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Report of the Forest Effects Review Panel

Review of the Forest Effects Research Program of the Office of Research and Development

REPORT OF THE

FOREST EFFECTS REVIEW PANEL

REVIEW OF THE AGENCY'S

FOREST EFFECTS RESEARCH PROGRAM

U.S. Environmental Protection Agency
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U.S. Environmental Protection Agency

Science Advisory Board

FOREST EFFECTS REVIEW PANEL

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I. EXECUTIVE SUMMARY

The Science Advisory Board's Forest Effects Review Panel has examined the research plan for forest dieback/decline at three different levels: 1) the organization of the research program, 2) specific research designs and plans, and 3) integration of research results. The Panel's overall assessment is that the current research plan, unless modified, is unlikely to achieve the three major goals stated for the Forest Effects Research Program. Further, the process of generating and integrating the research will require stable and sustained funding over a period lasting from five to ten years.

A. Research Program Organization

Many of the current managers of the research program serve in an acting capacity in which they possess a limited knowledge of the field of forest dieback/decline and a limited authority to formulate and execute program plans and decisions. The Panel concludes that it is essential to have permanently appointed managers who are aware of the science and are committed to the success of the program. Program managers who have the responsibility to implement research plans should possess a comparable degree of authority to carry out this responsibility.

The Panel recommends a separate organizational design for the Forest Effects Research Program to distinguish its mission and performance from those of the other agencies participating in the program. A separate organizational approach should also facilitate research planning, information exchange and evaluations of the program accountability and success.

The research organization and plan should explicity require research managers and investigators to exchange their views and research results on a continuing basis. One mechanism for such exchanges is periodic workshops. Workshops should also provide useful information on the need, if any, to modify the research plan.

The Panel has received no indication as to how Requests for Proposals (RFP) would be solicited. Issuance and funding of RFPs before the administrative structure and research plan are finalized would be a serious mistake.

B. Research

The Panel applauds the plan's broad scope and its particular emphasis on defining mechanistic linkages between causes and effects, development of mathematical models and evaluation of forest responses along a hierarchy of ecological levels. Areas that deserve specific emphasis include the following:

- Whole plant physiology (previous plant effects research placed an unbalanced emphasis on leaf physiology).

- Below-ground plant and soil processes, including root dynamics (in the past, research overly concentrated on above-ground processes).

- An ecosystem approach to the research effort (past research typically focused on specific ecosystem components without provision for integration).

- Development of theories regarding plant strategies to handle stress, allocate reserves, and allocate energy (previous research was totally empirical).

- Plant growth allocation strategy and responses (to expand previous work that emphasized photosynthesis, yield responses and visible injury).

- Coupling plant dynamics of all nutrients, including water (past research overly concentrated on carbon dynamics or treating dynamics of individual nutrients in isolation).

- Forest stand dynamics (not generally included in research conducted to date).

- Atmospheric depositional monitoring and meteorological monitoring coordinated with field effects research (these activities were previously conducted out of phase or not at all).

C. Integration

The Panel's major recommendations for integrating research results include the following:

- That research sites have concurrent meterological monitoring, atmospheric deposition monitoring and effects research.

- That research be conducted in areas subject to differing amounts of pollutant deposition in order to provide results along a pollution gradient that will address the problem of "no control" and to provide model validating opportunities.

- That workshops and other forms of communication be stressed in recognition of the multidisciplinary nature of the research.

- That both laboratory (controlled environment) and field studies be conducted. These studies should be designed to complement one another. Dose-response considerations are important in both the laboratory and field situations, and experimental designs should explicitly simulate natural conditions.

- That the research program have a unifying theme, such as "response of forests to interacting atmospheric pollutants and other stresses".

II. INTRODUCTION

In response to requests by the Deputy Administrator and the Assistant Administrator for Research and Development, the Science Advisory Board (SAB) has reviewed a number of the Environmental Protection Agency's research programs each quarter of the fiscal year. These officials have requested SAB review of the research program assessing forest dieback/decline. The Board accepted this request and created a Forest Effects Review Panel to evaluate this program.

