Summary of Assessment of Dry Deposition Methods / Throughfall Comparison

K.C. Weathers, G.M. Lovett and S. M. Simkin
Institute of Ecosystem Studies (IES), 65 Sharon Turnpike, Millbrook, NY 12545
Contacts: weathersk@ecostudies.org, simkins@ecostudies.org

May 2002

I. BACKGROUND

A. INTRODUCTION

Dry deposition is an important--sometimes dominant--component of total (wet + dry) deposition. It often comprises somewhere between 25 % and 75% of total deposition (e.g., Lovett 1994, Weathers and Likens 1998). Thus the ability to quantify dry deposition to real surfaces (mixed-canopy and fragmented forests, grasslands, buildings, etc.) is of enormous importance. In many cases, it will not be possible to quantify the effects of acid deposition, or the effectiveness of emissions reductions on rates and patterns of atmospheric deposition without accurate measurements of dry deposition. Despite this need for dry deposition data, reliable estimates of dry deposition are primarily limited to intensive monitoring sites, usually located at low-elevation sites in flat, homogenous terrain. The inferential methods of estimating dry deposition used by the networks CASTNet and AIRMoN, as well as by a variety of other independently-run programs, are a huge step forward: they allow the critical assessment of temporal changes in dry deposition, for example. However, these deposition estimates are (by necessity) built upon assumptions of homogeneous canopies and flat terrain, and therefore can not give an indication of the range of variation of deposition across non-homogenous canopies or over a complex landscape. In addition, direct measurement of atmospheric deposition rates via micrometeorological techniques is expensive, logistically challenging and difficult to implement and maintain, and the assumptions are not applicable to either heterogeneous canopies or complex topography (e.g. Weathers et al. 1995, 2000, Lovett 1994).

Net sulfate ($SO_4^{=}$) fluxes in throughfall (water that passes through the canopy) have also been used successfully to estimate dry deposition (e.g., Lovett 1994, Butler and Likens 1995, Lovett et al. 2000). Sulfate is a particularly good tracer of deposition because it encompasses every major deposition process, almost equally, including dry, wet and cloud deposition. In areas of high sulfur (S) deposition in the eastern U.S., forest canopies exchange only small amounts of S between internal assimilated pools and external pools on the leaf surface (Lindberg and Garten 1988). As a result, deposition of $SO_4^{=}$ in throughfall has been shown in a variety of forests to be a good measure of total S deposition to canopies. The throughfall method is relatively inexpensive and widely applicable, and, perhaps most important, is not subject to assumptions about homogeneity of terrain and canopy.

On the one hand, we have high quality data available from standardized networks that are used in models which cannot consider the complex terrain that characterizes most of the country. On the other, we have a direct measure of deposition that takes into account all the complexities of terrain and canopy heterogeneity. However, we have little idea how these different measures of dry deposition compare. Is there a relationship between inferentially modeled and measured dry deposition estimates?

B. GOAL

Our goal is to answer the question: Do CASTNet-derived deposition estimates and deposition calculated from the measurement of $SO_4^{=}$ in throughfall correspond? This assessment is long overdue: both methods are used to estimate deposition to forested canopies yet we do not know the relation between them. The resultant analysis will add greatly to the ability to quantify the relative importance of dry deposition to total deposition in complex terrain.

In collaboration with CASTNet personnel, we seek to collect throughfall and bulk deposition samples during the summer of 2002 from approximately 10 forested CASTNet sites. We will then subtract bulk deposition from throughfall to derive a net throughfall measurement of dry deposition flux, which can then be compared to the CASTNet deposition estimates for the same period at the same sites.

In summary, our goal is to create a linear least square regression that provides a quantitative assessment of the relationship between calculated CASTNet dry deposition fluxes to measured dry deposition fluxes from net throughfall (throughfall - bulk deposition).

C. REFERENCES

Butler T.J., and G.E. Likens. 1995. A direct comparison of throughfall plus stemflow to estimates of dry and total deposition for sulfur and nitrogen. Atmos. Environ. 29(11):1253-1265.

Lindberg, S. E., and C. T. Garten. 1988. Sources of sulfur in forest canopy throughfall. Nature 336:148-151.

Lovett, G.M. 1994. Atmospheric deposition of nutrients and pollutants in North America: An ecological perspective. Ecological Applications. 4:629-650.

