

**OAK RIDGE NATIONAL LABORATORY**

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**ORNL**  
**FOREIGN TRIP REPORT**

ORNL/FTR-3759

**DATE:** October 5, 1990

**SUBJECT:** Report of Foreign Travel of Samuel B. McLaughlin, Jr., Senior Research Staff, Environmental Sciences Division

**TO:** Alvin W. Trivelpiece

**FROM:** S. B. McLaughlin, Jr.

**PURPOSE:** Collaborative scientific exchange followed by participation in the International Conference on Acidic Deposition.

**SITES VISITED:**

8/6-9/16/90	Institute of Terrestrial Ecology Edinburgh, Scotland	D. Fowler
9/16-20/90	International Conference on Acidic Deposition, Glasgow, Scotland	G. D. Holmes

**ABSTRACT:** The traveler took the opportunity to participate in a mini-sabbatical at the Institute of Terrestrial Ecology (ITE) in Edinburgh, Scotland, as a part of planned travel to Glasgow, Scotland, to attend the International Conference on Acidic Precipitation. The purpose of the sabbatical was to provide quality time for study and interchange of ideas with scientists at ITE working on physiological effects of acidic deposition and to allocate significant time for writing and synthesizing of results of physiological studies from the National Forest Response Program's Spruce/Fir Research Cooperative. The study focused on the very significant cytological and physiological effects of calcium deficiency in trees, a response that appears to be amplified in spruce by acidic deposition. Three manuscripts were produced, two of which have been submitted for final prepublication review. Two talks were presented, one at ITE, and the second at the International Conference in Glasgow. The utilization of a critical mass of time for uninterrupted work and study proved both productive and scientifically stimulating for the traveler.

**SUMMARY OF ACTIVITIES, INCLUDING TRAVELER'S ROLE**

Interactions with researchers at the Institute of Terrestrial Ecology (ITE) were an important aspect of this trip. The team at ITE has been

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actively involved in research concerning the effects on winter hardiness of foliar exposure of red spruce to acid mist. This work has been an important part of the research conducted by the National Forest Response Program's Spruce/Fir Research Cooperative. Since the traveler was responsible for synthesizing material concerning physiological aspects of this research into a forthcoming book chapter, his stay at ITE provided an opportunity for interchange of concepts and results with this interdisciplinary group. The traveler shared results of Oak Ridge National Laboratory (ORNL) field and greenhouse studies on integrated plant physiological responses of red spruce to acidic deposition and engaged in numerous informal discussions concerning mechanisms of responses observed in ORNL and ITE studies. Interactions with the staff led to increased understanding of the traveler's original concepts of membrane-mediated effects of acid deposition, specifically calcium-mediated changes in membrane permeability. While at ITE, the traveler presented a formal seminar entitled "Physiological Perspectives on Effects of Regional Air Pollution and Global Environmental Change on Forests."

The traveler attended the initial day of an International Union of Forest Research Organizations symposium entitled "Ecology of Mixed Species Stands of Trees" at Harriot Watt University in Edinburgh on September 2. Significant interactions between tree species in rooting and growth patterns detected in the long-term Gisburn experiment in England have important implications for much-needed mixed species afforestation and silviculture on steep hills in the Scottish highlands. These results also relate to the need for better understanding of multilevel competitive interactions in our own mixed deciduous forests.

While at ITE the traveler worked on the following manuscripts:

1. "Growth and Physiology of Red Spruce Saplings in Relationship to Acid Deposition in High Elevation Stands" (S. B. McLaughlin and M. G. Tjoelker). The manuscript was written, reviewed, revised, and submitted as an invited paper to Forest Ecology and Management and will be included with 29 other papers in a special issue of that journal in this subject area from the Acid Deposition Conference.
2. "Changes in Soil and Wood Chemistry as an Indicator of Long Term Effects of Acid Deposition on Forests" (E. A. Bondiotti and S. B. McLaughlin). The second reviewer's comments were incorporated, and the manuscript was submitted as a chapter for the synthesis volume of the Electric Power Research Institute Integrated Forest Study (in review).
3. "Effects of Acid Deposition on Carbon Allocation and Related Physiological Processes" (S. B. McLaughlin and R. Kohut). The first 42-page draft was written and with coauthor's sections will form the first draft of a book chapter.

The traveler arrived in Glasgow on September 16 for the Fourth International Conference on Acidic Deposition. His paper (abstract included in Appendix C) summarized four years of research on responses of red spruce to regional air pollution. This work built on initial regional studies of tree growth patterns in the high-elevation spruce forests of the eastern United States and followed a sequence of hypothesis development and testing that led to the conclusion that acid deposition is currently amplifying natural patterns of base cation turnover and retention. Field and greenhouse studies indicate that calcium deficiency is currently occurring at high-elevation Appalachian forests and that acid deposition has exacerbated natural or induced nutrient deficiency, resulting in impaired carbon economy and growth reduction.

