# DERIVING METRICS OF FOREST MANAGEMENT HISTORY FROM SIZE-CLASSIFIED TREE STAND DATA

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## INTRODUCTION

Temperate forests in eastern North America have undergone many decades of direct anthropogenic-related changes (Orwig and Abrams 1994; Motzkin et al. 1996, 1999a; Donohue et al. 2000; Kittredge et al. 2003). Thus, an understanding of the patterns of species distributions and species diversity among forest patches or stands must be placed in the context of the human history related to the forest. This is particularly so for managed forests that experience repeated episodes of disturbance and often direct manipulation of species composition and structure. Kittredge et al. (2003) cite legacies of land ownership and timber harvesting in northeastern (US) forest lands that were nearly imperceptible to researchers using remote sensing but were exerting a major influence on forest composition, dynamics and habitat quality. These legacies result in weakened relationships between species distributions and environmental gradients that may persist for decades if not centuries (Foster et al. 2003; Vellend et al. 2007; Rhemtulla et al. 2009). If differences in species composition and diversity among forested sites arise primarily as artifacts of prior land use instead of the biotic and abiotic characteristics that are more routinely quantified, faulty hypotheses may be developed regarding the observed patterns of species distributions, species richness and beta diversity (Christensen 1989; Lawton 1999; Ricklefs 2008). This is a particularly relevant problem for community ecology because the covariation of species abundance data with environmental variables is most often interpreted without prior knowledge of land use Therefore; it is an appropriate task for ecologists to account for land use in any study of forested ecosystems. We restricted our analysis of land use to management history, and use this term throughout. Because management occurs at the scale of the forest stand[1], it is useful to quantify the effects of different management histories on the species composition and structure at that scale. Ordination and related multivariate techniques are the most promising avenue for deriving metrics of management history given that the primary data in community ecology are samples-by-species matrices that are inherently multivariate (Gauch 1982; Dray et al. 2012). These techniques require that the sample data are structured in a manner that incorporates both species diversity and structural complexity. What is needed is a simple and repeatable method for producing metrics of management history without the need for detailed records of prior land use. Although prior land use may be inferred from aerial photography, historical maps, or detailed historical records, this information is generally used for descriptive (i.e., comparing and contrasting patterns of species composition and diversity among forest types) rather than predictive purposes (Peet and Loucks 1977; Motzkin et al. 1999b; Sheil 1999; Verheyen et al. 1999; Jacquemyn et al. 2001; Aragon and Morales 2003; Herault and Honnay 2005; Hermy and Verheyen 2007; Vellend et al. 2007).

In the absence of historical data researchers must use metrics extracted from the sample data. Commonly, these metrics are sorting species data (abundance, cover, etc.) into classifications based on age (increment cores), size (stem diameters) or categorical stage-classes, (e.g., emergent canopy, subcanopy, saplings, seedlings, etc.) with the goal of extracting information about past disturbances and/or successional pathways. Despite the frequent use of these classifications, the strength of their relationships with actual management history are not explicit. In this paper we present methods of forest stand sampling and data analysis from a case study in inland dune and ridge woodlands on the lower Delmarva peninsula of Maryland. Specifically, our goal was to derive metrics of forest management history directly from size-classified sample data that may be used as explanatory variables in multivariate designs. We used Detrended Correspondence Analysis (DCA) to ordinate size-classified tree data and test the association of DCA scores (as response variables) with management data (as explanatory variables) using a general linear model (GLM). We were less interested in the significance and partitioning of individual effects via null hypothesis testing and instead focused on fitting an overall explanatory model (e.g. model selection, Johnson and Omland 2004).