its Applications VII Plenum Publishing Company
Tolley, H D , and A R Olsen 1985 A note on homogeneity tests when combining 2 x 2 tables Communication in Statistics Theory & Methods 14 2857-2871
Onishi, Y , A R Olsen, M A Parkhurst, and G Whelan 1985 Computer-based environmental exposure and risk assessment methodology for hazardous materials J Hazardous Materials 10 389-417
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Olsen, A R , J Seely, and D Birkes 1976 Invariant quadratic unbiased estimation for two variance components The Annals of Statistics 4(5) 878-890
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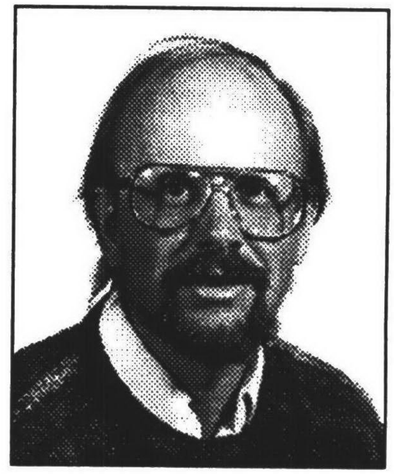

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Postdoctoral Fellowship, National Research Council, USEPA, ERL, Corvallis, OR, 1981-1983

Previous Positions:
1989: Associate Research Plant Physiologist, Statewide Air Pollution Research Center, Univ. of CA, Riverside
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1985-1988: Head of Plant Sciences Section; Statewide Air Pollution Research Center, Univ. of CA, Riverside
1981: Instructor, Department of Biology, Edgewood College, Madison, WI
1979-1981: Planning Analyst, Wisconsin Public Service Commission, Bureau of Environmental Review, Madison, WI

Research Interests and Skills:
Ecophysiological effects of environmental stress on plants and terrestrial ecosystems
Plant gas exchange, water relations, growth and productivity, chemistry

Professional Societies:
American Society of Agronomy
American Society of Plant Physiologists
American Society for the Advancement of Science Science

Appointments / Honors:
Courtesy Faculty Member and member of Graduate Faculty, Crop and Soil Science Dept., Oregon State Univ., 1989-present
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Associate Editor, *Agriculture, Ecosystems and Environment*, 1998-present
Associate Editor, *Journal of Environmental Quality*, 1986-91, 1995-1997

Selected Publications:
Olszyk, D.M., M. G. Johnson, D. L. Phillips, R. J. Seidler, D. T. Tingey, and L. S. Watrud. (In press). Interactive effects of CO_2 and O_3 on a ponderosa pine plant/litter/soil mesocosm. Environ. Pollut.
Hobbie, E.A., D.M. Olszyk, P.T. Rygiewicz, M.G. Johnson, and D.T. Tingey. (In press). Foliar Nitrogen Levels and Natural Abundance ^{15}N Reveal Mycorrhizal-Plant Patitioning and Recycling of N During Development Under Climate Change. Tree Physiol.

Lewis, J D , M Lucash, D Olszyk, and D T Tingey 2001 Seasonal patterns of photosynthesis in Douglas-fir seedlings during the third and fourth year of exposure to elevated carbon dioxide and temperature Plant Cell Environ 24 539-548

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Apple, M E , D M Olszyk, D P Ormrod, J Lewis, D Southworth, and D T Tingey 2000 Morphology and stomatal function of Douglas fir needles exposed to climate change elevated CO_2 and temperature Internat J Plant Scientists 16(1) 127-132

Tingey, D T , R S Waschmann, D L Phillips, and D M Olszyk 2000 The use of sulfur hexafluoride to measure the carbon dioxide leakage rate of sun-lit controlled environment chambers Environ Exp Bot 43 101-110

Olszyk, D M , H G S Centano, L H Ziska, J S Kern, and R B Matthews 1999 Global Change, Rice Productivity and Methane Emissions Comparison of Predicted and Experimental Results Agric For Meteorology 9 87-101

Lewis, J D , D Olszyk, and D T Tingey 1999 Seasonal patterns of photosynthetic light response in Douglas-fir seedlings subjected to elevated atmospheric CO_2 and temperature Tree Physiol 19 243-252

Weerakoon, W M , D M Olszyk, and D N Moss 1999 Effects of nitrogen nutrition on responses of rice seedlings to carbon dioxide Agriculture, Ecosystems and Environment 72 1-8

Apple, M E , M S Lucash, D L Phillips, D M Olszyk, and D T Tingey 1999 Internal temperature of Douglas-fir buds is altered at elevated temperature Environ Exp Bot 41 25-30

Ormrod, D P , V M Lesser, D M Olszyk, and D T Tingey 1999 Douglas-fir needle pigment responses to elevated CO_2 and/or temperature and correlations with needle weight and seedling growth Intl J Plant Sci 160 529-534

Olszyk, D M , C Wise, E VanEss, M Apple, and D T Tingey 1999 Phenology and growth of shoots, needles, and buds of Douglas-fir seedlings with elevated CO_2 and/or temperature Can J of Bot 76 1991-2001

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Guak, S -H , D M Olszyk, L H Fuchigami, and D T Tingey 1998 Effects of elevated CO_2 and temperature on cold hardiness and bud burst in Douglas-fir (*Pseudotsuga menziesii*) Tree Physiol 18 671-679

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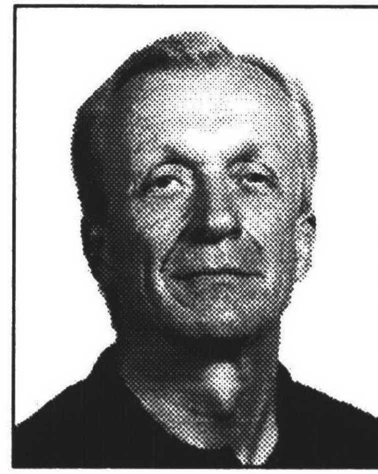

Education:
B.S., University of Wisconsin at Eau Claire; Geography, 1960
Graduate studies, University of Kansas; Geography and Cartography, 1960-61

Previous Positions:
1963-1972: Intelligence Research Specialist (Military Geographer), Defense Intelligence Agency, Arlington, VA

Professional Societies:
Association of American Geographers
Soil and Water Conservation Society
North American Lake Management Society

Appointments / Honors:
EPA Special Service Award, 1997
EPA Scientific and Technological Achievement Award (Level II), 1996
EPA Scientific and Technological Achievement Award, 1988
EPA Silver Medal for Superior Service, 1988
EPA Scientific and Technological Achievement Award, 1987
EPA Bronze Medal for Commendable Service, 1987
EPA Bronze Medal For Commendable Service, 1984

Selected Publications:
Omernik, J.M., S.S. Chapman, R.A. Lillie, and R.T. Dumke. 2000. Ecoregions of Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts and Letters 88:77-103.
Bryce, S.A., J.M. Omernik, and D.P. Larsen. 1999. Ecoregions: A geographic framework to guide risk characterization and ecosystem management. Environmental Practice, Journal of the National Association of Environmental Professionals 1(3):142-155.
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Omernik, J M , A R Abernathy, and L M Male 1981 Stream nutrient levels and proximity of agricultural and forest lands to streams Some relationships Journal of Soil and Water Conservation 36(4) 227-231

Omernik, J M 1977 Nonpoint source -stream nutrient level relationships A nationwide study (151pp) Map scale 1 7,500,000 EPA/600/2-77/105 US Environmental Protection Agency, Corvallis, OR

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MS., Miami University, Oxford, Ohio, 1983

Previous Positions:
1996-2000: Assistant Laboratory Director for Multimedia, Water Quality and Global Programs, Research Planning & Coordination Staff, USEPA, NHEERL, Research Triangle Park, NC.
1994-1996: Assoc. Director, Health and Ecological Criteria Division, Office of Science and Technology, Office of Water, Washington, D.C.
1989-1994: Chief, Drinking Water Section, Human Risk Assessment Br., HECD/OST/OW, Washington, D.C.
1985-1989: Toxicologist, Health Effects Branch, Criteria and Standards Division, Office of Drinking Water/OW, Washington, D.C.
1985: Biologist, Test Rules Development Branch, Existing Chemical Assessment Division, Office of Toxic Substances, Office of Pesticides and Toxic Substances, Washington, D.C.
1984-1985: Biologist, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, Ohio
1981-1984: Research Biologist, Target Organ Toxicity Branch, Toxicology and Microbiology Division, Health Effects Research Lab, ORD, Cincinnati, Ohio

Research Interests and Skills
Human health and ecological risk assessment: Drinking water and water quality risk assessment; Reproductive and developmental toxicity; Neurobehavioral toxicity; population ecology.

Professional Societies:
American Association for the Advancement of Science
Society of Toxicology
Society of Environmental Toxicology and Chemistry
National Environmental Health Association
Society for Risk Analysis
American Water Works Association

Appointments/Honors:
Corporate member, Underwriters' Laboratories, 1999-2003
Member, Board of Trustees, Toxicology Excellence for Risk Assessment, 1997-present
USEPA Gold Medal for Exceptional Service, 1996
Member, Environment and Public Health Council, Underwriters Laboratories, 1996-present
Member, Health Advisory Board, Drinking Water Additives Program, National Sanitation Foundation, 1986-present
USEPA Bronze Medals for Commendable Service 1988, 2 in 1992, 1994, 1997.
Reviewer for Reproductive Toxicology, Environmental Toxicology and Chemistry, J. Am. Water Works Assoc.

Councilor, Triangle Chapter, Society for Risk Analysis, 1997-1999
Chair, Health Research Committee, AWWA, 1995-1998
USEPA Risk Assessment Forum, 1995-1998
USEPA Science Policy Council Steering Committee, 1997-present
Temporary Advisor, International Agency for Research on Cancer, (IARC), Lyon, France, 1994
Temporary Advisor, World Health Organization's International Program on Chemical Safety (IPCS), Geneva, 1992, 1995
Sigma Xi student research award, 1980 Ohio Wesleyan Univ Chapter

Selected Publications:

Abernathy, C O , I S Dooley, J Taft, and J Orme Zavaleta 2000 Arsenic moving toward a regulation Chapter 16, pages 211-222 in Salam and Olajos, editors Toxicology in Risk Assessment Taylor & Francis Publishers

Stahl, R G , J Orme Zavaleta, K Austin, W Berry, J Clark, S Cormier, W Fisher, J Gardner, R Hoke, L Jackson, G L Kreamer, C Muslea, and M B Sierzen 2000 Use of ecological indicators in ecological risk assessment of aquatic systems proceedings of workshop, Human and Ecological Risk Assessment, August, 2000

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Gibson M , S deMonsabert, and J Orme 1997 Comparison of noncancer risk assessment approaches for use in deriving drinking water criteria Reg Tox and Pharm 26 243-256

Chiu, N , J Orme, A Chiu, C Chen, A DeAngelo, W Brattin, and J Blancato 1996 Characterization of cancer risk associated with exposure to chloroform Env Carcinogenesis & Ecotox Reviews, Part C J Env Sci and Health, C14 81-104

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Vanderslice, R R , E V Ohanian, J Orme, and C Sonich Mullin 1989 Risk assessment of complex mixtures in drinking water Tox and Indus Health 5 747-756

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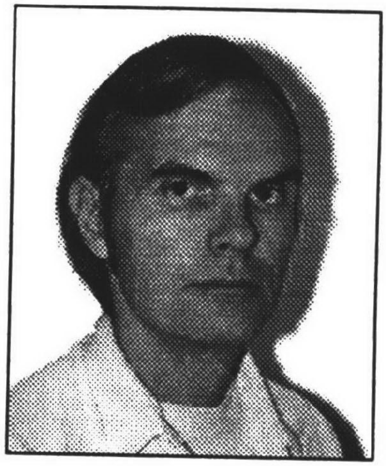

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B.S., Seattle University, Seattle, WA; Chemistry, 1969
M.S., Univ. of Washington, Seattle; Oceanography, 1971
Ph.D., Univ. of Washington, Seattle; Oceanography, 1976
Postdoctoral Research Associate, Dept. of Oceanography, Univ. of Washington, Seattle, 1977-78

Previous Positions:
1978-1980: Instructor, Department of Oceanography, Univ. of Washington, Seattle
1978-1980: Instructor, Chemistry Department, North Seattle Community College, Seattle, WA

Research Interests and Skills:
Drivers and consequences of time and space varying submarine light fields in estuaries.
Use of molecular biomarkers in ecosystem studies
Geochemistry of contaminated sediments

Professional Societies:
Estuarine Research Federation

Appointments/Honors:
USEPA Science Achievement Award in Biology/Ecology, 1995
USEPA Scientific and Technological Achievement Award, 1992
USEPA Scientific and Technological Achievement Award, Honorable Mention, 1991

Selected Publications:
Ozretich, R.J., D.R. Young, and D.B. Chadwick. (In press). Development and application of equilibrium partitioning sediment guidelines (ESGs) in the assessment of sediment PAH contamination. Chapter in American Chemical Society Book, Fate and Transport of Chemicals in the Environment: Impacts, Monitoring, and Remediation.