Lovett, G. M., M. M. Traynor, R. V. Pouyat, M. M. Carreiro, W. X. Zhu, and J. W. Baxter. 2000. Atmospheric deposition to oak forests along an urban-rural gradient. Environmental Science and Technology 34:4294-4300.

Weathers, K.C., G.M. Lovett, and G.E. Likens. 1995. Cloud deposition to a spruce forest edge. Atmospheric Environment. 29:665-672.

Weathers, K.C., and G.E. Likens. 1998. Acid rain. pp. 1549-1561 In: W. Rom, ed. Environmental and Occupational Medicine, 3rd edition. Lippincott-Raven Publishers, Philadelphia.

Weathers, K. C., G. M. Lovett, G. E. Likens, and R. Lathrop. 2000. The effect of landscape features on atmospheric deposition to Hunter Mountain, Catskill Mountains, New York. Ecological Applications 10:528-540.

II. Methods

A. Initial Field Work

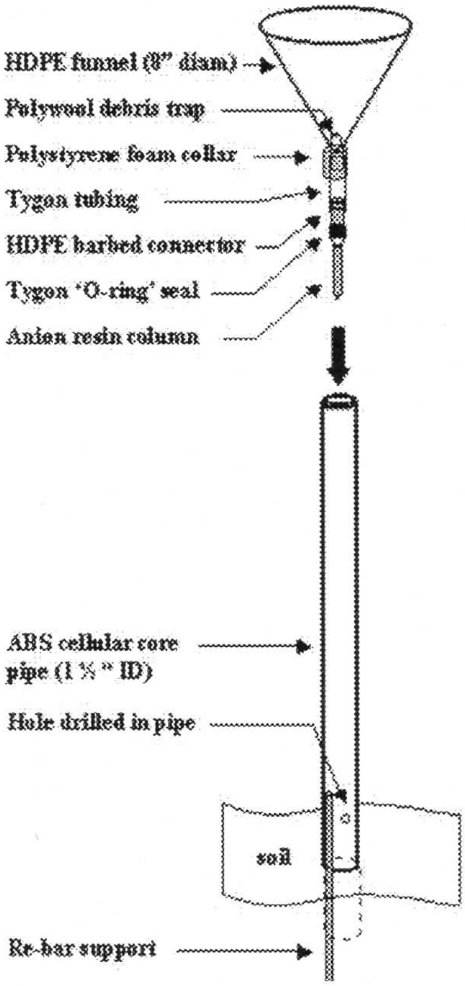
At each of the collaborating CASTNet sites, IES staff will install ~10 plastic pipes to support throughfall collectors in the forest surrounding the site, as well as 3 plastic pipes to support bulk collectors in the open clearing occupied by the CASTNet site. IES staff will give CASTNet site operators that agree to participate in this study all the materials they need to collect throughfall and bulk deposition samples. Those materials include: polyethylene funnels, poly-wool balls for the funnels, a polyethylene resin column containing OH- form ion-exchange resin, a pair of plastic tweezers, a sharpie marker, a squirt bottle for DI (deionized) water, and detailed instructions about how to collect samples and ship them to IES (See the attached sample collection instructions).

B. Sample collection

Sampling would begin in summer 2002 and end in fall 2002 before leaf-drop, for a total of about 2-3 sampling periods. Collaborating CASTNet site operators would place one funnel-resin column assembly at each of the 13 sampling locations described above, and then collect the 13 samples approximately every 4-6 weeks during rain-free conditions (See the attached sample collection instructions). If possible, spot checks of the funnels for problems with flow or animal damage are desirable. We do not anticipate that sample collection would require significant time, and it would be done during the same visit that the CASTNet site was serviced.

C. Chemical Analysis

All samples will be chemically analyzed at IES by IES staff. Throughfall samples will be extracted using 1N KI, and analyzed, primarily for sulfate, using a Dionex DX-500 Ion Chromatograph (IC) with ASG9-HC and AS9-HC columns. The instruments used for this project are under the aegis of the IES Analytical Laboratory staff.


HDPE funnel (8" diam)
Polywool debris trap
Polystyrene foam collar
Tygon tubing
HDPE barbed connector
Tygon 'O-ring' seal
Anion resin column
ABS cellular core pipe (1 ½ " ID)
Hole drilled in pipe
soil
Re-bar support