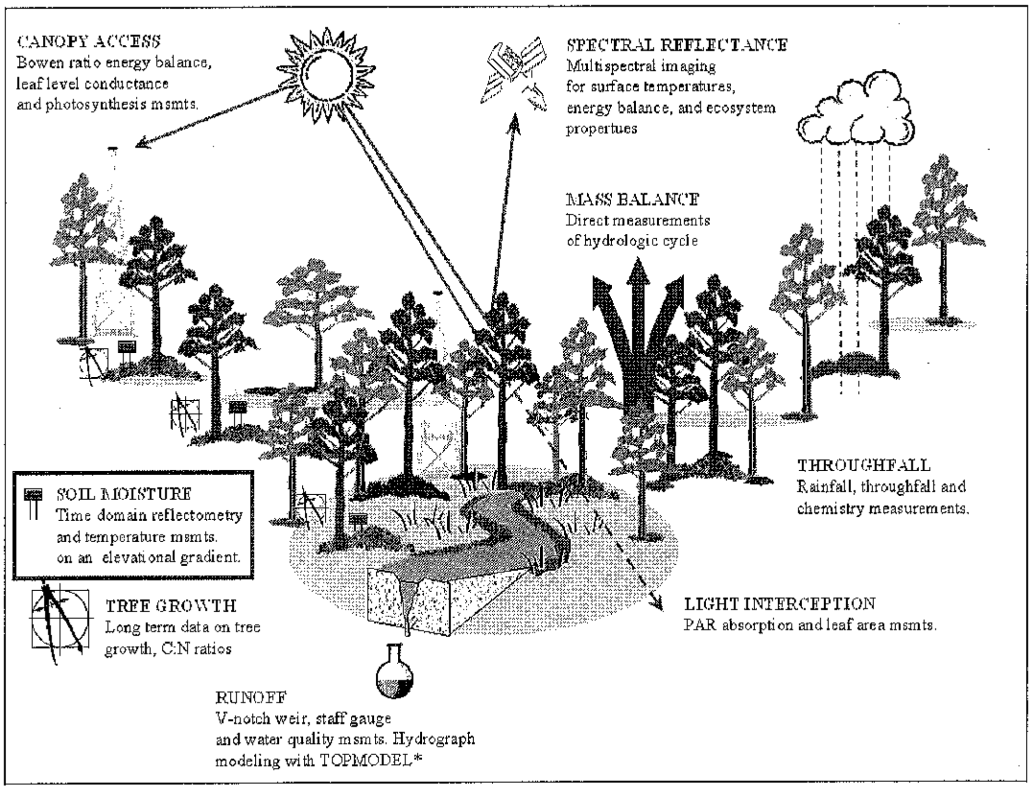
Summary Report for "Seasonal and Topographical Variation in Water Availability: Implications for Carbon and Nitrogen Cycling in the Cascade Watershed of Black Rock Forest." Black Rock Forest Consortium. 1998, $4,849 / 1 year (PI)

Prepared by K.J. Brown, K.L. Griffin and V.Engel

Funding was granted in 1998 by the Black Rock Forest Consortium for the investigation of soil moisture in the Cascade Brook Watershed. Funds were used to purchase soil moisture measurement devices and for research expenses related to measuring the soil moisture at the "high" and "low" sites in the Cascade Brook Watershed. A Columbia University doctoral student, Victor Engel, performed most of this research as part of his dissertation.

During the 1999 growing season, soil moisture probes were installed (in addition to a suite of additional micrometeorological instruments) at the "high" and "low" sites in the Cascade Brook Watershed at Black Rock Forest (Report Figure 1). The collection of soil moisture data (in the red box in Report Figure 1) was a component in a larger, multi-researcher effort to understand how the forest vegetation interacts with solar radiation, air temperature and humidity to affect the water balance in the Cascade Brook Watershed. In addition to measuring a large amount of these data, Victor Engel's dissertation will combine these elements with a modeling effort to understand the leaf-level and soil-level controls on energy balance in the Cascade Brook Watershed.