On July 16-17, 1985, the SAB's Forest Effects Review Panel met to review the jointly sponsored U.S. EPA/U.S. Forest Service research program that investigates the impacts of air pollutants upon American forests. This Panel, like all SAB review groups, consists of independent outside scientists who, due to their particular scientific expertise, were especially assembled to advise the Administrator. The panel was cochaired by Dr. Allan Legge and Dr. William Smith.

The focus of the review was a 202-page June 6, 1985 "Green Book", formally entitled, The Forest Effects Research Program. A team of fourteen scientists and research managers from the two agencies, academia, and industry prepared the Green Book, which describes, in very general terms, what research EPA and the Forest Service will carry out and/or sponsor and why. In contrast to other SAB panels conducting research reviews, the Forest Effects Review Panel reviewed proposed research, much of it conceptual, rather than ongoing or completed research. As a result, the Panel's comments are somewhat broader and less detailed, since less detail was available for review. At its meeting, the Panel members had the opportunity to hear and question scientists from the U.S. EPA, the U.S. Forest Service, and the National Council for Air and Stream Improvement (NCASI) and to discuss their findings with one another. This report presents the Panel's major findings and recommendations. It will be discussed personally with the Deputy Administrator by the Panel cochairmen.

III. FOREST EFFECTS RESEARCH PROGRAM REVIEW

A. Document Review

The Forest Effects Research Program (FERP) document outlines a very ambitious research effort. Because of the general nature of this document, the Panel members conclude that they can only make general comments at this time.

B. Research Program Organization

The FERP document was presented to the Panel by research managers, many of whom were uneasy with the scientific issues and plans they were presenting. Several of these managers function in an acting role which, as a result, creates a limited degree of managerial authority to make program plans and decisions. The Panel members believe it is absolutely

essential for a research program of the size and scope proposed by the FERP to have permanently appointed managers in place at the beginning of the program who are aware of the science and are both dedicated and committed to the success of the program. If this is not done, the program will flounder from lack of guidance, coordination, and integration and will, therefore, not meet its objectives on time or on budget. The FERP document clearly identifies the many organizations that will potentially participate in the research program. Since most of these organizations have different mandates, it is essential that an organizational structure be created at the outset of the research program that challenges the participating organizations in a positive manner to ensure their long-term, mutual cooperation. Mutual cooperation will help ensure program success. This does not mean to imply, however, that the organizational structure should be rigid. A large and/or overly complex management structure, however, is also not the solution. The structure should be kept small and relatively simple to more clearly delineate the roles and responsibilities of research managers, ensure effective communication and measure accountability for achieving research results. Program managers who have the responsibility to implement research plans should possess a comparable degree of authority to carry out this responsibility.

As appropriate during the course of the research program, the structure must be allowed to evolve. We recommend that a distinction be made between the organizational structure of the participating agencies in FERP and the FERP management structure to ensure that the latter's mission is clearly identified and separable from the missions of the participating agencies.

The Request For Proposal (RFP) process was another area of concern. The Panel was not given any indication as to how this process would function. It is our understanding that some RFPs have already been issued and projects funded. Should this be the case, it has been done without a well-defined administrative structure and agreed upon research plan. Coordination is essential to prevent unwanted duplication and omission. It is not clear how research will be integrated and coordinated for the RFP process.

It is unclear at this point how program integration will be achieved. As it presently stands, the program is not tied together. An efficient management structure will only provide a portion of the necessary program integration. Meetings among the principal participants to allow formal and informal information exchange would help. More thought and planning is needed in this area.

C. Research Program Design and Development

The research program is currently developed around a list of ten hypotheses to explain reported forest dieback/decline. The Panel finds that this list is neither comprehensive nor integrated. Many of the hypotheses are not mutually exclusive (as assumed in the document), and some are of questionable scientific importance. It is doubtful that

some hypotheses could be tested experimentally. The Panel believes that this approach is inherently weak. It recommends instead that the program managers adopt a more unifying or synthesized theme, such as "response of forests to interacting atmospheric pollutants and other stresses". Such an approach will greatly assist in program integration and will lead to information that will be applicable not only to immediate air pollution concerns but also to many other problems, such as predicting responses to carbon dioxide/climate change and nuclear winter scenarios.

