**Tree Allometry: Quantifying Variation Using Data from the Hubbard Brook Experimental Forest**

**Abstract**

**Background and Significance**

The complex, three-dimensional structure of forest vegetation has long been a subject of interest in the fields of ecology, forestry and plant physiology. This structure, and the development of it through time, has many important implications for understanding biomass structure, competition, and nutrient cycling in forest systems. Furthermore, the ability to accurately and inexpensively assess carbon stores has recently become desirable following increased interest in and monetization of carbon sequestration (citation). Therefore, the goal of extrapolating important three-dimensional measurements (i.e aboveground biomass, volume, and carbon) from more easily obtainable two-dimensional measurements (i.e. diameter and height) has been the goal of many field studies and manipulative experiments.

In order to make these predictions, it is important to first understand the growth trajectory of trees. This is often conceptualized as a series of resource allocation “decisions” made by the individual tree (Weiner 2004). According to the classical view, at each point in time a tree has a given amount of resources and allocates them to various structures proportionally. According the allometric view, a tree has a resource allocation trajectory along a size, rather than time, gradient. This trajectory can also change as a result of variation in environmental conditions. This is referred to as allometric plasticity (Weiner 2004). The relationships between the environment, tree size and and resource allocation can then be used to inform models of the relationship between two-dimensional measurements and the three-dimensional parameters of interest.

Another concept central to this question is the universality of scaling in plants. This refers to the observation that most physical attributes of plants adhere to very simple relationships when viewed as a function of size (West et al. 2005). This fundamental principle of biology suggests, in contradiction to ideas regarding allometric plasticity, that the allometric relationships of trees would remain constant regardless of age or species. If the universal scaling laws apply to trees, it would follow that the resource allocation trajectory of trees must follow similarly simple functions (i.e. of the form ). Furthermore, the universal scaling laws imply that resource allocation trajectories are deterministic, and are not affected by changes in environmental variables.

The ability to address these questions has been hampered in the past by the high cost and effort associated with obtaining good data. In order to explore allometric relationships in trees, detailed measurements of mass and volume must be taken for the entire tree. This typically involves destructive sampling, and is therefore inhibitive in many cases. The data for this project are a synthesis of data from a multitude of smaller samples taken at the Hubbard Brook Experimental Forest in New Hampshire. The data thus represent an unusually comprehensive sample across different stand ages. This provides the unique opportunity to look more robustly at allometric relationships than is usually possible given the constraints of designing such a study.

**Objectives**

This paper will aim to establish whether the allometric relationships of trees vary with differences in stand age and species. If it is found that they do vary, this study will attempt to quantify these variations and develop a modelling framework for application to similar forest systems.

**Hypothesis**

We hypothesize that, because of the universality of scaling in plants, the allometric relationships of trees are not affected by differences in stand age and species.

**Research Design and Methods**

The data for this study come from a series of previous studies conducted over a period of 50 years at the Hubbard Brook Experimental Forest. The first of these studies, Whittaker et al. (1974), measured 93 trees from three species representative of the Eastern Hardwood forest found in the White Mountains of New Hampshire. The species sampled were: *Acer saccharum, Betula alleghaniensis,* and *Fagus grandiflora*. An additional 15 trees of the species *Picea rubens* and *Acer spicatum* were sampled from high elevation plots. All of the trees were felled and then extensive dimensional measurements were taken, including stem weight, root weight, leaf weight, stem volume, and 5-year growth. These measurements were then used to calculate component biomass and total volumes.

Almost 40 years later, Fatemi et al (2010), sampled trees in four, young even-aged stands in Bartlett Experimental Forest and White Mountain National Forest. The purpose of this study was to determine whether young stands exhibited different allometric relationships than the ones observed by Whittaker et al. (1974). Similar species were measured, with the addition of

**References**