

# Taxonomic and functional based beta diversity in a western Wisconsin forest community understory: stochastic versus deterministic community assembly

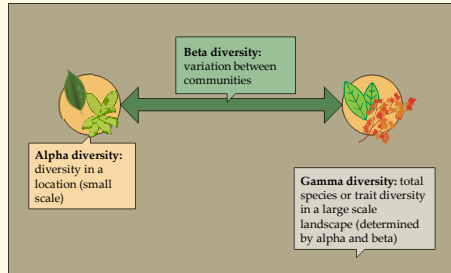


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## Introduction

Beta ( $\beta$ ) diversity is a measurement that defines the amount of variation between communities. High measures of  $\beta$ -diversity imply *stochastic* community assembly processes whereas low measures of  $\beta$ -diversity imply *deterministic* or niche-based assembly processes. This study investigates both taxonomic ( $\beta_{\text{species}}$ ) as well as functional ( $\beta_{\text{SLA}}$ )  $\beta$ -diversity in order to uncover the driving effects of environmental interactions on the assembly of plant communities.

## Alpha, beta and gamma diversity



## Definitions

**Stochastic community assembly:** organisms are randomly distributed into different communities (mixtures) based on dispersal and chance

**Deterministic community assembly:** organisms are selectively distributed into different communities based on their biotic and abiotic niche requirements

**Taxonomic Diversity:** species richness

**Functional Diversity:** richness of functional traits (attributes of a plant that aid in establishment, survival and fitness i.e. SLA)

## Methods

**Study Site:** Research was conducted June-August 2012 in the Chequamegon National Forest located near Medford, WI. The vegetation was primarily second growth sugar maple - hemlock forest.

23 relevés (sites with approximate homogeneous vegetation) spanned ridges, hillslopes, and wet swales

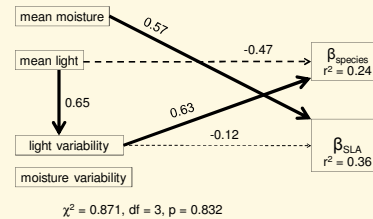
**Sampling:** 5 sample quadrats (1 m<sup>2</sup>) at each relevé; circular pattern (6 m diameter)

All understory plants were identified

**Specific Leaf Area** (cm<sup>2</sup> g<sup>-1</sup>) is a functional trait related to growth rate, shade tolerance, and drought intolerance. It was determined using the youngest, fully formed leaf collected from all species found within each quadrat. Imaging software was used to determine leaf area. Dry weight was also measured.

**Environmental variables:** Percent soil moisture was measured using the ThetaProbe soil moisture sensor at each quadrat. Light reaching the understory was measured as the fraction of full sun with a Decagon Accupar ceptometer.

## Results (1) $\beta_{\text{species}}$ was dependent on light, while $\beta_{\text{SLA}}$ was dependent on moisture



- ❖  $\beta_{\text{species}}$  increased with light variability, as might be expected from deterministic assembly processes
- ❖  $\beta_{\text{species}}$  decreased with light availability
- ❖ Light availability had direct negative effects on  $\beta_{\text{species}}$  and indirect positive effects (via variability); its net effect was close to zero ( $-0.47 + 0.65 \cdot 0.63 = -0.06$ )
- ❖  $\beta_{\text{SLA}}$  increased with soil moisture; however, there was no significant effect of moisture variability on  $\beta_{\text{species}}$  or  $\beta_{\text{SLA}}$

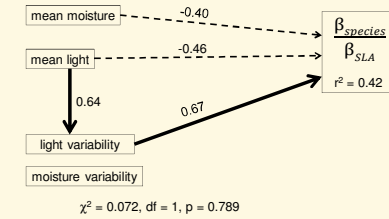


From left to right: Ilse Renner, Kaleigh Spickerman, Erik Lindberg, Vladislav Suntsov. Not pictured: Mariah Quick. Credit: Dr. Evan Weiher.

## Data Analysis: Structural Equation Modeling

- ❖ Structural Equation Modeling (SEM) was performed with the lavaan package in R
- ❖ SEM is a form of graphical modeling, and thus, a system in which relationships can be represented in either graphical or equational form
- ❖  $\beta_{\text{species}}$  was calculated using the mean Jaccard distance between the 5 quadrats in each relevé:  $J = (A + B + C)/C$
- ❖ C is the number of species found in both quadrats
- ❖ A and B are the number of unique species found between two quadrats
- ❖ Trait-based  $\beta$ -diversity ( $\beta_{\text{SLA}}$ ) was calculated as the mean difference in  $\log(\text{SLA})$  between the species found in one quadrat and the species found in a second quadrat
- ❖ The ratio ( $\beta_{\text{species}}/\beta_{\text{SLA}}$ ) is the degree that species assembly is stochastic relative to functional trait assembly

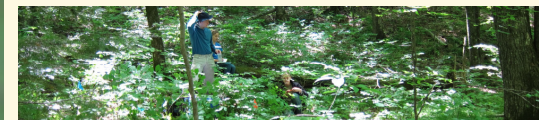
## Results (2) brighter and wetter conditions decreased the stochasticity of species assembly



- ❖ The ratio of the  $\beta$ -diversity measurements shows that species composition becomes relatively more stochastic than the trait composition at lower soil moisture and lower light availability
- ❖ At low soil moisture, plants were assembled deterministically based off their traits, but stochastically by species (drought filters species by their traits)
- ❖ There was no significant effect of moisture variability on the ratio
- ❖ The effect of light was complex

## Discussion

- ❖  $\beta_{\text{trait}}$  has been documented to a lesser extent than  $\beta_{\text{species}}$  in the literature, and virtually no publications look at the ratio of the two
- ❖ Different measures of  $\beta$ -diversity yield different implications for community assembly
- ❖ An integrated approach to measuring ecosystem function by including measures of species and trait  $\beta$ -diversity may be more informative than examining measures independently
- ❖ More studies of this sort are necessary for determining the best integrated approach in order to understand community assembly processes



## Acknowledgements

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## Sources

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