D. Role of Modeling

The program should make use of models to help provide a unifying or synthesizing theme and to project the consequences of possible effects of pollutants over longer space and time scales. The investigators have recognized both the hierarchical nature of the ecosystem with which they are dealing and differences in individual tree/physiology models and stand/tree population models. The Panel commends the awareness of ecological scales in the design of this program.

As described in the FERP document, the models are to be used primarily to project the consequences of certain effects. The Panel encourages this logical application of the models. An additional use of models is to predict a priori the response of the ecosystem and then to test whether this prediction holds true. This latter, hypothetical-deductive approach is not strongly in evidence and could considerably increase the scientific content of the program.

The Panel believes that the formation of the modeling team represents a critical element in the success of the program. Research managers should make every effort to develop this team with a wide range of expertise—particularly in stand dynamics, basic ecology of forests, soils, macro- and micrometeorology, and atmospheric chemistry and deposition. We recommend, therefore, that the modeling team be assembled as soon as possible, since the use of models will strongly enhance program integration.

The process given the most emphasis in the program is tree growth as the integration of a spectrum of morphological, physiological, and biochemical responses to pollutants and other stresses. For this reason, the Panel recommends efforts toward development of a model of individual tree responses. This model could become an invaluable tool to synthesize results, to provide reasonable effects estimates for a stand simulation model and to guide the design of sampling schemes for micrometeorological effects. The need for this model is sufficiently great and the problem is sufficiently difficult that the work should begin early in the program. It would be appropriate to fund alternative model development in this area to incorporate more ideas and approaches to this difficult problem. These models should be developed in the context of scaling-up the consequences of smaller-scale, tree-level responses to the stand and ecosystem levels.

By shifting the modeling process forward in the research program schedule, missing information that is often needed in modeling projects can be collected early in the research program. This would also force some early synthesis in anticipation of developing the data collection efforts. This synthesis also could guide the greenhouse, chamber, and field studies in collecting data that could be designed to larger scales.

While the idea of using "conceptual models" in the initial parts of a research program is useful to frame ideas and to organize research program priorities, the process of developing and, particularly, in validating a quantitative model is a powerful test of the completeness of the research plan that is under development.

E. Field and Laboratory Research: Dose-Response Considerations

Dose-response considerations are important for both field and laboratory research. The coordination and integration of these efforts is essential in assessing forest dieback/decline. Generating dose-response data in the laboratory can elucidate mechanisms of toxicity; researchers should exercise similar care to obtain dose-response data in field studies so that each type of research complements the other. The research plan should develop a balanced approach to laboratory and field studies, recognizing the strengths and weaknesses of each.

The FERP document provides little detail concerning the modeling of exposure. The Panel recommends that the diurnal timing and intensity and the meteorological timing and intensity of exposure be considered. Since plants function in modal diurnal patterns and aerial toxicants are delivered in diurnal patterns, the exposure of the toxicant to the organism should be explicitly stated. Because meteorological patterns tend to vary on a 3-4 day cycle, air quality and deposition monitoring should consider that period instead of some arbitrary period of sample integration. The Panel recommends that program planners design an explicit mechanism to jointly plan and evaluate meteorological monitoring, deposition monitoring and terrestrial effects studies.

F. Research Field Locations

The concentration of initial work in southeastern commercial forests and in eastern spruce-fir ecosystems is understandable on both political and economic grounds. The Panel recommends that EPA and the Forest Service should also conduct research along adequate gradients of pollutant concentration to validate models. They should include locations which form both an elevational and latitudinal gradient. The question of adequate reference locations should also be addressed. Research managers should also consider expanding the initial research effort to include less polluted areas of the country to study portions of the Western coniferous forest and the Eastern deciduous forest.