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Lee II, H , A Lincoff, B L Boese, F A Cole, S P Ferraro, J O Lamberson, R J Ozretich, R C Randall, K R Rukavina, D W Schults, K A Sercu, D T Specht, R C Swartz, and D R Young 1994 Ecological Risk Assessment of the Marine Sediments at the United Heckathorn Superfund Site USEPA, ERL-N-269 Final Report to Region IX, Pacific Ecosystems Branch, ERL-N, USEPA, Newport, OR 97365 EPA-600/X-94/029

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Ozretich, R J , R Randall, B Boese, W Schroeder, and J Smith 1983 Acute toxicity of butylbenzyl phthalate to shiner perch (Cymatogaster aggregata) Arch Environ Contam Toxicol 12 655-660

Ozretich, R J 1981 Increased oxygen demand and microbial biomass Marine Mining 3 108-119

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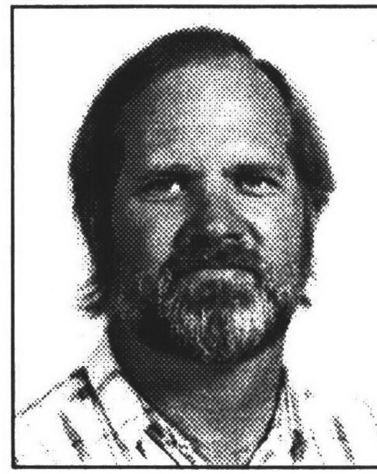

Education:
B.A., The Colorado College; Biology, 1974
University of Northern Colorado; Secondary Teaching Certificate (Science), 1977
M.S., Iowa State University; Animal Ecology (Limnology), 1982
Ph.D., Univ. of California, Davis; Ecology (Limnology), 1987

Previous Positions:
1996-1998: Director, Environmental Monitoring and Assessment Program, USEPA, WED, Corvallis, OR
1989-1995: Technical Director, EMAP-Surface Waters, USEPA, WED, Corvallis, OR
1987-1994: Associate Research Professor, Limnologist, Environmental Research Center, University of Nevada at Las Vegas
1986-1987: Postdoctoral Research Assistant, University of California, Davis

Research Interests and Skills:
Regional Aquatic Ecology
Aquatic Nutrient Cycling

Professional Societies:
American Association for the Advancement of Science (AAAS)
Ecological Society of America (ESA)
American Society of Limnology and Oceanography (ALSO)

Appointments/Honors:
USEPA Bronze Medal, 1992, 1995, 1999, 2001
USEPA Award for Exceptional ORD Technical Assistance to the Regions and Program Offices, 2001
USEPA Scientific and Technological Achievement Award, 1996
USEPA Honor Award, 1999
National Academy of Science Delegate to Romanian Academy of Science
National Academy of Science Twinning Partnership with University of Bucharest
Senior Advisor to National Academy of Science Young Scientist Exchange with Romania

Selected Publications:
Herlihy, A.T., D.P. Larsen, S.G. Paulsen, N.S. Urquhart, B.J. Rosenbaum. 2000. Designing a spatially balanced, randomized site selection process for regional stream surveys: the EMAP mid-Atlantic pilot study. Environ. Mont. Assess. 63:95-113.
Hughes, R.M., S.G. Paulsen, and J.L. Stoddard. 2000. EMAP-Surface Waters: a multiassemblage probability survey of ecological integrity. Hydrobiologia. 442/443:429-443.
Allen, A.P., T.R. Whittier, P. R. Kaufmann, D. P. Larsen, R.J. O'Connor, R.M. Hughes, R.S. Stemberger, S.S. Dixit, R.O. Brinkhurst, A.T. Herlihy, and S. G. Paulsen. 1999. Concordance of taxonomic richness patterns across five assemblages in lakes of the northeastern USA, Can. J. Fish. Aquat. Sci. 56(5):739-747.

Dixit, S S , J P Smol, D F Charles, R M Hughes, S G Paulsen, and G B Collins 1999 Assessing water quality changes in the lakes of the northeastern United States using sediment diatoms Can J Fish Aquat Sci 56 131-152

Landers, D H , R M Hughes, S G Paulsen, D P Larsen, and J M Omernik 1998 How can regionalization and survey sampling make limnological research more relevant? Verh Int Verein Limnol 26 2428-2436

Paulsen, S G , R M Hughes, and D P Larsen 1998 Critical elements in describing and understanding our nation's aquatic resources J Am Water Res Assn 34(5) 995-1005

Peterson, S A , D P Larsen, S G Paulsen, N S Urquhart 1998 Regional lake trophic patterns in the Northeastern United States Three approaches Environ Mgt 22(5) 789-801

Thornton, K W , and S G Paulsen 1998 Can anything significant come out of monitoring? Hum & Ecol Risk Assess 4 797-805

Urquhart, N S , S G Paulsen, and D P Larsen 1998 Monitoring for policy-relevant regional trends over time Ecological Applications 8 246-257

Whittier, T R , D B Halliwell, and S G Paulsen 1997 Cyprinid distributions in Northeast USA lakes evidence of regional-scale minnow biodiversity losses Can J Fish Aquat Sci 54 1593-1607

Stemberger, R S , A T Herlihy, D L Kugler, S G Paulsen 1996 Climatic Forcing on Zooplankton Richness in Lakes of the Northeastern United States Limnology and Oceanography 41 1093-1101

Williamson, C T , R S Stemberger, D P Morris, T M Frost, and S G Paulsen 1996 Attenuation of UV radiation in North American lakes estimates from DOC measurements and implications for plankton communities Limnology and Oceanography 41 1024-1034

Larsen, D P , K W Thornton, N S Urquhart, and S G Paulsen 1994 The role of probability-based surveys for monitoring the condition of the nation's lakes Environ Mont Assess 32(2) 101-134.

Paulsen, S G , and R A Linthurst 1994 Biological monitoring in the Environmental Monitoring and Assessment Program Pages 297-322 in S L Loeb and A Spacie, editors Biological Monitoring of Aquatic Systems Lewis Publishers, Ann Arbor

Whittier, T R , and S G Paulsen 1992 The surface waters component of the Environmental Monitoring and Assessment Program (EMAP) an overview J Aquatic Ecosystem Health 1 119-126

Larsen, D P , D L Stevens, A R Selle, and S G Paulsen 1991 Environmental Monitoring and Assessment Program, EMAP-Surface Waters A northeast lakes pilot Lake and Res Mgt 7(1) 1-11

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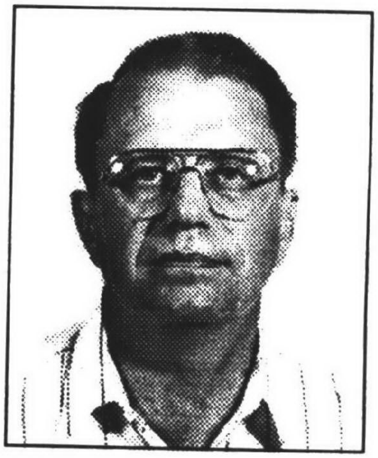

Education:
B.S., Sioux Falls College, Sioux Falls, SD; Biology, 1965
M.S., Univ. of ND, Grand Forks; Fisheries Biology, 1967
Ph.D., Univ. of ND, Grand Forks; Limnology, 1971

Previous Positions:
1988-1990: ORD Regional Scientist, USEPA, Region 10, Seattle, WA
1987-1988: Branch Chief, USEPA, Watershed Branch
1983-1987: Branch Chief, USEPA, Hazardous Waste and Water Branch
1979-1983: Team Leader, USEPA, Hazardous Materials Assessment Team
1974-1979: Team Leader, USEPA, National Lake Restoration Research
1972-1974: Research Aquatic Biologist, USEPA, National Eutrophication Research Program
1971-1972: Project Director, Michigan Department of Natural Resources, Houghton Lake Water Quality Project

Professional Societies:
North American Lake Management Society (Board Dir. 1981-1983; Sci. Adv. Bd., 1994-present)
Oregon Lakes Association
Sigma Xi

Appointments/Honors:
Affiliate Professor, 1988-present, Univ. of Washington, Dept. of Civil and Environmental Engineering
EPA Bronze Medal for outstanding contributions to environmental protection, Region 10, 1990
North American Lake Management Society Technical Excellence Award, 1990
EPA Special Achievement Award, 1989
EPA Technical Achievement Awards, 1974, 1985, 1988, 1989
Recipient of three graduate fellowships: 2 at Univ. N. Dakota, 1 at Stanford Univ.
Environment International Journal (Guest Editor) Vol. 7, No. 2, Special Issue: Management of Bottom Sediments Containing Toxic Substances, 1982

Selected Publications
Peterson, S.A., and N.S. Urquhart. 2000. Estimating Trophic State Proportions of a Regional Lake Population: Are Larger Samples Always Better? Environ. Mont. Assess. 62:71-89.
Peterson, S.A., N.S. Urquhart, and E.B. Welch. 1999. Sample representativeness: a must for reliable regional lake condition estimates. Environ. Sci. & Tech. 33(10):1559-1565.
Peterson, S.A., D.P. Larsen, S.G. Paulsen, and N.S. Urquhart. 1998. Regional lake trophic patterns in the northeastern United States: Three approaches. Environ. Mgt. 22(5):789-801.
Cowardin, L.M., and S.A. Peterson. 1997. Introduction (pages 1-9) in S.A. Peterson, L. Carpenter, G. Guntenspergen, and L.M. Cowardin, editors. Pilot Test of Wetland Condition Indicators in the Prairie Pothole Region of the United States, EPA/620/R-97/002
Peterson, S.A., R.M. Hughes, D.P. Larsen, S.G. Paulsen, and J.M. Omernik. 1995. Regional lake quality patterns: Their relationship to lake conservation and management decisions. Lakes and Reservoirs: Res.& Mgt. 1(3):163-167.

Peterson, S A , R M Hughes, D P Larsen, S G Paulsen, and J M Omernık 1995 The sıgnıficance of regıonal lake qualıty patterns to management/restoratıon of specıfic lakes Proceedıngs of 6th Internatıonal Conference on the Management of Lakes Kasumıgaura '95 Tsukuba, Japan
Peterson, S A 1994 The Envıronmental Monıtorıng and Assessment Program (EMAP) Its objectıves, approach, and status relatıve to wetlands Pages 181-195 ın G Aubrecht, G Dıck and C Prentıce, edıtors Monıtorıng of ecologıcal change ın wetlands of Mıddle Europe Proc Internatıonal Workshop, Lınz, Austrıa, 1993 Joınt Publıcatıon Numbers Stapfia No 31, Lınz, Austrıa, and IWRB No 30, Slımbrıdge, U K
Cooke, G D , E B Welch, S A Peterson, and P R Newroth 1993 Restoratıon and Management of Lakes and Reservoırs Second Edıtıon (548 pages) Lewıs Publıshers, Boca Raton, FL
Peterson, S A , J C Greene, and W E Mıller 1990 Toxıcologıcal assessment of hazardous waste samples extracted wıth deıonızed water or sodıum acetate (TCLP) leachıng medıa Pages 107-129 ın D Frıedman, edıtor Waste Testıng and Qualıty Assurance Vol II ASTM Press, Phıladelphıa
Cooke, G D , E B Welch, S A Peterson, and P R Newroth 1986 Lake and Reservoır Restoratıon Butterworth Press, Boston
Mıller, W E , S A Peterson, J C Greene, and C A Callahan 1985 Comparatıve toxıcology of laboratory organısms for assessıng hazardous waste sıtes J Envıron Qual 14(4) 569-574
Peterson, S A 1982 Lake restoratıon by sedıment removal Water Resources Bull 18 423-435

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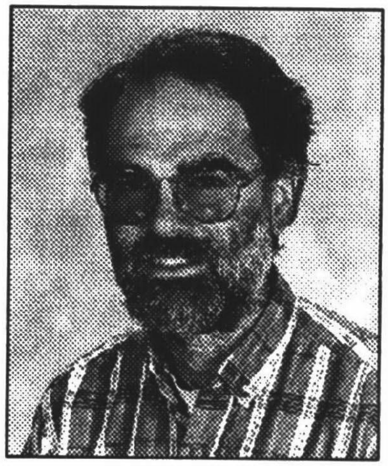

Education:
B.S., SUNY Syracuse; Biological Sciences, 1974.
M.S., Oregon State Univ.; Plant Ecology, 1991.
Ph.D., Oregon State Univ.; Plant Ecology, 1998.

Previous Positions:
1985-1990: Plant Physiologist, USEPA, Corvallis Environmental Research Laboratory
1979-1985: Biological Technician, USEPA, Corvallis Environmental Research Laboratory

Research Interests and Skills:
Plant and plant community response to biotic and abiotic stress
Plant ecotoxicology

Professional Societies:
British Ecological Society
Society of Environmental Toxicology and Chemistry
Ecological Society of America

Appointments/Honors:
Steering Committee on Issues of Nontarget Plant Toxicity (1998-present)
Curriculum development on vegetation for the Corvallis School District, Outdoor School (1997- present)
EPA Scientific and Technological Achievement Award, 1996 Level I
Environmental Protection Agency Scientific and Technological Achievement Award, 1988 Level III

Selected Publications:
Pfleeger, T.G., M.A. da Luz, and C.C. Mundt. 1999. Lack of synergistic interaction between ozone and wheat leaf rust in wheat swards. Environ. & Exp. Bot. 41(3):195-207.
Pfleeger, T.G., C.C. Mundt, and Michelle A. da Luz. 1999. Effects of wheat leaf rust on interactions between wheat and wild oats planted at various densities and proportions. Can. J. Bot. 77:1669-1683.
Pfleeger, T.G. and C.C. Mundt. 1998. Wheat leaf rust severity as affected by plant density and species proportion in simple communities of wheat and wild oats. Phytopathology 88:708-714.
Pfleeger, T.G., A. Fong,, R. Hayes, H. Ratsch, and C. Wickliff. 1996. Field evaluation of the EPA (Kenaga) nomogram, A method for estimating wildlife exposure to pesticide residues on plants. Environ. Tox. & Chem. 15:534-543.
Fletcher, J.S., T.G. Pfleeger, H.C, Ratsch, and R. Hayes. 1996. Potential impact of low levels of chlorsulfuron and other herbicides on growth and yield of nontarget plants. Environ. Tox. & Chem. 15:1189-1196.
Pfleeger, T. and D. Zobel. 1995. Organic pesticide modification of species interactions in annual plant communities. Ecotoxicology 4:15-37.
Fletcher, J.S., T.G. Pfleeger, and H.C. Ratsch.1995. Chlorsulfuron influence on garden pea reproduction. Physiologia Plantarum 94:261-267.