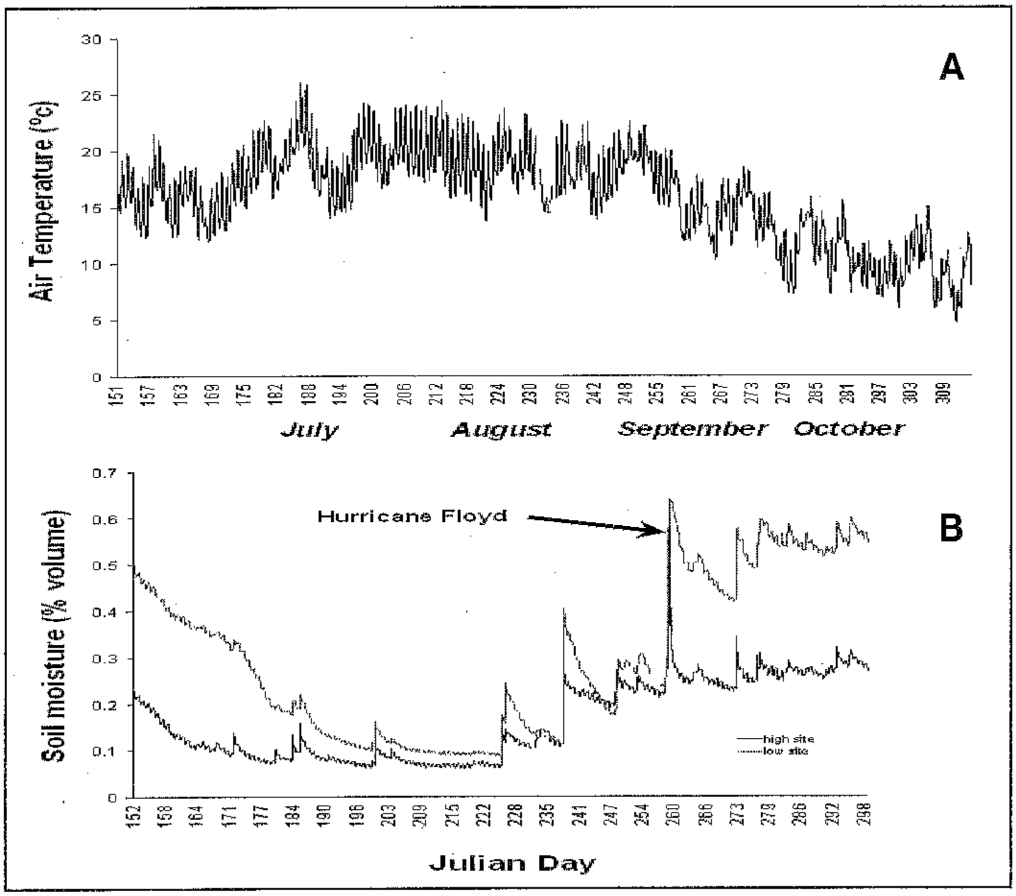


Report Figure 1. Many elements of the energy and water balance of the Cascade Brook Watershed are being measured by a number of collaborators: runoff and throughfall (J. Nichols, J. Simpson, and BRF staff); leaf-level conductance, long-term tree growth data, C:N ratios, tree sap flow, soil moisture, light interception and micrometeorological data (V. Engel and K. Griffin); leaf area index measurements (K.J. Brown and V. Engel); and forest inventory (W. Schuster and Black Rock Staff).