The FERP proposal aims to explain pollutant impact on forest growth but only makes limited mention of forest stand dynamics. One of the overall objectives of the research program is to determine whether exposure of forest ecosystems to air pollutants produces an economic impact on the forest industry. Therefore, stability measures of forest systems under air pollutant stress should be emphasized, because they can provide an early warning of potential growth impact and of changes in quality of the forest community.

G. National Vegetation Survey

A great deal of background information on forests exists as a result of the National Vegetation Survey. The usefulness of this data base has largely been overlooked in the FERP document. As the foundation of any future work using the National Vegetation Survey, existing data should be intensively and comprehensively analyzed to characterize the conditions (both past and present) of the forest. These data would prove very useful to the FERP. This effort should be preceded by a workshop composed of an interdisciplinary team of scientists representing the perspectives of data collection, analysis, interpretation, as well as potential users of the analytical results, e.g., assessment. The objective of the workshop would be to review the characteristics of existing data and to develop a consensus plan for analysis. This plan should be subjected to an independent peer review. Results of subsequent data analysis should be published in a timely fashion in the refereed literature.

The workshop will benefit not only existing efforts of data analysis but would also promote discussions on such subjects as the efficacy of dendrochronological techniques for estimating changes on forest growth. Development of the plan to analyze existing data as well as the analysis itself will undoubtedly be useful in redesigning Forestry Inventory and Analysis (FIA) or designing long-term monitoring projects to eliminate deficiencies in existing data. A more comprehensive, systematic, and long-term forest growth and health monitoring strategy should be a goal (and legacy) of this research program.

H. Forest/Ecosystem/Atmosphere Interactions

The FERP document emphasizes atmospheric deposition-canopy interactions, while paying less attention to the effect of deposition on soil acidification, aluminum toxicity, loss of fine roots and nutrient leaching. This initial emphasis on gaseous air pollutants is correctly placed in that less is known about their impact on forest ecosystem behavior. In addition, the forest canopy is far more susceptible to direct effects than is the well-buffered soil system. The potential of most soils to shift significantly in pH due to atmospheric inputs over either a short or long period of time is minimal. Soil processes, such as respiration, decomposition leading to the production of organic acids and nitrification, are all acidifying in their reactions at rates that can be significantly higher than acidification through atmospheric deposition. The relative contribution of these natural acidification processes should be recognized in this forest effects program.

Planners of this program should recognize, however, that the forest canopy-atmospheric depositional processes should not be examined in isolation from other ecosystem-related processes, including those below ground. For example, canopy changes due to deposition can potentially affect carbon allocation, fine root development, and nutrient uptake and cycling. Special attention should be given to soils and soil-depositional interaction where sulfates and nitrates are in excess or potentially exceed the adsorption/immobilization capacity of the soil. Under these conditions, the soil could experience leaching losses and may, if continued over a long period of time, lead to a decrease in site productivity, a consequence of greater significance than changes in growth due to a pollutant damage to the canopy.

I. Air Quality Research and Monitoring

The relationship between air quality/deposition monitoring and forest effects research is very loose as described in the FERP document. The term deposition support program is used, which has the connotation of being some sort of add-on activity in which data will be collected and handed over to the forest researchers. This clearly should not be the case, and the monitoring program, to be successful and responsive to the needs of effects research, must be an integral part of the Research Cooperatives program.

The section on monitoring covers a large number of pollutants to be measured and gives some indication of the time resolution required, but these are not specifically related to the hypotheses to be tested or the modeling needs. A summary table is necessary to show these needs more clearly.[1]

The question of the time scales over which various pollutant and other environmental factors stress the forests and the time resolution of the monitoring required to study these stresses is still unanswered. More discussion of what is known about this issue is required before a monitoring system is designed.

Program managers need to recognize that the relationship between time scales and biological system responses to atmospheric deposition will not be resolved in the short term. The hierarchical approach to research from physiological effects to whole stand dynamics will require different time resolutions for each level. The monitoring needs, therefore, should also be stratified according to these levels.