Fletcher, J S , J E Nellessen, and T G Pfleeger 1994 Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants Environ Tox & Chem 13 1383-1391

Pfleeger, T , H Ratsch, and R Shimabuku 1993 A review of terrestrial plants as biomonitors Pages 317-330 in J Gorsuch, J Dwyer, C Ingersoll and T La Point, editors Environmental Toxicology and Risk Assessment, 2nd Vol ASTM STP 1216 ASTM, Philadelphia

Fletcher, J S , T G Pfleeger, and H C Ratsch 1993 Potential environmental risks associated with the new sulfonylurea herbicides Environ Sci Technol 27 2250-2252

Pfleeger, T , J Fletcher, and H Ratsch 1992 Effects of Glean, a sulfonylurea herbicide, on the reproductive biology and fruit set in cherry trees U S Environmental Protection Agency EPA/600/R-92/020

Pfleeger, T G , J C McFarlane, R Sherman, and G Volk 1991 A short-term bioassay for whole plant toxicity Pages 355-364 in J W Gorsuch, W R Lower, M A Lewis and W Wang, editors, Plants for Toxicity Assessment 2nd vol ASTM STP 1115 ASTM, Philadelphia

McFarlane, C , T Pfleeger, and J Fletcher 1990 Effect, uptake and disposition of nitrobenzene in several terrestrial plants Environ Tox & Chem 9 512-520

Fletcher, J S , J C McFarlane, T Pfleeger, and C Wickliff 1990 Influence of root exposure concentration on the fate of nitrobenzene in soybean Chemosphere 20 513-523

McFarlane, C , and T Pfleeger 1987 Plant exposure chambers for the study of toxic/plant interactions J Environ Qual 16(4) 361-371

McFarlane, C , T Pfleeger, and J Fletcher 1987 Transpiration effect on the uptake and distribution of bromacil, nitrobenzene, and phenol in soybean plants J Environ Qual 16(4) 372-376

McFarlane, J C , C Nolt, C Wickliff, T Pfleeger, R Shimabuku, and M McDowell 1987 The uptake, distribution and metabolism of four organic chemicals by soybean plants and barley roots Environ Tox Chem 6 847-856

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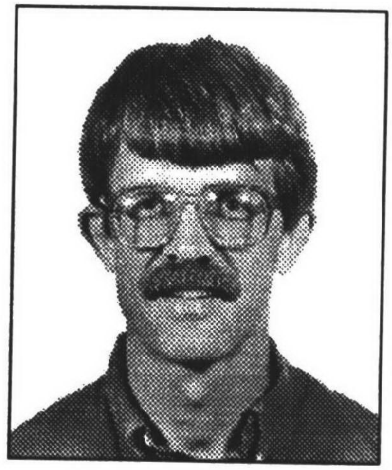

Education:

B.S. (With High Honor), Michigan State University, E. Lansing, MI; Zoology, 1974

M.S., Utah State University, Logan, UT; Biology, 1977

Ph.D., Utah State University, Logan, UT; Biology (Statistics minor), 1978

Previous Positions:

1983-1988: Supervisory Mathematical Statistician, Center for Environmental Health, Centers for Disease Control, Atlanta, GA

1983-1988: Adjunct Asst. and Assoc. Professor, Biology Dept., Emory University, Atlanta, GA

1978-1983: Asst. Professor, Biology Dept., Emory University, Atlanta, GA

Research Interests and Skills:

Effects of elevated CO_2 and climate change on terrestrial ecosystems
Statistical ecology--uncertainty analysis, mixing models, geostatistics

Professional Societies:
Ecological Society of America

Appointments/Honors:

Principal Investigator, Effects of Elevated CO2 on Root Dynamics and Root Function in a Mojave Desert Ecosystem, funded by NSF/DOE/NASA/USDA

Terrestrial Ecology and Global Change Program, 1996-2002

Secretary, Statistical Ecology Section, Ecological Society of America, 1996-2000

U.S. EPA/ORD Scientific and Technical Achievement Award, 1993, 1996, 1998; Honorable Mention, 1994, 1997

U.S. EPA, Special Act or Service Award, 1992, 1997, 1998, 1999, 2000, 2001

U.S. EPA, Superior Work Performance Award, 1991, 1992, 1993

U.S. EPA, Quality Step Increase Award, 1994, 1996, 1997

Secretary of U.S. Dept. of Health and Human Services Recognition Award, 1987

U.S. Centers for Disease Control, Special Act or Service Award, 1988

U.S. Centers for Disease Control, Superior Work Performance Award, 1986, 1987, 1988 Certified Senior Ecologist, Ecological Society of America, 1982

Grants from National Science Foundation (1980-1984) and U.S. Forest Service (1981-1984) for forest ecology research

Trustee, Highlands Biological Foundation, 1980-1988

Reviewer for National Science Foundation, U.S. Dept. of Energy, Intergovernmental Panel on Climate Change

Reviewer for John Wiley Publishing Co., *BioScience, Ecological Applications, Ecological Monographs, Ecology, Environmetrics, Forest Science, Global Biogeochemical Cycles, Journal of Environmental Quality, Journal of Hydrology, Journal of Soil and Water Conservation, Oecologia*, and 20 other journals.

Project Officer for Interagency Agreements with NOAA, DOE, and NASA, and Cooperative Agreements with several universities for global climate change research

Selected Publications (within last 5 years):

Phillips, D L and P L Koch (In press) Incorporating concentration dependence in stable isotope mixing models Oecologia

Olszyk, D M , M G Johnson, D L Phillips, R J Seidler, D T Tingey, and L Watrud 2001 Interactive effects of CO_2 and O_3 on a ponderosa pine plant/litter/soil mesocosm Environmental Pollution (in press)

Phillips, D L 2001 Mixing models in analyses of diet using multiple stable isotopes a critique Oecologia 127 166-170

Phillips, D L and J W Gregg 2001 Uncertainty in source partitioning using stable isotopes Oecologia 127 171-179

Johnson, M G , D T Tingey, D L Phillips, and M J Storm 2001 Advancing fine root research with minirhizotrons Environ Exp Botany 45 263-289

Phillips, D L , M G Johnson, D T Tingey, C Biggart, R S Nowak, and J Newsom 2000 Minirhizotron installation in sandy, rocky soils with minimal soil disturbance Soil Science Soc Am J 64 761-764

Phillips, D L , S L Brown, P E Schroeder, and R A Birdsey 2000 Toward error analysis of large-scale forest carbon budgets Global Ecology and Biogeography 9 305-313

Tingey, D T , D L Phillips, and M G Johnson 2000 Elevated CO_2 and conifer roots Effects on growth, life span and turnover New Phytologist 147 87-103

Johnson, M G , D L Phillips, D T Tingey, and M J Storm 2000 Effects of elevated CO2, N-fertilization and season on survival of ponderosa pine fine roots Can J For Res 30(2) 220-228

Lee, J J , D L Phillips, and V W Benson 1999 Soil erosion and climate change assessing potential impacts and adaptation practices J Soil and Water Cons 54(3) 529-536

Apple, M E , M S Lucash, D L Phillips, D M Olszyk, and D T Tingey 1999 Internal temperature of Douglas-fir buds is altered at elevated temperature Environ Exp Botany 41 25-30

Murtaugh, P A , and D L Phillips 1998 Temporal correlation of classifications in remote sensing J Agr , Biol , and Environ Statistics 3(1) 99-110 Riley, R H , D L Phillips, M J Schuft, and M C Garcia 1997 Resolution and error in measuring land-cover change effects on estimating net carbon release from Mexican terrestrial ecosystems Internatl J Remote Sensing 18(1) 121-137

Phillips, D L , E H Lee, A A Herstrom, W E Hogsett, and D T Tingey 1997 Use of auxiliary data for spatial interpolation of ozone exposure in southeastern forests Environmetrics 8 43-61

Cairns, M A , J K Winjum, D L Phillips, T P Kolchugina, and T S Vinson 1997 Terrestrial carbon dynamics case studies in the former Soviet Union, the conterminous United States, Mexico, and Brazil Mitigation and Adaptation Strategies for Global Change 1 363-383

Phillips, D L , and D G Marks 1996 Spatial uncertainty analysis Propagation of interpolation errors in spatially distributed models Ecological Modelling 91 213-229

Phillips, D L , J J Lee, and R F Dodson 1996 Sensitivity of the U S Corn Belt to climate change and elevated CO_2 I Corn and soybean yields Agricultural Systems 52 481-502

Lee, J J , D L Phillips, and R F Dodson 1996 Sensitivity of the U S Corn Belt to climate change and elevated CO_2 II Soil erosion and organic carbon Agricultural Systems 52 503-521

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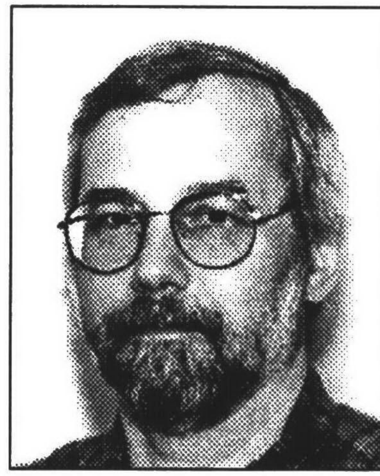

Education:
B.S., The Pennsylvania State University, University Park, PA; Biology, 1975
M.S., The University of Maine, Orono, ME; Zoology, 1978
Ph.D.,The University of Maine, Orono, ME; Zoology, 1982

Previous Positions:
1991-1997: Associate Professor, Louisiana State University, Baton Rouge, LA
1985-1991: Assistant Professor, Louisiana State University, Baton Rouge, LA
1984-1985: CIMAS Postdoctoral Fellow, University of Miami, Miami, FL
1982-1983: National Research Council Research Associate, National Marine Fisheries Service, La Jolla, CA

Research Interests and Skills:
Marine larval ecology
Quantitative marine ecology and modeling
Fisheries oceanography

Professional Societies:
American Association for the Advancement of Science
American Geophysical Union
Estuarine Research Federation
Sigma Xi

Selected Publications:
Power, J.H. and E.B. Moser. 1999. Linear model analysis of net catch data using the negative binomial distribution. Can. J. Fisheries & Aquatic Sci. 56:191-200.
Power, J.H. 1997. Time and tide wait for no animal: Seasonal and regional opportunities for tidal and stream transport or retention. Estuaries 20:312-318. (See also *http://www.lsu.edu/guests/jpower/tidetran.html*)
Power, J.H. 1996. Simulations of the effect of advective-diffusive processes on observations of plankton abundance and population rates. J. Plankton Res. 18:1881-1896.
Power, J.H. 1996. Errors associated with using Archimedes' principle to determine mass and volume of small aquatic organisms. Hydrobiologia 335:141-145.
Power, J.H., and Walsh, P.J. 1992. Metabolic scaling, buoyancy, and growth in larval Atlantic menhaden, *Brevoortia tyrannus*. Marine Biology 112:17-22.
Power, J.H., W.L. Morrison, and J. Zeringue. 1991. Determining the mass, volume, density, and weight in water of small zooplankters. Marine Biology 110:267-271.
Power, J.H., and L.N. May, Jr. 1991. Frontal zones, thermal variability, and yellowfin tuna catch and effort in the Gulf of Mexico. Fishery Bulletin, U.S. 89:429-439.
Wiseman, W.J. Jr., E.M. Swenson, and J.H. Power. 1990. Salinity trends in Louisiana estuaries. Estuaries 13:265-271.

Power, J H 1989 Sink or swim Growth dynamics and zooplankton hydromechanics The Am Naturalist 133 706-721

Power, J H 1986 A model of the drift of northern anchovy (*Engraulis mordax*) larvae in the California Current Fishery Bulletin, U S 84 585-603

Power, J H 1984 A numerical method for simulating plankton transport Ecological Modelling 23 53-66

Power, J H 1984 Advection, diffusion, and drift migrations of larval fish Pages 27-37 in J D McCleave, G P Arnold, J J Dodson, and W H Neill, editors Mechanisms of Migration in Fishes Plenum Press, New York

Power, J H , and J D McCleave 1983 Simulation of the North Atlantic Ocean drift of *Anguilla leptocephali* Fishery Bulletin, U S 81 483-500

Power, J H , and J D McCleave 1980 Riverine movements of hatchery-reared Atlantic salmon (*Salmo salar*) upon return as adults Environmental Biology of Fishes 5 3-13

McCleave, J D , and J H Power 1978 Influence of weak electric and magnetic fields on turning behavior in elvers of the American eel *Anguilla rostrata* Marine Biology 6 29-34

McCleave, J D , J H Power, and S A Rommel, Jr 1978 Use of radio telemetry for studying upriver migration of adult Atlantic salmon (*Salmo salar*) Journal of Fish Biology 12 549-558

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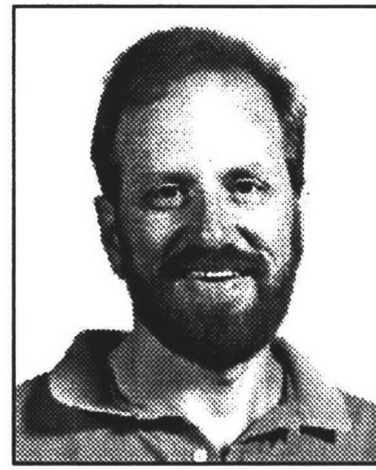

Education:
B.A., Univ. of Pennsylvania, Philadelphia; Biology, 1973
Ph.D., The Johns Hopkins University, Baltimore, MD; Marine Ecology, 1980

Previous Positions:
1988-1994: Ecologist, Office of Environmental Processes and Effects Research, Office of Research and Development, USEPA, Washington, D.C.
1984-1988: Senior Ecologist, Acting Executive Director, or Associate Director, National Acid Precipitation and Assessment Program, Washington, D.C., on assignment from the Brookhaven National Laboratory
1983-1984: Manager, Ocean Discharge Project, National Wildlife Federation, Washington, D.C.
1980-1983: Ecologist, Office of Ecology and Conservation, Office of Policy and Planning, National Oceanic and Atmospheric Administration, Washington, D.C.. on IPA assignment from The Johns Hopkins University.