The conference was attended by over 600 participants, who listened to a series of plenary talks that characterized the significant progress made in documenting the effects of ambient levels of acid rain on many components of both terrestrial and aquatic ecosystems. Major themes of the conference were relationships between patterns and processes controlling wet and dry deposition of pollutants and effects on soils, vegetation, aquatic systems, and building surfaces.

Overall, substantial progress has also been made in understanding changes in physiological processes associated with these effects on both physical and biological systems. However, much research effort is still needed to adequately understand the mechanisms underlying these process-level changes, and this information is vital to predicting the consequences of long-term, multifaceted stress regimes on forest growth and vigor. Unfortunately, many of the studies will be curtailed with the decommissioning of the National Acid Precipitation Assessment Program. The important understanding that has been gained, however, should be a valuable base in considering forest responses to a variety of stresses in which pollution and other aspects of global change may be involved.

There is, for example, increasing evidence of pollution-induced enhancement of susceptibility of trees to insect attacks. The traveler had been formulating research plans for addressing the question of the potential predisposition of Fraser fir in the southern Appalachians to anthropogenically derived nutrient imbalances. Based on discussions with Dr. Nigel Bell of Imperial College in London, he found considerable support for those concepts. The group at Imperial College has substantial experience in assessing the effects of stress on aphid-plant interactions and would be a potential source of collaborative interaction should such a project develop. Further contact with this group is planned.

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**APPENDIX A****ITINERARY**

August 5	Travel from Oak Ridge, Tennessee, to Edinburgh, Scotland
August 6-11	Work/study at the Institute of Terrestrial Ecology (ITE), Edinburgh, Scotland
August 12-19	Personal travel during off-duty hours including five days of vacation in northeastern Scotland and England
August 20- September 15	Work/study at ITE, Edinburgh, Scotland
September 16	Travel to Glasgow, Scotland, for International Conference on Acidic Deposition
September 17-20	International Conference on Acidic Deposition
September 21	Travel from Glasgow, Scotland, to Oak Ridge, Tennessee

## APPENDIX B

PRINCIPAL CONTACTS AT THE INSTITUTE OF TERRESTRIAL ECOLOGY  
EDINBURGH, SCOTLANDMajor Topic Area

Dr. Melvin G. Cannell	Global Climate Change
Dr. Neil J. Cape	Physiological and chemical markers
Dr. David Fowler	Deposition processes and physiological responses
Dr. Lucy J. Sheppard	Chemical and physiological aspects of acid mist effects on winter injury
Dr. John Thornley	Whole plant models of carbon and nitrogen utilization

## APPENDIX C

ABSTRACT OF AUTHOR'S PRESENTATION AT  
INTERNATIONAL CONFERENCE ON ACIDIC DEPOSITION

Growth and Physiology of Red Spruce Saplings in Relationship to Acid Deposition in High Elevation Southern Appalachian Red Spruce Stands

S. B. McLaughlin, C. P. Andersen, N. T. Edwards,  
P. J. Hanson, M. J. Tjoelker, and W. K. Roy

Exploratory studies were initiated at two high-elevation red spruce (Picea rubens Sarg.) stands in the Great Smoky Mountains of eastern Tennessee to evaluate the magnitude and physiological basis of differences in growth decline at high elevations. Increment core data indicated that conditions have become relatively less favorable for mature trees at the upper site during the past 20 years. Annual height growth of sapling trees has been 40% less at that site compared to a similar site 215 m lower in elevation. Seasonal measurements of net photosynthesis (Ps) and dark respiration (Rs) rates of saplings indicated that reduced sapling growth rates at the upper site were associated with increases in Rs and less favorable Ps:Rs ratios. Reduced foliar calcium and magnesium, reduced foliar chlorophyll, increased foliar aluminum, and 50% lower ratios of Ca:Al were found at the upper site, where rainfall was 30% higher. Tissue and soil aluminum levels that are in the range of those associated with aluminum toxicity to red spruce provided preliminary indication that current high atmospheric inputs of the strong anions  $SO_4$  and  $NO_3$  to acidic soils may be adversely affecting growth and physiology of trees at the high-elevation site. Followup studies of the observed patterns of Ps:Rs during a second growing season at three elevations on three mountains revealed a consistent reduction of Ps:Rs by about 50% at high-elevation sites compared to low- and medium-elevation sites. Subsequent greenhouse studies involving red spruce seedlings grown on soil from a high-elevation site indicate that acid rain and acid mist in the acidity range of current ambient levels at high-elevation sites can substantially reduce photosynthesis, increase respiration, reduce growth, and limit rooting depth. Soil amendments of Mg and Ca can partially offset this effect. Positive effects of acid deposition on net photosynthetic rates noted at higher soil fertility were reversed when seedlings were exposed to acid deposition under unamended soils of low fertility.

**- END -**

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