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[1]A good start was made at the EPA/NSF Workshop on "Atmospheric Deposition and its Impact on High Elevation Mountain Forest Systems" held in Albany, New York, April 5-7, 1984. The report of this meeting is entitled Atmospheric Deposition to Mountain Forest Systems: Workshop Proceedings, April 1984 by V.A. Mohnen and is available from the National Technical Information Service, Springfield, Virginia as PB84-246412 or EPA-600/9-84-023.

The document provided no information on how the monitoring data might be used to test the specific hypotheses proposed. This omission is of less significance if the approach is modified as recommended. Because of the large variability of the pollution doses and other meteorological parameters, it may be impossible to generate sufficient data in a reasonable time to test hypotheses using the "traditional" statistical approaches.

Since models will be extensively used in this program, they should be driving the monitoring needs in terms of: 1) the input meteorological and pollution data required, and 2) the data necessary to test or validate the models. Since these models are not yet developed, the monitoring system should be as flexible as possible. Some essential parameters can probably be identified immediately but others may have to await the initial model development. As the important dose-response time scales become evident from the initial experimentation and model development, they should determine the monitoring needs.

The program plan places insufficient emphasis on the natural environmental measurements required, changes of which can also produce stresses on the forest. Changes in standard meteorological variables, such as wind speed, temperature (extremes), rainfall, and solar radiation are all important and can often act as predisposing or inciting factors that outweigh any pollutant stresses. Thus, if hypotheses are to be tested and accepted or rejected, then equal weight must be given to the monitoring of natural environmental factors as well as pollution parameters. The intensive research sites must collect <u>all</u> the needed meteorological and pollution measurements on-site because of the risks and possible errors involved in interpolating from nearby sites, especially where elevations differ significantly.

To ensure that the monitoring program and the data interpretation are fully integrated into the program, full-time dedicated micrometeorologist and atmospheric chemistry staff members are essential in the Corvallis integration group and possibly in each of the Research Cooperatives. The team developing the quantitative models under Goal 3 must include an expert in micrometeorology and forest canopy-atmospheric interactions in addition to the biological experts.[2]

J. Forest Effects Research Program Research Plan Document

While we think highly of many aspects of the research plan, we were disappointed in the document describing the plan. If the sole purpose of this document were to explain the plan to the Panel, we certainly would not

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[2]Goal 3 is described on page 93 of the FERP Document as: "Develop and test quantitative models to predict changes in forest ecosystems over time and to extrapolate from site-specific research results to regional effects of air pollutants."

recommend a revision at this time. However, if there are plans to publish or circulate this document, then we strongly recommend major revisions. The document is highly repetitious and lengthy. It could easily be reduced to a fraction of its present size while losing nothing of substance. In addition, sections II and III are technically superficial and weak. There are too many citations of unpublished work or secondary sources. The discussions of the hypotheses are technically superficial, and the figures used to illustrate them are vacuous. The sections fail to relate their subject matter to either the mainstream of air pollution effects or plant sciences research.

K. Emphasis and Priorities

The research plan mentions many of the factors whose emphasis we consider important; however, since we cannot be sure which factors will ultimately be emphasized when the plan is implemented, we wish to point out the factors we consider most important. We strongly applaud the plan's broad scope and its emphasis on defining mechanistic linkages between causes and effects, development of mathematical models and evaluation of responses along a hierarchy of ecological levels of organization. In addition, however, we point out the need to emphasize as well whole plant physiology (previous plant effects research has placed an unbalanced emphasis on leaf physiology); below-ground plant and soil processes including root dynamics (in the past, research has overly concentrated on above-ground processes); an ecosystem approach to the research effort (past research has typically focused on specific ecosystem components without provisions for integration); development of theories regarding plant strategies to handle stress, allocate reserves, and allocate energy (previous research has been totally empirical); plant growth allocation strategy and responses (to expand previous work that emphasized photosynthesis, yield responses and visible injury); coupling plant dynamics of all nutrients, including water (past research has overly concentrated on carbon dynamics or treating dynamics of individual nutrients in isolation); forest stand dynamics (not generally included in research conducted to date); and atmospheric depositional monitoring and meteorological monitoring coordinated with field effects research (these activities were previously conducted out of phase or not at all).