Research Interests and Skills:
Integrated risk assessments
Ecological responses to stressors at large scales
Monitoring system design
Riparian monitoring

Professional Societies:
Ecological Society of America
American Association for the Advancement of Science

Appointments/Honors:
Chair (Elected), Applied Ecology Section, Ecological Society of America, 1997-1999
Vice-Chair (Elected), Work Group on Effects, Long-Range Transboundary Air Pollution Convention UN Economic Commission for Europe, 1990-1992
Member, United Nations Task Force on Mapping Critical Loads, 1989-1992
USEPA Bronze Medal 1995
Member, Aquatic Nuisance Species Task Force: Working Group, 1992-1994
Co-Chair, US Interagency Arctic Monitoring and Assessment Work Group, 1992-1994
Chair, Riparian and Aquatic Monitoring Work Group, Research and Monitoring Committee for the Implementation of the Pacific Northwest Forest Plan, 1995
Ecological Society of America, Sustainable Biosphere Initiative, Steering Committee 1995-1999

Selected Publications
Barker, J., J. Bollman, and P. Ringold. In Press. Evaluation of metric precision for a Riparian Forest Survey. Environ. Mont. Assess.
Barker, J. R., P. Ringold, and M. Bollman. In Press. Patterns of Tree Dominance in coniferous riparian

forests Forest Ecology and Management
Ringold, P L , M Bollman, J Van Sickle, J Barker, and J Welty 2000 Predictions of stream wood recruitment from riparian forests Effects of data resolution Pages 505-510 in P J Wigington, Jr , and R L Beschta, editors, Riparian Ecology and Management in Multi-Land Use Watersheds, Proc AWRA Specialty Conference, Portland, OR, Aug 28-31, 2000
Ringold, P L , B Mulder, J Alegria, R L Czaplewski, T Tolle and K Burnett 1999 Establishing a regional monitoring strategy The Pacific Northwest Forest Plan Environmental Management 23(2) 179-192
Haeuber, R and P L Ringold 1998 Ecology, the social sciences, and environmental policy Ecological Applications 8(2) 330-331
Ringold, P L , and P M Groffman 1997 Inferential studies of climate change Ecological Applications 7(3) 751-752
Ellis, J H , P L Ringold, et al 1996 Emission reductions and ecological response Management models for acid rain control Socio-Economic Planning Sciences
Strickland, T , G Holdren, P Ringold, D Bernard, K Smythe, and W Fallon 1993 A national critical loads framework for atmospheric deposition effects assessment I Method summary Environ Management 17(3) 329-334
Hunsaker, C , R Graham, P Ringold, G Holdren, and T Strickland 1993 A national critical loads framework for atmospheric deposition effects assessment II Defining regulatory endpoints, indicators, and functional subregions Environ Management 17 (3)335-341
Holdren, G R , T C Strickland, P W Shaffer, P F Ryan, P L Ringold, and R S Turner 1993 Sensitivity of critical loads estimates for surface waters to model selection and regionalization schemes J Environ Quality 22 279-289
Ringold, P 1991 Ecosystem services valuation Nitrogen retention capacity in waterbasins Presentation to Society of Environmental Toxicology and Contamination
Ringold, P L , and J Clark 1980 The Coastal Almanac W H Freeman, San Francisco

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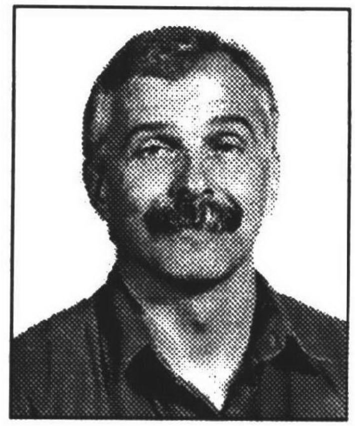

Education:
B.S., Univ. Illinois, Urbana-Champaign; Forest Science (cum laude), 1974
M.S., Univ. California, Berkeley; Forest Biology & Wood Science, 1976
Ph.D., Univ. Washington; Tree & Rhizosphere Physiology, 1983

Previous Positions:
1984-1985: Assistant Research Soil Microbiologist, Plant & Soil Biology, Univ. California, Berkeley
1983-1984: Microbiologist, Centre National de Recherches Forestiéres, Champenoux, France
1979-1983: Research Associate, Forest Resources, University of Washington, Seattle
1978-1979, and 1974-1976: Research Assistant, Forestry & Forest Products, Univ. California, Berkeley
1977: Research Wood Technologist, ITT Rayonier Inc., Shelton, WA

Research Interests and Skills:
Ecological physiology of woody plants and associated soil microorganisms
Carbon, Nitrogen, Molecular Ecology, Rhizosphere Ecology, Stable Isotopes

Professional Societies:
Ecological Society of America
Soil Ecological Society

Appointments/Honors:
Courtesy Faculty, Forest Science, Oregon State University
Sigma Xi, Xi Sigma Pi, Gamma Sigma Delta
Societal Committees: Student Presentation Awards, Ecological Society of America, 1994 & 1995
Journal Editor - Editorial Review Board, Tree Physiology, 1997 and 2001
Consulting Technical Editor, Plant and Soil, 1997 to present
Reviewer of manuscripts for *Annales des Sciences Forestiéres, Arctic and Alpine Research, Biogeochemistry, Canadian Journal of Botany, Ecological Monographs, International Union of Forestry Research Organizations, Forest Science, Journal of Tropical Forest Science, Molecular Ecology, Mycology, Mycorrhiza, Physiologia Plantarum, Plant and Soil, Proceedings of the National Academy of Sciences, The New Phytologist, Tree Physiology, Trees, Water Air* and *Soil Pollution*
Reviewer of proposals for NSF International Science, Ecosystems, and Ecology programs; USDA Forest Biology, Innovative Business Research, Forest/Range/Crop Ecosystems, Soil and Soil Biology, and Plant Responses to the Environment programs; UK Natural Environment Research Council; US National Institute for Global Environmental Change (NIGEC)
Panel Member: USDA Competitive Grants - Forest, Crop & Rangeland Ecosystems, 1992; and Soils & Soil Biology, 1994
Co-Founder and Co-Organizer, First International Symposium, *Dynamics of physiological processes in woody roots*, Ithaca, NY, 1995
Physiology Session Organizer, First International Conference on Mycorrhizae, Berkeley, CA, 1996
International Steering Committee, Second International Symposium, *Dynamics of physiological processes in woody roots*, Nancy, France, 1999
Advisor, CNPq (Brazilian National Science Foundation), Universidade Federal de Santa Catarina Graduate Biotechnology Program, 1990-99

Visiting Instructor, Universidade Federal de Santa Catarina Graduate Biotechnology Program, 1992-99
Taught short courses on molecular ecology of plants and soil microorganisms, and the graduate course *Biodiversity, Complexity and Ecosystem Sustainability* Advised on graduate student research

Visiting Lecturer, Graduate Agronomy Program, 1995, Universidad de la República, Facultad de Agronomia, Montevideo, Uruguay Taught short course *Molecular Ecology and Identification of Soil Fungi*

Fellowships République Française & French Ministry of Foreign Affairs, 1983, French Scientific Mission, 1983, Weyerhaeuser Company, 1978, University Regents, University of California, Berkeley, 1974

Best Scientific Paper, U S EPA, Corvallis, 1989, EPA Scientific and Technological Achievement Awards, 1990, 1992, 1994, 1997 (2)

Selected Publications:

Entry, J A , P T Rygiewicz, L S Watrud and P K Donnelly (In press) Influence of adverse soil conditions on the formation and function of arbuscular mycorrhizae Advances in Environ Res

Hobbie, E A , D M Olszyk, P T Rygiewicz, M G Johnson and D T Tingey (In press) Foliar nitrogen concentrations and natural abundance ^{15}N suggest nitrogen allocation patterns of Douglas-fir and mycorrhizal fungi differ in their response to climate change Tree Physiology

Cordoba, A S , M M de Mendonça., S L Sturmer and P T Rygiewicz (In press) Diversity of arbuscular mycorrhizal fungi along a sand dune stabilization gradient A case study at Joaquina Beach on the Island of Santa Catarina. South Brazil Mycoscience

Dong, S , C F Scagel, L Cheng, L H Fuchigami, and P T Rygiewicz 2001 Soil temperature and plant growth stage influence nitrogen uptake and amino acid content of apple during early spring growth Tree Physiology 21, 541-547

Lin, G , P T Rygiewicz, J R Ehleringer, M G Johnson and D T Tingey 2001 Time-dependent responses of soil CO_2 efflux to elevated atmospheric $[CO_2]$ and temperature treatments in experimental forest mesocosms Plant and Soil 229(2) 259-270

Botton, B , M Chalot, P Dizengremel, F Le Tacon, P Rygiewicz and M Topa, editors 2001 Dynamics of Physiological Processes in Woody Roots Second Symposium Tree Physiology Vol 21, No 2 & 3

Rygiewicz, P T , K J Martin and A R Tuininga 2000 Morphotype community structure of ectomycorrhizas on Douglas-fir (*Pseudotsuga menziesii* Mirb Franco) seedlings grown under elevated atmospheric CO_2 and temperature Oecologia 124(2)299-308

Rygiewicz, P T and E R Ingham 1999 Soil biology and ecology Pages 564-567 in R W Fairbridge and D E Alexander, editors Encyclopedia of Environmental Science, Kluwer Academic Publishers, Dordrecht, The Netherlands

Andersen, C P and P T Rygiewicz 1999 Understanding plant-soil relationships using controlled environment facilities Advances in Space Research 24(3) 309-318

Lin, G , J R Ehleringer, P T Rygiewicz, M G Johnson and D T Tingey 1999 Elevated CO_2 and temperature impacts on different components of soil CO_2 efflux in Douglas-fir terracosms Global Change Biology 5 157-168

Rygiewicz, P T , M G Johnson, L Ganio, D T Tingey and M Storm 1997 Lifetime and temporal occurrence of *Pinus ponderosa* seedling ectomycorrhizae grown under varying atmospheric CO_2 and nitrogen levels Plant and Soil 189 275-287

Rygiewicz, P T , K J Martin and A R Tuininga 1997 Global climate change and diversity of mycorrhizae Pages 91-98 in M T Martins, M I Z Sato, J M Tiedje, L C N Hagler, J D Bereiner and P S Sanchez, editors Progress in Microbial Ecology International Symposium on Microbial Ecology Published by Brazilian Society for Microbiology

Topa, M A , P T Rygiewicz and J R Cumming, editors 1996 Dynamics of Physiological Processes in Woody Roots First symposium Tree Physiology (special double issue), Vol 16, No 11 & 12

Andersen, C P and P T Rygiewicz 1995 Allocation of carbon in mycorrhizal *Pinus ponderosa* seedlings exposed to ozone The New Phytologist 131 471-480

Rygiewicz, P T and C P Andersen 1994 Mycorrhizae alter quality and quantity of carbon allocated belowground Nature 369 58-60

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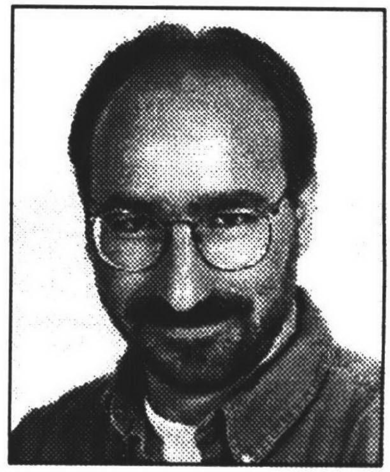

Education:
B.S., University of Santa Cruz, Santa Cruz, CA; Physics, 1985
B.S., University of Santa Cruz,; Mathematics, 1985
M.S., University of Washington, Seattle, WA; Applied Mathematics, 1989
Ph.D., University of Washington, Seattle, WA; Forest Ecosystem Analysis, 1995

Previous Positions:
1996-1997: Assistant Professor, Dept. of Fisheries and Wildlife, Oregon State University, Corvallis, OR
1995-1996: Project Scientist, ManTech Environmental Technologies, Inc., Corvallis, OR

Research Interests and Skills:
Landscape ecology
Simulation modeling
Population viability analysis

Professional Societies:
Ecological Society of America
Society for Conservation Biology

Appointments / Honors:
State of Oregon, Governor's 4(d) Scientific Review Team, 1997
IAI-AMIGO Workshop on Landscape Fragmentation Effects on Faunal Biodiversity in the Americas: Maitencillo, Chile, 1996
Consultant to U.S. Fisheries and Wildlife Department, 1996-1997
Workshop on Patch Dynamics in Terrestrial, Marine and Freshwater Ecosystems, Cornell University, 1991
Undergraduate Thesis Honors, University of California at Santa Cruz, Physics Department

Selected Publications:
Carroll, C., R.F. Noss, N.H. Schumaker, and P.C. Paquet. (In press). Is the return of the wolf, wolverine, and grizzly bear to Oregon and California biologically feasible? In D. Maehr, R. Noss, and J. Larkin, editors. Large Mammal Restoration: Ecological and Sociological Implications. Island Press, Washington, D.C.
Wilhere, G., and N.H. Schumaker. 2001. A spatially realistic population model for informing forest management decisions. Pages 538-544 in D. H. Johnson, and T. A. O'Neil (eds), Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.
Calkin, D., C.A. Montgomery, N. H. Schumaker, S. Polasky, J. A. Arthur, and D. J. Nalle. Modeling the compatibility of biological and economic objectives on a forested landscape. In CD-ROM, Proceedings of the Biennial Conference of the International Institute of Fisheries Economics and Trade, July 10-14, 2000, Corvallis, Oregon.
Schumaker, N.H. 1998. A users guide to the PATCH model. EPA/600/R-98/135, U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR.