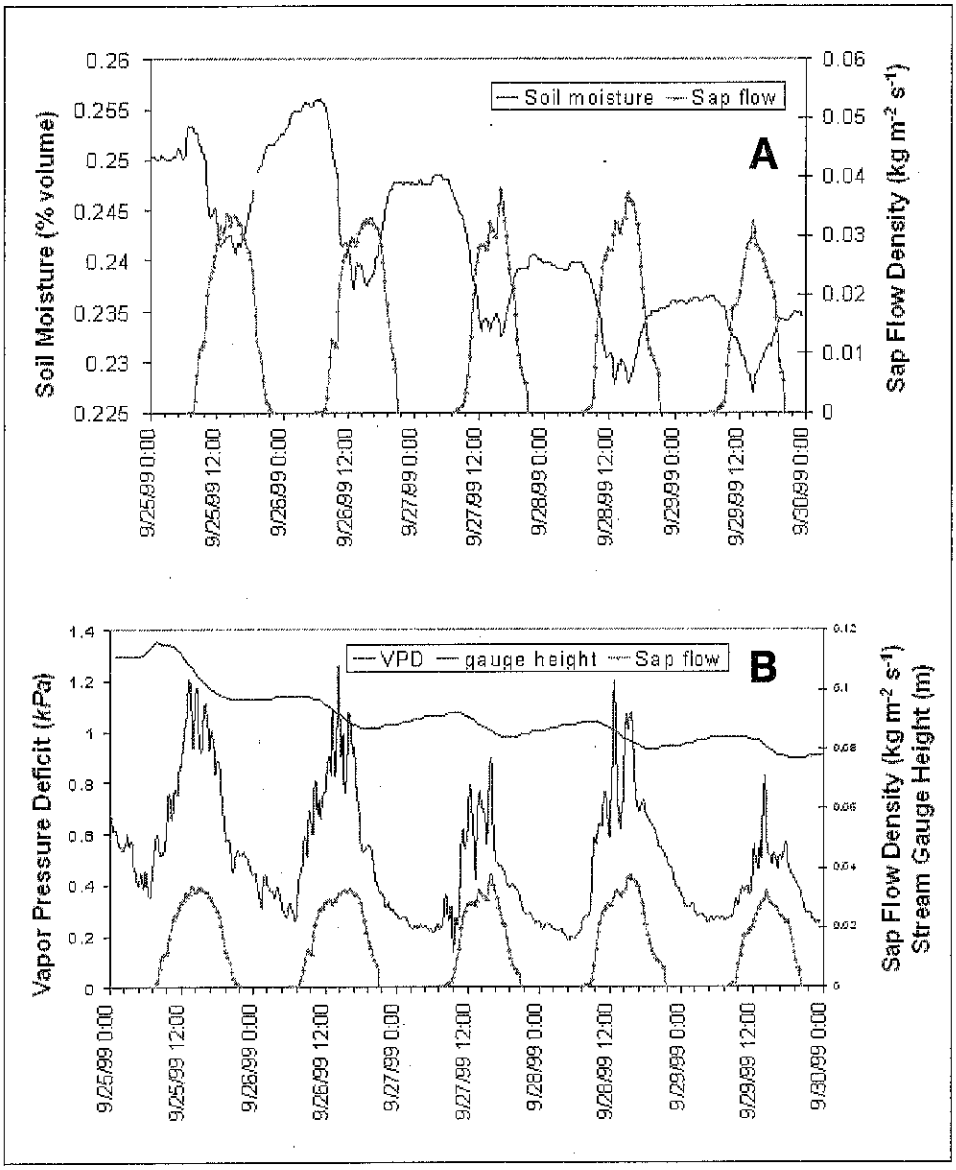
Results to Date

Air temperature, photosynthetically active flux density, net solar radiation, vapor pressure deficit, and soil moisture were successfully recorded for the 1999 growing season (with the exception of some missing data days due to data logger battery failure) (Report Figure 2). The soil moisture at the "low" site was found to be greater overall, with more rapid declines from conditions of high soil moisture than observed at the "high" site (Report Figure 2B). The larger amounts of soil available water at the "low" site were not surprising, as the site is at the bottom of the watershed catchment, where the soils are more organic and deeper. We hypothesize that the rapid drawdowns observed at the "low" site were a cause of the larger trees and larger amounts of functional leaf area at that site. In contrast, the "high" site lost quite a significant amount of leaf area due to the drought in 1999 and soil moisture drawdown rates were not as fast (Report Figure 2B). Hurricane Floyd, a significant soil moisture regeneration event, was clearly detected and resulted in a doubling of the soil moisture in an extremely short time period (Report Figure 2B).

Patterns of daily sap flux density were observed to closely follow patterns of vapor pressure deficit and soil moisture (Report Figure 3A and 3B), showing the close relationship between these variables in this system. Sap flow responses from trees in the "low" site may not be as quick to follow declines in soil and air moisture as those responses observed in the "high" site trees, due to the water capacitance in the larger trees and deeper soil of the "low" site (data not shown). Such interdependence between tree water use and soil and air moisture indicates that the energy and water balance closure of this system should be attainable.



Report Figure 2. Air temperature (A) and soil moisture measurements (B) made at "high" and "low" sites in the Cascade Brook Watershed during the 1999 growing season. (Air temp shown for "high" site only"). V. Engel, unpublished data.



Report Figure 3. Patterns of daily sap flow from a "high" site *Quercus rubra* closely follow patterns of vapor pressure deficit, stream gauge height, and percent soil moisture (Figures A and B).

Student Progress

Mr. Engel is preparing to present and defend his dissertation proposal in March 2000. In addition, the following abstract submitted to the Ecological Society of America's August 2000 Annual Meeting:

Controls on ecosystem water use in a forest characterized by moderate topographic relief: modeling results.

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# Marine Biological Laboratory, Woods Hole, Mass.

A coupled land-surface and hydrology model was developed by combining the SPA (Soil-Plant-Atmosphere; Williams *et.al.*, 1996) model with the modified TOPMODEL equations, snow and soil models from Stieglitz (1995). The model is driven by meteorological data collected in the Cascade Brook watershed (1.5km^2) in the Black Rock Forest near Cornwall, New York. The combined model is capable of simulating liquid and vapor phase fluxes of water from the leaf to watershed level. Model results are compared with observed data on leaf level gas exchange, tree sap flux, land-surface energy balance, soil moisture, and stream discharge.