

MEASUREMENT OF FOREST CONDITION AND RESPONSE ALONG THE PENNSYLVANIA ATMOSPHERIC DEPOSITION GRADIENT

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Abstract: Research in the oak-hickory forest of northcentral Pennsylvania is being conducted to detect anomalies in forest condition that may be due to atmospheric deposition, with the intent that such anomalies will be further studied to determine the role, if any, of atmospheric deposition. This paper presents the status of research along a 160-km gradient of sulfate/nitrate deposition across northern Pennsylvania begun in 1986 by a multidisciplinary group of researchers at Penn State University and Ohio State University. Four general objectives of the study are: (1) estimate atmospheric deposition loadings across the gradient and at the specific study sites, (2) locate ecologically analogous intensive study sites across the deposition gradient to minimize extraneous variability in forest response, (3) measure and relate forest responses to environmental factors, including atmospheric deposition, and, (4) estimate effects of ambient ozone concentrations on tree seedling growth along the deposition gradient by use of open-top chambers.

The study region lies within the southern portion of the Allegheny Plateau physiographic province, a strongly dissected, large unglaciated tableland with elevations of 500-700 m. Forest types within the region include oak-hickory, mixed deciduous, and northern hardwoods, depending on aspect, slope position, and other factors. Thirteen ecologically analogous stands, ranging from 7 to 58 ha, were selected for intensive measurement of forest response across the deposition gradient from an initial set of 53 candidate stands. Selection procedures included qualitative evaluations to ensure that minimum criteria were met, followed by statistical comparisons of soils and amounts of canopy species to establish similarity on the basis of factors unlikely to have been affected by atmospheric deposition (nonresponse variables). The stands were distributed approximately equally among four uniformly-spaced core areas across the 160-km gradient. They are ridgetop northern red oak-dominated stands, 70-80 years of age, with no evidence of intermediate cutting, severe defoliation or other major disturbance. Soils are coarse-textured, stony, acidic, and low in base saturation.

Bulk deposition estimates based on intensive deposition monitoring at ten sites across the gradient indicate that annual sulfate deposition (wet plus dry) averages 57 kg/ha at the western end and 38 kg/ha at the eastern end. A coincident gradient of nitrate and other ions also exists. The gradient monitoring also points out the large spatial variability and importance of intensive monitoring for accurate assessment of causal relationships. Surfacing

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techniques employing the Pennsylvania monitoring network data from 1982-1987 were used to estimate average deposition of various ions at the forest response study sites. These estimates are being used to study relationships between deposition and forest response.

Forest community response to sulfate/nitrate deposition is hypothesized to occur earliest within the herb stratum. Particular emphasis is therefore being placed on measures of herb-layer biomass, species richness, and elemental status of selected species in relation to forest overstory, soil and deposition factors. Numbers and size of woody species in other strata were also determined. Correlation/regression analysis of community parameters with deposition estimates and soil/site factors are being determined.

Soils were intensively sampled by horizon, and comparisons of chemical and physical properties in relation to deposition and other site/forest community parameters are underway. Forest floor mass and humus metals loadings are undergoing similar comparisons.

Tree growth relationships are being studied using standard dendroecological procedures to model red oak, white oak and tuliptree tree-ring width response to climate, site and deposition. Chronologies for host (oaks) and non-host (tuliptree) species will be compared to develop techniques for detecting and assessing past impacts of major oak insect defoliators. Red oak height growth for selected time periods based on stem analysis data is being used to model relationships with soil, site and deposition factors.

Forest health assessments include crown transparency and twig dieback surveys, as well as bole evaluations, within all study stands. Leaf symptoms are being identified and quantified on annual samples of over 14,000 leaves collected from these three species. Ancillary to the leaf assessment program, an expert computer system was developed as a training aid for symptom identification and rating. Crown and bole assessments for each of the 13 stands indicated no unusual tree health conditions. Certain foliar disorders (e.g., galls) appear to be related to deposition patterns.

A lichen survey revealed that lichen richness was comparatively greater on the low sulfate deposition portion of the gradient. Concentrations of Al, Fe, Cr, and Cu in *Hypogemnia physodes* thalli were greater on the high-deposition portion of the gradient. These findings are suggestive of an air pollution effect.

Red maple sap chemistry was monitored for 2 years at seven sites along the gradient to determine the usefulness of sap constituency as a biomonitor of soil and atmospheric deposition chemistry. Preliminary analyses indicate that elemental content of red maple sap may be a valuable tool to indicate biological effects of chronic atmospheric deposition along the gradient, but may not be useful in detecting short-term effects of artificially added sulfate.

Open-top chamber studies at three remote sites along the deposition gradient are underway to assess the foliar and growth impacts of ozone concentrations representing ambient, half-filtered, and full-filtered levels. Ozone levels in 1988 exceeded the standard of 120 ppb numerous times; the standard was not exceeded in 1989. An ozone gradient coincident with the sulfate/nitrate deposition gradient was found. Ambient ozone levels induced foliar

symptoms on black cherry and tuliptree (sensitive species), but slight to no symptoms on more tolerant red maple and red oak. Increasing basal diameter and height of black cherry during the growing season was negatively correlated with ozone dose. Ozone stimulated premature fall coloration and defoliation on black cherry.

IMPACT OF SMALL MAMMALS ON REGENERATION OF NORTHERN RED OAK

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Abstract: The impact of small mammals on regeneration of northern red oak (*Quercus rubra*) was studied from October 1989 to December 1990 in Huntingdon County, Pennsylvania. Acorns were planted in two replicates each of three silvicultural treatments: 20% shelterwood, 70% improvement, and untreated mature forest. Four hundred acorns were planted in a 0.8-ha study site in each replicate, giving a total of 2400 acorns in each of six trials (Nov-Dec, Mar-Jun). One-half of the total acorns were direct-seeded 2 cm below the soil surface, and one-half were surface-seeded in a shallow depression on the soil surface. Acorn loss was compared between autumn (Nov-Dec) and spring (Mar-Jun), among treatments and between acorn depths. Most acorn loss was attributed to white-footed mice (*Peromyscus leucopus*). Total acorn loss (direct-seeded, surface-seeded) in the 20% shelterwood ranged from 28% to 68% in autumn and from 96% to 100% in spring. Total loss in the 70% improvement ranged from 44% to 84% in autumn and from 94% to 100% in spring. Total loss in the untreated mature forest ranged from 67% to 88% in autumn and from 99% to 100% in spring. Loss of direct-seeded acorns ranged from 17% in the 20% shelterwood during autumn to 60% in the 70% improvement during autumn. Loss of surface-seeded acorns ranged from 40% in the 70% improvement during autumn to 83% in the 20% shelterwood during autumn. Preliminary evidence indicated that acorn loss was lower in autumn than in spring, and acorn loss in autumn was greater in untreated forest sites than in treated sites.

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