Schumaker, N H 1996 Using landscape indices to predict habitat connectivity Ecology 77 1210-1225
Schumaker, N H 1995 Habitat connectivity and spotted owl population dynamics Ph D dissertation, University of Washington, Seattle
Groom, M J , and N H Schumaker 1993 Evaluating landscape change Patterns of worldwide deforestation and local fragmentation Pages 24-44 in P M Kareiva, J G Kingsolver, and R B Huey, editors Biotic Interactions and Global Change Sinauer Assoc , Sunderland, MA
Deutschman, D H , G A Bradshaw, W M Childress, K L Daly, D Gruunbaum, M Pascual, N H Schumaker, and J Wu 1993 Mechanisms of patch formation Pages 184-209 in S A Levin, T M Powell, and J H Steele, editors Patch Dynamics Lecture Notes in Biomathematics 96 Springer-Verlag New York
Lee, R G , R Flamm, M G Turner, C Bledsoe, P Chamdler, C DeFerrari, R Gottfried, R J Naiman, N H Schumaker, and D Wear 1992 Integrating sustainable development and environmental vitality A landscape ecology approach Pages 497-519 in R H Naiman, editor Watershed Management Balancing Sustainability and Environmental Change Springer-Verlag New York

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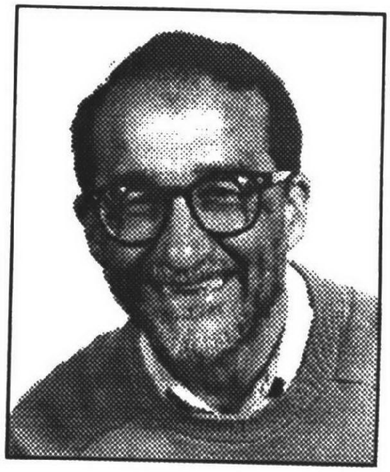

Education:
B.S., California State Univ.; Mechanical Engineering, 1959
M.S., Univ. of Washington; Mechanical Engineering, 1960
Ph.D., Univ. of Illinois; Mechanical Engineering, 1966

Previous Positions:
1966-1969: Research Engineer, Hercules Inc.
1960-1961: Research Engineer, Boeing Company

Professional Societies:
American Society of Mechanical Engineers
American Society of Agronomy
American Geophysical Union

Selected Publications:
Shirazi, M.A., L. Boersma, and C.B. Johnson. 2001. Particle size distributions: comparing texture systems, adding rock, and predicting soil properties. Soil Sci Soc of Am J 65:300-310.
Shirazi, M.A., L. Boersma, P.K. Haggerty and C.B. Johnson. 2001. Spatial extrapolation of soil characteristics using whole soil particle size distributions. J. Environ. Qual. 30:101-111.
Shirazi, M.A., L. Boersma, C.B. Johnson and P.K. Haggerty. 2001. Predicting physical and chemical water properties from relationships with watershed soil characteristics. J. Environ. Qual. 30:112-120.
Shirazi, M.A., P. K. Haggerty, C.W. Hendricks, and M. Reporter. 1998. The role of thermal regime in tundra plant community restoration. Restoration Ecology 6(1):111-117.
Callahan, C.A., M.A. Shirazi, E.F. Neuhauser. 1994. Comparative toxicity of chemicals to earthworms. Environ. Toxicol. and Chem. 13:291-298.
Shirazi, M.A., R.S. Bennett, and R.K. Ringer. 1994. An interpretation of toxicity response of bobwhite quail with response to duration of exposure. Arch. Environ. Contam. Toxicol. 26:417-424.
Shirazi, M.A., M. Robideaue, L. Kapustka, J. Wagner, and M. Reporter. 1994 Cell growth in plant culture: An interpretation of the influence of initial weight on Cadmium and Copper toxicity tests. Arch. Environ. Contam. Toxicol. 27:331-337.
Shirazi, M.A., H.C. Ratsch and B.E. Peniston. 1992. The distribution of relative error of toxicity of herbicides and metals to Arabidopsis. Environ. Toxicol. Chem. 11:237-243.
Shirazi, M.A. and D.A. Dawson. 1991. Developmental malformation of frog embryos: An analysis of teratogenicity of chemical mixtures. Arch. Environ. Contam. Toxicol. 21:177-182.
Shirazi, M.A., and G. Linder. 1991. An analysis of biological response to chemical mixtures. Arch. Environ. Contam. Toxicol. 21:183-189.
Shirazi, M.A., B.J. Erickson, R.J. Hinsdill, and J.A. Wyman. 1990. An analysis of risk from exposure to aldicarb using immune response of nonuniform populations of mice. Arch. Environ. Contam. Toxicol. 19:447-456.
Shirazi, M.A., and Lowrie, L.N. 1990. A probabilistic statement of the structure activity relationship for environmental risk analysis. Arch. Environ. Contam. Toxicol. 19:597-602.
Shirazi, M.A., R.S. Bennett, and L.N. Lowrie. 1988. An approach to environmental risk assessment using avian toxicity tests. Arch. Environ. Contam. Toxicol 16:263-271.

Shirazi, M A , and L N Lowrie 1988 Comparative toxicity based on similar asymptotic endpoints Arch Environ Contam Toxicol 16 273-280
Shirazi, M A , L Boersma and J W Hart 1988 A unifying quantitative analysis of soil texture improvement of precision and extension of scale Soil Sci Soc of Am J 52(1) 181-190
Shirazi, M A , S A Peterson, L Lowrie and J W Hart 1986 Computer-based land classification for management of hazardous wastes Hazardous Waste and Hazardous Materials 3(1) 77-100
Shirazi, M A 1984 Land classification used to select abandoned hazardous waste sites Environ Mgt 8(3) 1-6
Shirazi, M A and L Boersma 1984 A unifying quantitative analysis of soil texture Soil Sci Soc of Am J 48(1) 142-147
Shirazi, M A , B Lighthart, and J Gillett 1984 A method for scaling biological response of soil microcosms Ecological Modeling 23 203-226
Shirazi, M A and W K Seim 1981 Stream system evaluation with emphasis on spawning habitat of salmonids Water Resources Res 17 592-594
Shirazi, M A , and R T Riley 1981 Estimation of molecular diffusivity in isolated animal tissue J of Theoretical Biology 93 1033-1036
Riley, R T , M A Shirazi, and R C Swartz 1981 Transport of Naphalene in the oyster *Ostrea epulis* J of Marine Biology 63(3) 325-330
Shirazi, M A and L R Davis 1976 Analysis of buoyant surface jets Journal of Heat Transfer, Transactions of the ASME 98(3) 367-372
Shirazi, M A and L R Davis 1974 Workbook of thermal plume prediction, vol 2, Surface Discharge Environmental Protection Agency Corvallis Oregon EPA-R2-72-005b NTIS PB 235 841($11 75)
Shirazi, M A , R S McQuivey, and T H Keefer 1974 Heated water jet in a co-flowing turbulent stream Am Soc Of Civil Engineers, Hydraulic Division Journal HY7 919 934
Shirazi, M A 1972 Dry cooling towers for steam electric power plants in arid regions Water Research 6 1309-1319
Shirazi, M A and L R Davis 1972 Workbook of thermal plume prediction, vol 1, Submerged Discharge Environmental Protection Agency Corvallis Oregon EPA-R2-72-005a NTIS PB 228 293($7 50)
Shirazi, M A 1968 The effects of closure ejection of sprint nozzle structural integrity Third International Congress for Rocket Propulsion and Guidance American Institute of Aeronautics 1 31
Shirazi, M A , B T Chao, and B G Jones 1967 On the motion of small particles in a turbulent fluid field Developments in Mechanics, Proceedings of the Tenth Midwestern Mechanics Conference 4 1179

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Education:
B.A., University of New Mexico, Albuquerque, NM; Anthropology, 1966
M.S., University of New Mexico, Albuquerque, NM; Geology, 1970
Ph.D., University of Arizona, Tucson; Geosciences, 1977
Postdoctoral Fellowship, Dept. of Chemistry, University of Maryland, College Park, 1977-1979

Previous Positions:
1987-1990: Hydrologist, U.S. Geological Survey, Denver, CO
1980-1987: Geologist, US Geological Survey, Reston, VA

Research Interests and Skills:
Biogeochemical cycles in coastal ecosystems, and the transport and fate of toxicants by natural products

Professional Societies:
The Geochemical Society
The American Chemical Society
American Geophysical Union
Estuarine Research Federation

Appointments/Honors:
Associate Professor (Courtesy), Oceanic and Atmospheric Science, Oregon State University, Corvallis, OR
Intergovernmental Panel for Climate Change (IPCC), reviewer 1994-1995
Scientific Committee on Problems of the Environment (SCOPE), U. N. Environment Programme (UNEP), Effects of Ultraviolet Radiation on Global Ecosystems, October 1992
Chair and organizer, Symposium on Marine and Estuarine Geochemistry, American Chemical Society, 1984
Chair, Symposium on Geochemistry of Stream Waters, American Chemical Society, 1982
Chair, Symposium on Marine Chemistry, American Chemical Society, 1981

Selected Publications:
Sigleo, A.C., P.J. Neale, and A. Spector. Phytoplankton pigments at the Weddell-Scotia confluence during the 1993 austral spring. 2000. Journal of Plankton Research 22(10):1426-1441.
Hannach, G., and A.C. Sigleo. 1998. Photoinduction of UV- absorbing compounds in six species of marine phytoplankton. Marine Ecology, Progress Series 174:207-222.
Sigleo, A.C. 1996. Biochemical components in suspended particles and colloids: Carbohydrates in the Potomac and Patuxent estuaries. Organic Geochemistry 24:83-93.
Sigleo, A.C., and P.J. Neale, 1995. Phytoplankton pigment profiles at the Weddell-Scotia Confluence during the 1993 austral spring. Antarctic Journal of the U.S. 29(5):147-148.
Sikorski, R.J., A.C. Sigleo, and P.J. Neale, 1995. Spectral measurements of ultraviolet and visible solar irradiance at the Weddell-Scotia Confluence during the 1993 austral spring. Antarctic Journal of the U.S. 29(5):272-274.

Sigleo, A C , and D J Shultz 1993 Amino acid composition of suspended particles, sediment trap material and benthic sediment in the Potomac Estuary, U S A Estuaries 16 405-415

Sigleo, A C , and J C Means 1990 Organic and inorganic composition of estuarine colloids Implications for sorption and transport of pollutants Rev Environmental Contamination and Toxicology 112 123-147

Sigleo, A C , K M Cunningham, M C Goldberg, and B A Kimball 1989 Hydroxyl radical formation in St Kevin Gulch, an iron-rich stream in Colorado U S Geological Survey Toxic Substances Hydrology Program Proceedings of the Technical Mtg , Phoenix, AZ, USGS Water Investigations Report 88-4220 125-129

Sigleo, A C , and A Hattori, editors 1985 Marine and Estuarine Geochemistry, 331 pages Lewis Publishers, Chelsea, MI

Sigleo, A C , and S A Macko 1985 Stable isotope and amino acid composition of estuarine dissolved colloidal material Pages 29-46 in A C Sigleo and A Hattori, editors Marine and Estuarine Geochemistry Lewis Publishers, Chelsea, MI

Helz, G R , R Sugam, and A C Sigleo 1984 Chemical modification of estuarine water by a continuously chlorinating power plant Environmental Science and Technology 18 192-199

Sigleo, A C , P E Hare, and G R Helz 1983 Amino acid composition of estuarine colloidal material Estuarine Coastal and Shelf Science 17 87-96

Sigleo, A C , and G R Helz 1981 Composition of estuarine colloidal material Major and trace elements Geochemical and Cosmochimica Acta 45 2501-2509

Sigleo, A C , G R Helz, and W H Zoller 1980 Organic-rich colloidal material in estuaries and its alteration by chlorination Environmental Science and Technology 14 673-679

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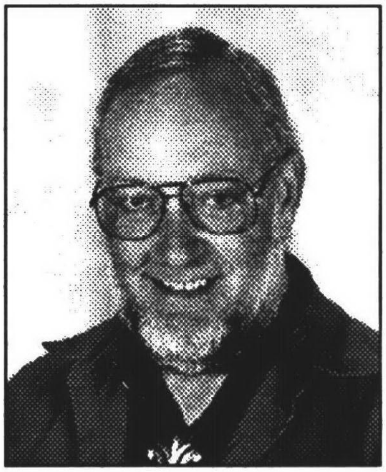

Education:
B.A., Univ. of Michigan, Ann Arbor, MI; Biology, 1965
Ph.D., Rutgers Univ., New Brunswick, NJ; Botany (Plant Ecology), 1970

Previous Positions:
1999-2001, Senior Policy Analyst, Office of Science and Technology Policy, Executive Office of the President, Washington D.C.
1990-1992: Co-Director, Lake Superior Ecosystems Research (LaSER) Center, Michigan Technological Univ., Houghton, MI
1989-1992: Professor (tenured), Forest Ecology, School of Forestry & Wood Products, Michigan Technological Univ., Houghton, MI
1987-1990: Leader, Biosphere Dynamics Project, International Institute for Applied Systems Analysis, Laxenburg, Austria
1976-1987: Staff Ecologist, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN
1970-1976: Assistant Professor of Paleoecology, Department of Geosciences, University of Arizona, Tucson, AZ

Research Interests and Skills:
Global change, Global ecology, Plant ecology (measures, models, and predictions of regional-to-global responses to environmental change)
Paleoecology (pollen analysis and tree rings in reconstruction of past ecological responses to environmental change)

Professional Societies:
American Assn. for the Advancement of Science, 1966-present
American Quaternary Association, 1970-present; Editor, The Quaternary Times, 1979-1985
American Institute for Biological Sciences
Ecological Society of America, 1967-present; Life member; *ESA Bulletin*, Editor-in-Chief, 1992-present
International Association for Vegetation Science (1985-present)
International Tree Ring Society

Appointments/Honors:
Intergovernmental Panel on Climate Change (IPCC): Convening lead author, 1993-1996; Lead author, 1998-2000; member, US delegation, Working Group II Plenary, Third Assessment Report, 2001.
Netherlands National Institute for Public Health and Environmental Protection, Advisory Panel on IMAGE Model Development, 1993-1999.
United Nations Environmental Program, Ad Hoc Scientific and Technical Planning Group for a Global Terrestrial Observing System (GTOS), and Joint Panel for a GTOS/GCOS, 1993-present
Professor (courtesy), Forest Science, College of Forestry, Oregon State University, Corvallis
Professor (courtesy), Geography, University of Oregon, Eugene

Reviewed for *American J of Botany, American Naturalist, Bioscience, Climate Research, Climatic Change, Ecology-Monographs, Ecological Modeling, Global Biogeochemical Cycles, J of Vegetation Science, Nature, Palynology, Proceedings National Academy of Sciences, Quaternary Research, Science, Vegetatio*, and others

Selected Publications (total, 77):

Hostetler, S W , P J Bartlein, P U Clark, E E Small and A M Solomon 2000 Simulated influences of Lake Agassiz on the climate of central North America 11,000 years ago Nature 405 334-337

Bugmann, H K M , and A M Solomon 2000 Explaining forest composition and biomass across multiple biogeographical regions Ecological Applications 10(1) 95-114

Kirilenko, A P , and A M Solomon 1998 Modeling dynamic vegetation response to rapid climate change using bioclimatic classifications Climatic Change 38 15-49

Solomon, A M , and A P Kirilenko 1997 Climate change and terrestrial biomass What if trees do not migrate? Global Ecology and Biogeography Letters 6 139-148

Solomon, A M 1997 Natural migration rates of trees Global terrestrial carbon cycle implications Pages 455-468 in B Huntley, W P Cramer, A V Morgan, H C Prentice and J R M Allen, editors Past and future rapid environmental changes The spatial and evolutionary responses of terrestrial biota Springer-Verlag, New York

Solomon, A M , and R Leemans 1997 Boreal forest carbon stocks and wood supply past, present and future responses to changing climate, agriculture and species availability J Agr Forestry Meteor 86 137-151

Solomon, A M , N H Ravindranath, R Stewart, M Weber, and S Nilsson 1996 Wood production under changing climate and land use Chapter 15 in Second Assessment Report, IPCC Working Group II, Cambridge U Press, Cambridge, UK

Bugmann, H K M , and A M Solomon 1995 The use of a European forest model in North America A study of ecosystem response to climate gradients J Biogeography 22 477-484

Solomon, A M , and H H Shugart, Jr , editors 1993 Vegetation Dynamics and Global Change 338 pages Chapman and Hall, New York

Solomon, A M 1996 Potential responses of global forest growing stocks to changing climate, land use and wood consumption Commonw For Rev 75 65-75

Dixon, R K , S Brown, R A Houghton, A M Solomon, M C Trexler and J Wisniewski 1994 Carbon pools and flux of global forest ecosystems Science 263 185-190

Solomon, A M , I C Prentice, R Leemans and W P Cramer 1993 The interaction of climate and land use in future terrestrial carbon storage and release Water, Air, and Soil Pollution 70 595-614

Solomon, A M and D C West 1993 Evaluation of stand growth models for predicting afforestation success during climatic warming at the northern limit of forests p 167-188 IN R Wheelon, ed Forest Development in Cold Regions Proceedings, NATO Advanced Research Workshop Plenum Publ Corp , NY, NY

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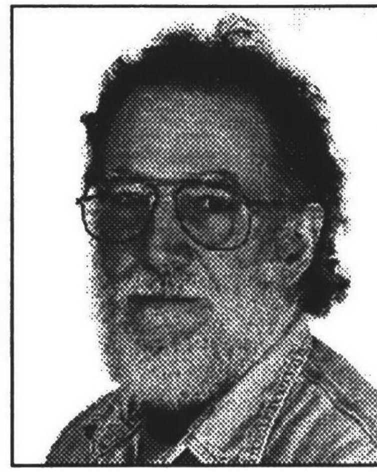

Education:
B.A., Western State College of Colorado; Biology, 1965
M.A., Western State College of Colorado; Science, Botany, 1967
Post-graduate studies: Oregon State University, Dept. of Botany and Plant Pathology, 1967-1970.

Previous Positions:
1970-1980 Aquatic Biologist, U.S. EPA, Corvallis, OR.
1980-1995 Research Aquatic Biologist, Marine Division, U.S. EPA, ERL-Narragansett, Newport, OR

Research Interests and Skills:
Environmental factors affecting distribution of *Zostera* (eelgrass) species in Pacific Northwest estuaries; Ecology and pollutant impacts on marine clam *Macoma nasuta*
Effects of chlorinated organic pollutants on estuarine species

Professional Societies:
American Association for the Advancement of Science
Estuarine Research Federation
Pacific Estuarine Research Society
Rocky Mountain Biological Laboratory

Appointments/Honors:
U.S. Environmental Protection Agency Science Achievement Award in Biology/Ecology (Joint EPA-American Fisheries Society Award), 1995
U.S. Environmental Protection Agency Special Achievement Award, 1992
Nominated for EPA Gold Medal for Exceptional Service, as member of Algal Assay Team, National Eutrophication Research Program, 1974

Selected Publications:
Young, D.R., D.T. Specht and R.J. Ozretich. 2001. Early Warning Marine Water Supply Protection Strategy: The Threat of Oil Spill (Petroleum Hydrocarbon) Contamination. Platform co-presentation, Pacific Estuarine Research Society Meeting, 17-19 May, Tacoma, WA.
Specht, D.T., D.R. Young, and P.J. Clinton. 2000. Near infrared aerial photo-detection of *Zostera japonica* communities in Pacific Northwest estuarine intertidal habitats. Pages 161-167, Vol. 2, in Proceedings Sixth International Conference on Remote Sensing for the Marine and Coastal Environments, Charleston, South Carolina, May 2000, Veridian ERIM International, Ann Arbor.
Clinton, P.J., D.R. Young, B.D. Robbins, and D.T. Specht. 2000. Issues in digital image processing of aerial photography for mapping submersed aquatic vegetation. Pages 292-298, Vol. 2, in Proceedings Sixth International Conference on Remote Sensing for the Marine and Coastal Environments, Charleston, South Carolina, May 2000, Veridian ERIM International, Ann Arbor.
Young, D.R., S.P. Cline, D.T. Specht, P.J. Clinton, B.D. Robbins, and J.O. Lamberson. 2000. Mapping spatial/temporal distributions of green macroalgae in a Pacific Northwest coastal estuary via small format color infrared aerial photography. Pages 285-286, Vol. 2, in Proceedings Sixth International

Conference on Remote Sensing for the Marine and Coastal Environments, Charleston, South Carolina, May 2000, Veridian ERIM International, Ann Arbor

Young, D R , D T Specht, P J Clinton, and H Lee II 1998 Use of Color Infrared Aerial Photography to Map Distributions of Eelgrass and Green Macroalgae in a Non-urbanized Estuary of the Pacific Northwest, U S A Vol II, pages 37-45 in Proceedings of the Fifth International Conference on Remote Sensing for Marine and Coastal Environments, October 1998, San Diego, USA ERIM International, Ann Arbor

Specht, D T 1997 Risk Evaluation Through Estuarine Modeling Pages 68-70 in K Patten, editor Proceedings of the Second International Spartina Conference, Olympia, WA , Washington State University - Cooperative Extension, Long Beach, WA

Boese, B L , H Lee II, D T Specht, J Pelletier, and R C Randall 1996 Evaluation of PCB and Hexachlorobenzene biota-sediment accumulation factors based on ingested sediment in a deposit-feeding clam Environ Toxicol Chem 15(9) 1584-1589

Winsor, M , B L Boese, H Lee II, R C Randall, and D T Specht 1990 Determination of the ventilation rates of interstitial and overlying water by the clam *Macoma nasuta* Environ Toxicol Chem 9 209-213

Specht, D T , and H Lee II 1989 Direct measurement technique for determining ventilation rate in the deposit feeding clam *Macoma nasuta* (Bivalvia, Tellinaceae) Marine Biology, 101(2) 211-218

Callaway, R J , D T Specht, and G R Ditsworth 1988 Manganese and suspended matter in the Yaquina Estuary, Oregon Estuaries 11(4) 217-225

Callaway, R J and D T Specht 1982 Dissolved Silicon in the Yaquina Estuary, Oregon Estuarine and Coast Shelf Science 15 561-567

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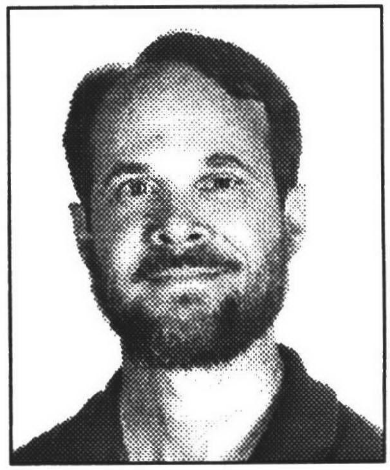

Education:
B.A., University of California, Santa Cruz, 1979.
M.A., Biological Sciences, Univ. of California, Santa Barbara, 1982
Ph.D., Biological Sciences, Univ. of California, Santa Barbara, 1986

Previous Positions:
1989-1997: Project Scientist, Long-Term Monitoring and Temporally Integrated Monitoring of Ecosystems Projects, ERL, Corvallis, OR
1985-1989: Director of Research and Methods Development, New York City Department of Environmental Protection: Limnological Research and Methods Development
1988-1989: Adjunct Professor, Biology Department, Fordham University: Graduate Limnology.
1985: Post-doctoral Research Biologist, U.C. Santa Barbara: Sierra Nevada Paleolimnological Research

Research Interests and Skills:
Effects of human disturbances on aquatic ecosystems
Air pollution effects in forested watersheds

Professional Societies:
American Association for the Advancement of Science
American Geophysical Union
American Society of Limnology and Oceanography
Ecological Society of America

Appointments/Honors:
U.S. representative to the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes, and the International Cooperative Programme on Integrated Monitoring on Air Pollution Effects.
Regular peer reviewer for: Water Resources Research; Ambio; Water, Air and Soil Pollution; Environmental Science and Technology; Biogeochemistry.

Selected Publications:

Stoddard, J. L., T. S. Traaen, B. L. Skjelkvåle, and M. Johannessen. (In press). Assessment of nitrogen leaching at UN/ECE ICP-Waters sites. Water Air Soil Pollut.

McCormick, F. H., R. M. Hughes, P. R. Kaufmann, A. T. Herlihy, J. L. Stoddard, W. Davis, and D. V. Peck. (In press).. Development of an index of biotic integrity for the Mid-Atlantic Highlands region. Trans. Amer. Fish. Soc. .

Sickman, J. O., A. Leyedecker, C. C. Y. Chang, C. Kendall, J. Schimel, and J. L. Stoddard. (In press). Seasonal export of N from high-elevation catchments of the Sierra Nevada, California. Water Resources Res.

Sickman, J. O., J. M. Melack, and J. L. Stoddard. (In press). Regional analysis of inorganic-nitrogen yield and retention in high-elevation ecosystems of the Sierra Nevada and Rocky Mountains. Biogeochemistry.

Skjelkvåle, B L , J L Stoddard, and T Andersen (In press) Trends in surface water acidification in Europe and North America (1989-1998) Water Air Soil Pollut

Driscoll, C T , G B Lawrence, A J Bulger, T J Butler, C S Cronan, C Eagar, K F Lambert, G E Likens, J L Stoddard, and K E Weathers 2001 Acidic deposition in the northeastern U S Sources and inputs, ecosystem effects, and management strategies BioScience 51 180-198

Stoddard, J L , D S Jeffries, A Lukewille, M Forsius, J Mannio, and A Wilander 2000 Environmental chemistry Is acidification still an ecological threat? Reply Nature 407 857-858

Hughes, R M , J L Stoddard, and S G Paulsen 2000 A national, multiasseblage, probability survey of ecological integrity Hydrobiologia 422/423 429-443

Stoddard, J L , D S Jeffries, A Lukewille, T A Clair, P J Dillon, C T Driscoll, M Forsius, M Johannessen, J S Kahl, J H Kellogg, A Kemp, J Mannio, D Monteith, P S Murdoch, S Patrick, A Rebsdorf, B L Skjelkvåle, M Stainton, T Traaen, H van Dam, K E Webster, J Wieting, and A Wilander 1999 Regional trends in aquatic recovery from acidification in North America and Europe Nature 401 575-578

Lawrence, G B , M B David, G M Lovett, P S Murdoch, D A Burns, J L Stoddard, B P Baldigo, J H Porter, and A W Thompson 1999 Soil calcium status and the response of stream chemistry to changing acidic deposition rates Ecological Applic 9 1059-1072

Herlihy, A T , J L Stoddard, and C B Johnson 1998 The relationship between stream chemistry and watershed land use data in the mid-Atlantic region, U S Water Air Soil Pollut 105 377-386

Stoddard, J L , C T Driscoll, J S Kahl, and J Kellogg 1998 A regional analysis of lake acidification trends for the northeastern U S , 1982-1994 Environ Mont Assess 51 399-413

Stoddard, J L , C T Driscoll, S Kahl, and J Kellogg 1998 Can site-specific trends be extrapolated to a region? An acidification example for the Northeast Ecological Applic 8 288-299

Stoddard, J L , A D Newell, N S Urquhart, and D Kugler 1996 The TIME project design II Detection of regional acidification trends Water Resources Res 32 2529-2538

Young, T C , and J L Stoddard 1996 The TIME project design I Classification of Northeast lakes using a combination of geographic, hydrogeochemical, and multivariate techniques Water Resources Res 32 2517-2528

Stoddard, J L 1995 Episodic acidification during snowmelt of high elevation lakes in the Sierra Nevada Mountains of California Water Air Soil Pollut 85 353-358 Stoddard, J L , and T S Traaen 1995 The stages of nitrogen saturation Classification of catchments included in "ICP on waters" Pages 69-76 in M Hornung, M A Sutton, and R B Wilson, editors Mapping and modelling of critical loads for nitrogen - a workshop report U K Department of the Environment, Grange-over-Sands, Cumbria, U K

Stoddard, J L 1994 Long-term changes in watershed retention of nitrogen its causes and aquatic consequences Pages 223-284 *in* L A Baker, editor Environmental Chemistry of Lakes and Reservoirs American Chemical Society, Washington, D C

Stoddard, J L , and J H Kellogg 1993 Trends and patterns in lake acidification in the state of Vermont evidence from the Long-Term Monitoring project Water Air Soil Pollut 67 301-317

Murdoch, P S , and J L Stoddard 1993 Chemical characteristics and temporal trends in eight streams of the Catskill Mountains, New York Water Air and Soil Pollution 67 367-395

Murdoch, P S , and J L Stoddard 1992 The role of nitrate in the acidification of streams in the Catskill Mountain of New York Water Resources Res 28 2707-2720

Stoddard, J L , and P S Murdoch 1991 Catskill Mountains Pages 237-271 *in* D F Charles, editor Acidic Deposition and Aquatic Ecosystems Regional Case Studies Springer-Verlag, New York

Stoddard, J L 1991 Trends in Catskill stream water quality evidence from historical data Water Resources Res 27 2855-2864

Melack, J M , and J L Stoddard 1991 Sierra Nevada Pages 503-530 in D F Charles, editor Acidic Deposition and Aquatic Ecosystems Regional Case Studies Springer-Verlag, New York, NY

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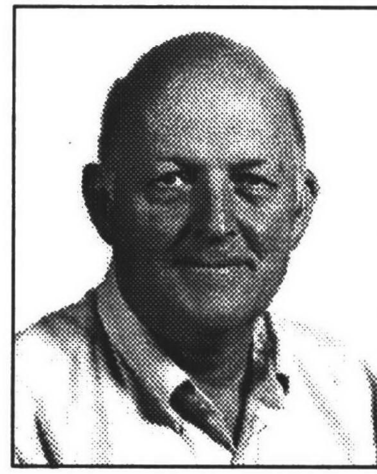

Education:
B.A., Univ. of Utah, Salt Lake City; Biology Education, 1966
M.A., Univ. of Utah, Salt Lake City; Botany (minor Air Pollution Science), 1968
Ph.D., North Carolina State Univ., Raleigh; Plant Physiology (minor Cell Biology), 1972

Previous Positions:
1991-1999: Plant and Rhizosphere Ecology Team Leader, USEPA, ERL, Corvallis, OR
1984-1990: Ozone Team Leader, USEPA, ERL, Corvallis, OR
1973-1983: Plant Physiologist, USEPA, ERL, Corvallis, OR
1969-1973: Plant Physiologist, USEPA, ERC, RTP, NC
1968-1969 Botanist, DHEW, Air Pollution Control Office, Cincinnati, OH

Research Interest and Skills:
Effects of environmental factors on plant physiological processes and carbon allocation.
In vivo monitoring of plant root processes and root dynamics.
Using models to determine the effects of anthropogenic stressors on terrestrial ecosystems.

Professional Societies:
American Society of Plant Physiologists
Societas Physiologiae Plantarum Scandanavica
Phi Sigma
Phi Kappa Phi
Sigma Xi
Listed in American Men and Women of Science
Listed in Who's Who in Technology Today

Appointments/Honors:
Associate Editor for Atmospheric Environment, 1978-1995
Editorial Board, Environmental and Experimental Botany, 1990-present
Editorial Board, Tree Physiology, 1994-present
Editorial Board, Plant Physiology, 1989-1992
Professor of Plant Physiology (courtesy) and member interdepartmental Plant Physiology faculty, Oregon State University, 1973-present
Member, DOE Advisory Committee for Aspen FACE Site (Rhinelander, WI), 1996-present

Selected Publications:
Tingey, D.T., J. Laurence, J.A. Weber, J. Greene, W.E. Hogsett, S. Brown and E.H. Lee. (In press). Elevated CO_2 and temperature alter the response of *Pinus ponderosa* to ozone: A simulation analysis. Ecological Applications

Lin, G, P.T. Rygiewicz, J.R. Ehleringer, M.G. Johnson and D.T. Tingey. 2001. Time-dependent responses of soil CO_2 efflux components to elevated atmospheric [CO_2] and temperature treatments in experimental forest mesocosms. Plant and Soil 229:259-270.

Johnson, M J , D T Tingey, D L Phillips and M J Storm 2001 Advancing fine root research with minirhizotrons Environmental and Experimental Botany 45 263-289

Tingey, D T , R S Waschmann, D L Phillips, and D M Olszyk 2000 The carbon dioxide leakage from chambers measured using sulfur hexafluoride Environ and Exp Bot 43 101-110

Lewis, J D , D Olszyk, and D T Tingey 1999 Seasonal patterns of photosynthetic light response in Douglas-fir seedlings subjected to elevated atmospheric CO_2 and temperature Tree Physiology 19 243-252

Tingey, D T , D L Phillips, M G Johnson, M J Storm, and J T Ball 1997 Effects of elevated CO_2 and N-fertilization on fine root dynamics and fungal growth in seedling *Pinus ponderosa* Environ Exp Botany 37 73-83

Tingey, D T , M G Johnson, D L Phillips, D W Johnson, and J T Ball 1996 Effects of elevated CO_2 and nitrogen on the synchrony of shoot and root growth in ponderosa pine Tree Physiology 16 905-914

Tingey, D T , B D McVeety, R Waschmann, M G Johnson, D L Phillips, P T Rygiewicz, and D M Olszyk 1996 A versatile sun-lit controlled-environment facility for studying plant and soil processes J Environmental Quality 25 615-625

Tingey, D T , M G Johnson, D L Phillips, and M J Storm 1996 Effects of elevated CO_2 and nitrogen on ponderosa pine fine roots and associated fungal components Journal Biogeography 22 281-287

Tingey, D T , W E Hogsett, K D Rodecap, E H Lee, and T J Moser 1994 The impact of O_3 on leaf construction cost and carbon isotope discrimination Essener Ökologische Schriften 4 195-206

Tingey, D T , D M Olszyk, A H Herstrom, and E H Lee 1994 Effects of ozone on crops Pages 175-206 in D J McKee, editor Tropospheric Ozone Human Health and Agricultural Impacts Lewis Publishers, Ann Arbor

Tingey, D T and C P Andersen 1991 The physiological basis of differential plant sensitivity to changes in atmospheric quality Pages 209-235 in G E Taylor Jr , L F Pitelka and M T Clegg, editors Ecological Genetics and Air Pollution Springer-Verlag, Berlin

Tingey, D T , W E Hogsett, E H Lee, A A Herstrom, and S H Azevedo 1991 An evaluation of various alternative ambient ozone standards based on crop yield loss data Pages 272-288 in R L Berglund, D R Lawson and D J McKee, editors Tropospheric Ozone and the Environment Air & Waste Management Association, Pittsburgh

Tingey, D T , D P Turner, and J A Weber 1991 Factors controlling the emissions of monoterpenes and other volatile organics Pages 93-119 in T D Sharkey, E A Holland and H A Mooney, editors Trace Gas Emissions by Plants Academic Press, San Diego

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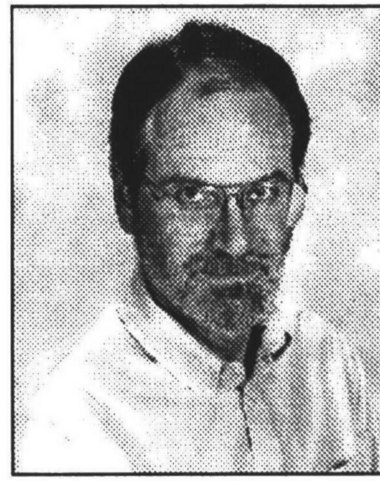

Education:
B.S., Michigan State University, Mathematics, 1969
M.S., Michigan State University, Mathematics, 1972
Ph.D., Michigan State University, Systems Science/ Electrical Engineering, 1975
M.S., Oregon State University, Statistics, 1991

Previous Positions:
1992-1998: Environmental statistician, Dynamac Inc. and ManTech Environmental Technology, NHEERL, WED, Corvallis, OR
1990-1991: Research Assistant, Global Climate Research Group, USEPA Corvallis, OR
1988-Present: Statistical and modeling consultant
1984-1988: Assistant Professor, Dept. Biological Sciences, University of Zimbabwe
1983-1984: Assistant Professor, Dept. Mathematics, Oregon State University, 1983-84
1982-1983 and 1990: Research Associate, School of Oceanography, Oregon State University
1978-1981: Assistant Professor, Dept. Electrical and Computer Engineering, Oregon State University
1975-1977: Operations Research Analyst, USEPA, Corvallis ERL
1970-1975 Graduate Assistant, Departments of Mathematics and of Electrical Engineering and Systems Science, Michigan State University

Research Interests and Skills:
Environmental Statistics
Stream ecosystem modeling

Professional Societies:
Member, American Statistical Association (ASA).

Appointments/Honors
Courtesy faculty, Dept. of Statistics, Oregon State Univ.

Selected Publications:
Van Sickle, J. and R.M. Hughes. 2000. Classification strengths of ecoregions, catchments, and geographic clusters for aquatic vertebrates in Oregon. J. N. Am. Benthological Soc.19(3):370-384.
Van Sickle, J. 2000. Modeling variable-width riparian buffers, with an application to woody debris recruitment. Pages 107-112, in P.J. Wigington, Jr., and R.L. Beschta, editors, Riparian Ecology and Management in Multi-Land Use Watersheds, Proc. AWRA Specialty Conference, Portland, OR, Aug. 28-31, 2000.
Church, M. R. and J. Van Sickle. 1999. Potential relative future effects of sulfur and nitrogen deposition on lake chemistry in the Adirondack Mountains, United States. Water Resource. Res. 35:2199-2211.
Van Sickle, J. 1997. Using mean similarity dendrograms to evaluate classifications. J. Agricultural, Biological, Environmental Statistics 2:370-388.
Van Sickle, J., P.J. Wigington, Jr., and M.R. Church. 1997. Estimation of episodic acidification based on monthly or annual sampling. J. Am. Water Resources Assn. 33:1-8.

Van Sickle, J , J P Baker, H A Simonin, B P Baldigo, W A Kretser, W E Sharpe 1996 Episodic acidification of small streams in the Northeast United States III Effects on fish mortality during bioassays Ecological Applications 6 408-421

Baker, J P , J Van Sickle, C J Gagen, D R DeWalle, W E Sharpe, R F Carline, B P Baldigo, P S Murdoch, D W Bath, W A Kretser, H A Simonin, and P J Wigington, Jr 1996 Episodic acidification of small streams in the Northeast United States IV Effects on fish populations Ecological Applications 6 422-437

Van Sickle, J 1990 Dynamics of African ungulate populations with fluctuating, density-independent calf survival Theor Pop Biol 37 424-437

Van Sickle, J , and S V Gregory 1990 Modeling inputs of large woody debris to streams from falling trees Can J For Res 20 1593-1601

Feresu, S B and J Van Sickle 1990 A study of coliform bacteria levels in a sewage contaminated river system in Zimbabwe J Appl Bacteriol 68 397-403

Van Sickle, J , and R J Phelps 1988 Age distributions and reproductive status of declining and stationary populations of *Glossina pallipides* Austen (*Diptera Glossinidae*) in Zimbabwe Bull Ent Res 78 51-61

Van Sickle, J , C A M Attwell, and G C Craig 1987 Estimating population growth rate from an age distribution of natural deaths J Wildl Manage 51 941-948

Van Sickle, J and R L Beschta 1983 Supply-based models of suspended sediment transport in streams Water Resource Res 19 768-778

Van Sickle, J , W W Weimer, and D P Larsen 1983 Mixing rates in Shagawa Lake, Minnesota, sediments as determined from ^{106}Ru profiles Geochim et Cosmochim Acta 47 2189-2197

Van Sickle, J 1982 Stochastic predictions of sediment yields from small coastal watersheds in Oregon, USA J Hydrol 56 309-323

Van Sickle, J 1981 Long-term distributions of annual sediment yields from small watersheds Water Resource Res 17 659-663

Van Sickle, J 1977 Mortality rates from size distributions the application of a conservation law Oecologia 27 311-318

Lidia S. Watrud
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Education:
B.S., City College of New York, NY; Biology, 1963
M.S., Michigan State University, East Lansing; Mycology/ Genetics, 1965
Ph.D., Michigan State University, East Lansing; Mycology/ Genetics, 1972

Previous Positions:
1986-1990: Manager, Commercial Development of New Technologies, Plant Sciences Dept., Monsanto Co., St. Louis, MO
1984-1986: Manager, Environmental Microbiology and Molecular Biology, Monsanto Co., St. Louis, MO
1982-1984: Senior Research Group Leader, Crop Protection Dept., Monsanto Co., St. Louis, MO
1977-1982: Senior Research Specialist and Group Leader, Cell Biology Group and Crop Protection Dept., Monsanto Co., St. Louis, MO
1973-1975: Post-Doctoral Fellow, Dept. of Agronomy, and Visiting Assistant Professor, Dept. of Microbiology, University of Illinois, Urbana

Research Interests and Skills:
Development and use of molecular ecology methods to study efforts of biotic and abiotic stressors on plant/microbe interactions in the rhizosphere and on plant community composition, health and sustainability

Professional Societies:
Sigma Xi Research Honorary
American Association for the Advancement of Science
American Society for Microbiology
Ecological Society of America

Appointments/Honors:
Member, Institutional Biosafety Committee, Oregon State University, 1995-present
Member, Editorial Board, Environmental Toxicology and Chemistry, 2000-present
Member, Editorial Board, Journal of Molecular Ecology, 1992-1997
Adjunct Professor of Botany and Member of Graduate Faculty, Oregon State University, 1992-present
Advisor, USEPA Research Associateship Program, National Research Council, 1993-present
Member, USEPA Workgroups for Proposed/Final Rules on Microbial Pesticides and Pesticidal Plants, 1993-1994
Member, Research Subcommittee on Biotechnology for the 21st Century, National Science and Technology Council, 1994-95
Reviewer, USDA Competitive Grants Program for Risk Assessment of Biotechnology Products, 1993-94
Reviewer, NSF research proposals, 1987-90, 1997

Selected Publications:

Winton, L M , J K Stone, L S Watrud, and E M Hansen (In press) Simultaneous one-tube quantification of host and pathogen DNA using Taq-man real-time PCR Phytopathology

Donegan, K K , L S Watrud, R J Seidler, S P Maggard, T Shiroyama, L A Porteous, and G Di Giovanni 2001 Soil and litter organisms in Pacific northwest forests under different management practices Appl Soil Ecol 535 1-17

Olszyk, D M , D T Tingey, L Watrud, R Seidler and C Andersen 2000 Interactive effects of O_3 and CO_2 implications for terrestrial ecosystems Pages 97-136 in S N Singh, editor Trace Gas Emissions and Plants, Klower Academic Publishers, Netherlands

Watrud, L S , 2000 Genetically Engineered Plants in the Environment–Applications and Issues, Pages 59-79 in N S Subbarao and Y R Dommergues (eds), Microbial Interactions in Agriculture and Forestry, Vol 2 Oxford and IBH Publishing Co, New Delhi

Di Giovanni, G D , L S Watrud, R J Seidler, and F Widmer 1999 Comparison of parental and transgenic alfalfa rhizosphere communities using Biolog GN metabolic fingerprinting and enterobacterial repetitive intergeneric consensus sequence-PCR (ERIC-PCR) Microbial Ecol 37 129-139

Widmer, F , R J Seidler, P M Gillevet, L S Watrud, and G D Di Giovanni 1998 A highly selective PCR protocol for detecting 16S rRNA genes of the genus *Pseudomonas* (sensu stricto) in environmental samples Appl Environ Microbiol 64(7) 2545-2553.

Entry, J A , L S Watrud, and M Reeves 1998 Accumulation of ^{137}Cs and ^{90}Cs by three grass species inoculated with mycorrhizal fungi Environ Pollution 100 1-9

Porteous, L A , R J Seidler, and L S Watrud 1997 An improved method for purifying DNA from soil for polymerase chain reaction amplification and molecular ecology applications Molec Ecol 6 787-791

Widmer, F , R J Seidler, and L S Watrud 1996 Sensitive detection of transgenic plant marker gene persistence in soil microcosms Molec Ecol 5 603-613

Watrud, L S , and R J Seidler 1996 Ecological effects of plant, microbial and chemical introductions to terrestrial systems Pages 313-340 in P M Huang, editor Soil Chemistry and Ecosystem Health Special Publication No 52, Soil Science Society of America, SSSA, ASA, Madison, WI

Kim, Y , L S Watrud,, and A Matin, 1995 A carbon starvation survival gene of *Pseudomonas putida* is regulated by &^{54} J Bacteriol 177(7) 1850-1859

Pfender, W F , S P Maggard, and L S Watrud 1995 Soil microbial activity and plant/microbe symbioses as indicators for ecological effects of bioremediation technology Pages 269-279 in Publication #1001 Univ of Maryland Biotechnology Institute #TP9501

Obukowicz, M G , F J Perlak, and L S Watrud 1993 Combating plant insect pests with plant-colonizing microorganisms containing the toxin gene of *B thuringiensis* as a chromosomal insertion U S Patent No 5,229, 112 Issued July 20, 1993 Assignee Monsanto Co , St Louis

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Western Ecology Division, NHEERL
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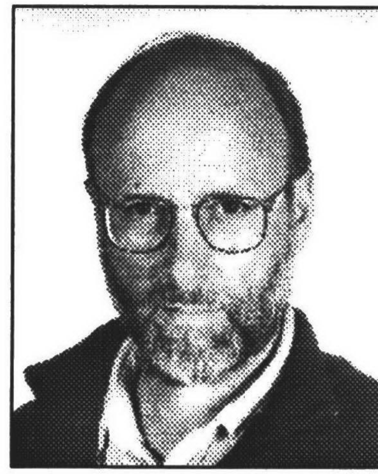


Education:

B.A., University of Wisconsin, Madison, Computer Science (with distinction), 1969

M.A., Department of Geography, Boston University, Boston, MA, 1984

Previous Positions:

1993 - 1998: Faculty Research Assistant, Department of Geosciences, Oregon State University, Corvallis.

1988 - 1992: Research Scientist, ManTech Environmental Technology, Inc., Corvallis, OR.

1985 - 1988: Associate Director and Senior Research Associate, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, MA.

1975 - 1985: Research Associate, Lead Programmer, Senior Programmer, and Applications Programmer, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, MA.

1982 - 1988: Lecturer, Department of Landscape Architecture, Graduate School of Design, Harvard University, Cambridge, MA.

1972 - 1975: Scientific Programmer, Department of Earth and Planetary Science, Massachusetts Institute of Technology, Cambridge, MA.

Professional Societies:

Association of American Geographers
Society for Conservation Biology

Appointments/Honors:

Andrew McNally Award for best paper on cartography published in 1992 by the American Congress on Surveying and Mapping (shared with A. J. Kimerling and W. S. Overton).

Jury committee for awards by the Applied Geography Speciality Group, Association of American Geographers, 1992-1993.

Presidential Citation for Meritorious Service, American Society for Photogrammetry and Remote Sensing, 1991.

Selected Publications:

White, D., and J.C. Sifneos. (Accepted). Regression tree cartography. J. Computational and Graphical Statistics.

Santelmann, M, K. Freemark, D. White, J. Nassauer, M. Clark, B. Danielson, J. Eilers, R. Cruse, S. Galatowitsch, S. Polasky, and J. Wu. 2001. Applying ecological principles to land-use decision-making in agricultural watersheds. Pages 226-252 in V.H. Dale and R. Haeuber, editors. Ecological Principles in Land Use Planning. Springer-Verlag, New York.

White D. 2000. Global grids from recursive diamond subdivisions of the surface of an octahedron or icosahedron. Environ. Mont. Assess. 64(1):93-103.

Hulse D , J E Eilers, K E Freemark, D White, and C Hummon 2000 Planning alternative future landscapes in Oregon evaluating effects on water quality and biodiversity Landscape Journal 19(2) 1-19

Polasky S , J D Camm, A R Solow, B Csuti, D White, and R Ding 2000 Choosing reserve networks with incomplete species information Biological Conservation 94(1) 1-10

White, D , E M Preston, K E Freemark, and A R Kiester 1999 A hierarchical framework for conserving biodiversity Pages 127-153 in J M Klopatek and R H Gardner, editors, Landscape Ecological Analysis Issues and Applications Springer-Verlag, New York

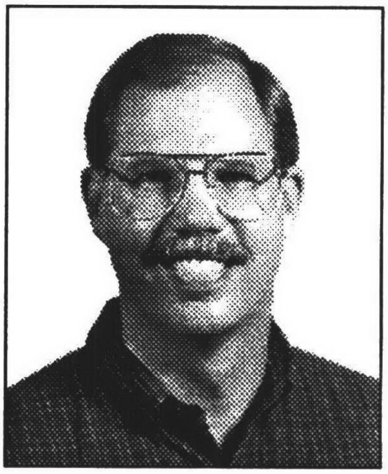
Montgomery, C A , R A Pollak, K E Freemark, and D White 1999 Pricing biodiversity J Environ Econ & Mgt 38 1-19

Rathert D , D White, J Sifneos, and R M Hughes 1999 Environmental associations of species richness in Oregon freshwater fishes J Biogeography 26(2) 257-274

White, D , A J Kimerling, K Shar, and L Song 1998 Comparing area and shape distortion on polyhedral-based recursive partitions of the sphere Internat J Geographical Info Sys 12(8) 805-827

White D , P G Minotti, M J Barczak, J C Sifneos, K E Freemark, M V Santelmann, C F Steinitz, A R Kiester, and E M Preston 1997 Assessing risks to biodiversity from future landscape change Conservation Biology 11(2) 349-360

White D , A J Kimerling, and W S Overton 1992 Cartographic and geometric components of a global sampling design for environmental monitoring Cartography & Geog Info Sys 19(1) 5-22



Parker J. Wigington, Jr.
Research Hydrologist
Western Ecology Division, NHEERL
Telephone: 541-754 4341
Email: wigington.jim@epa.gov

Education:
B.S., Virginia Tech, Blacksburg; Forestry and Wildlife, 1974
M.S., Utah State Univ., Logan; Watershed Science, 1977
Ph.D., Virginia Tech, Blacksburg; Environmental Sciences and Engineering, 1981

Previous Positions:
1981-1985: Assistant Professor, Forest Hydrology, Dept. of Forestry, Oklahoma State University, Stillwater

Research Interests and Skills:
Watershed influences of salmon and native fish
Riparian hydrology, ecology and biogeochemistry
Stream hydrochemistry

Professional Societies:
American Geophysical Union
American Water Resources Association
Ecological Society of America

Appointments/Honors:
Professor (courtesy appointment), Dept. of Forest Engineering, Oregon State University, Corvallis
Member of Board of Directors, American Water Resources Association

Selected Publications:
Fernald, A.G., P.J. Wigington, Jr., and D.H. Landers. 2001. Transient storage and hyporheic flow along the Willamette River, Oregon: field measurements and model estimates. Water Resources Res. 37:1681-1694.

Wigington, P.J. Jr., and R.L. Beschta, editors. 2000. Riparian Ecology and Management in Multi-Land Use Watersheds, Proc. AWRA Specialty Conference, Portland, OR, Aug. 28-31, 2000.

Dykaar, B.B., and P.J. Wigington, Jr. 2000. Floodplain formation and cottonwood colonization patterns on the Willamette River, Oregon, USA. Environ. Mgt. 25(1):87-104.

Schuft, M.J., T.J. Moser, P.J. Wigington, Jr., D.L. Stevens, Jr., L.S. McAllister, S.S. Chapman, and T.L. Ernst. 1999. Development of landscape metrics for characterizing riparian-stream networks. Photogrammetric Engineering and Remote Sensing 65:1157-1167.

Davies, T.D., M. Tranter, P.J. Wigington, Jr., K.N. Eshleman, N.E. Peters, J. Van Sickle, D.R. DeWalle, and P. Murdoch. 1999. Prediction of episodic acidification with an empirical/mechanistic approach. Hydrological Processes 13:1181-1195.

Wigington, P.J., Jr., M.R. Church, T.C. Strickland, K.N. Esheleman, and J. Van Sickle. 1998. Autumn chemistry of Oregon Coast Range streams. J. Am. Water Resources Assn. 34:1035-1049.

Van Sickle, J., P.J. Wigington, Jr., and M.R. Church. 1997. Estimation of episodic acidification based on monthly or annual sampling. J. Am. Water Resources Assn. 33(2):359-366.

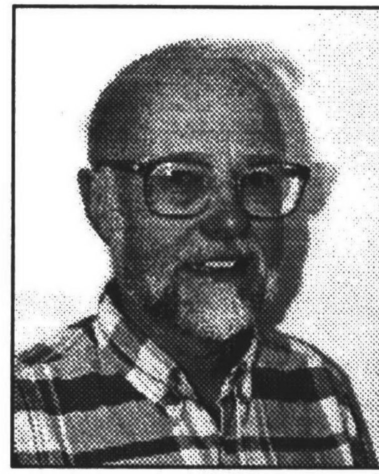
Griffith, S M , J S Owen, W R Horwath, P J Wigington, Jr , J E Baham, and L F Elliott 1997 Nitrogen movement and water quality at a poorly drained agricultural and riparian site in the Pacific Northwest Plant and Soil 195 521-526

Evans, C , T D Davies, P J Wigington, Jr , M Tranter, and W A Kretser 1996 Use of factor analysis to investigate processes controlling the chemical composition of four streams in the Adirondack Mountains, New York J Hydrol 185 297-316

Wigington, P J Jr , J P Baker, D R DeWalle, W A Kretser, P S Murdoch, H A Simonin, J Van Sickle, D V Peck, and W R Barchet 1996 Episodic acidification of small streams in the Northeast United States I Episodic Response Project Ecological Applic 6 374-388

Wigington, P J Jr , D R DeWalle, P S Murdoch, W A Kretser, H A Simonin, J Van Sickle, and J P Baker 1996 Episodic acidification of small streams in the Northeast United States Ionic controls of episodes Ecological Applic 6 689-407

Wigington, P J Jr , T D Davies, M Tranter, and K N Eshleman 1990 Episodic acidification of surface waters due to acidic deposition In Acidic Deposition State of Science and Technology, National Acid Precipitation Assessment Program, Volume II, NAPAP SOS/T Report 12 Washington, D C



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Research Interests and Skills:
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Estuarine Sedimentation
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Professional Societies:
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Adjunct Professor of Oceanography, Oregon State University, 1986-present

Selected Publications:
Young, D.R., R.J. Ozretich, H. Lee II, S. Echols, and J. Frazier. 2001. Persistence of DDT residues and dieldrin off a pesticide processing plant in San Francisco Bay, California. Chapter 15, pages 204-217 in R.L Lipnick, J.L.M. Hermens, K.C. Jones, and D.C.G. Muir, editors, Persistent Bioaccumulative Toxic Chemicals I: Fate and Exposure, American Chemical Society, Washington DC.
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¶ National Research Councl post doc
✧ Deceased WED author

Goal 2 Publications

Abbruzzese, B., and **S.G. Leibowitz** 1997. A synoptic approach for assessing cumulative impacts to wetlands Environmental Management 21(3) 457-475 NHEERL-COR-1676J

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◇ Deceased WED author

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