Does Biodiversity Make a Difference? Evolutionary Diversity Indicators of Forest Ecosystem Function Across Broad Regions

Northern riparian hardwood forest, Polk County, Iowa

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Southern longleaf pine savanna, Hale County, Alabama

Introduction

Biodiversity conveys numerous functional benefits to forested ecosystems, including community stability and resilience. Biodiversity metrics that account for evolutionary relationships among species may be better surrogates for functional diversity than traditional measures such as species richness.

Better understanding relationships between tree biodiversity and biomass stocking could guide management activities aimed to maximize carbon storage and/or biomass available for bioenergy.

We assessed trends in live aboveground tree biomass (LAGB) in relation to tree biodiversity calculated on Forest Inventory and Analysis (FIA) plots across the United States, controlling for site productivity and live tree stocking (Potter and Woodall 2014).

Methods

We calculated tree live aboveground biomass (LAGB), species richness (SR) and evolutionary diversity statistics (**Inset 1**) on 79,324 USDA Forest Service FIA plots (**Figure 1**).

To assess the relationship between LAGB and biodiversity, we controlled for stand stocking by calculating stand relative density (RD). We also divided plots into site productivity classes based on FIA productivity classifications.

We assessed correlations between LAGB and biodiversity within site productivity classes, after separating plots into stand stocking (RD) classes. Analyses were conducted nationally and within ecoregions.

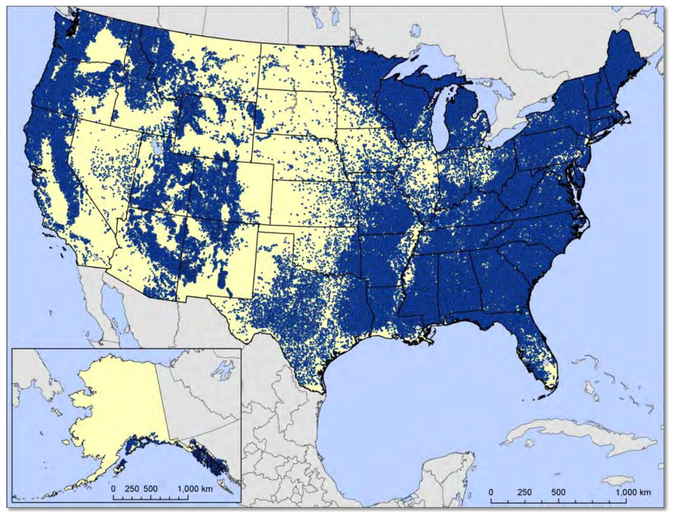
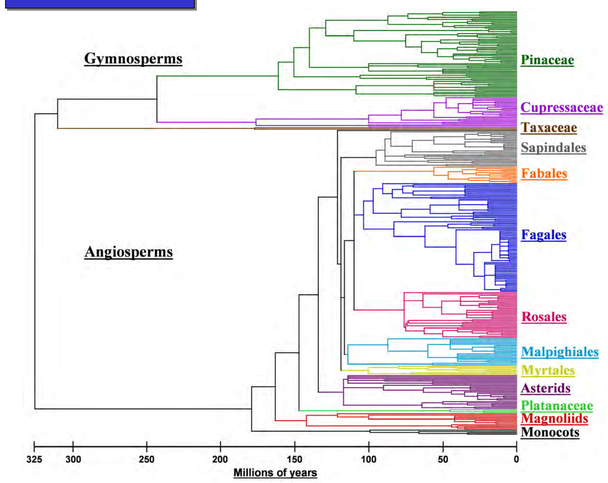


***Figure 1:** The 79,324 Forest Inventory and Analysis (FIA) plots included in this study.*

Inset 1



***Inset Figure:** Phylogenetic "supertree" of the 311 tree species inventoried by FIA, constructed in part based on a survey of re-\cent molecular systematic studies (Potter and Woodall 2012).*

Phylogenetic diversity (PD) is the total phylogenetic tree branch lengths (in millions of years) spanning the species in a community, taken from a phylogenetic "supertree" (**above**). PD is a more meaningful measure of biodiversity than species richness because taxonomically distinct species contribute more to the trait diversity within a community (Faith 2002).

Phylogenetic species clustering (PSC) quantifies the branch-tip clustering of species across the phylogenetic tree; it approaches 1 as species in a community are less closely related and 0 as they are more closely related (Helmus and others 2007).

Results

- Biodiversity is generally more closely associated with biomass on poorer sites and in less-densely stocked stands (Table 1).
- Exception: PSC increases with greater stand density on lower-productivity sites.
- Important regional differences exist in the association between biomass stocking and biodiversity (Figure 2); correlations are generally more positive and stronger on lower-productivity sites in the West and on higher-productivity sites in the East.

***Table 1:** Correlations between LAGB and biodiversity metrics within site productivity/relative density (RD) combinations*

***Low* site productivity**

RD	SR	PD	PSC
Low	0.50	0.41	0.42
Medium	0.44	0.31	0.47
High	0.38	0.27	0.49

***High* site productivity**

RD	SR	PD	PSC
Low	0.21	0.24	0.21
Medium	ns	-0.03	ns
High	-0.30	-0.24	-0.20

Discussion

- Complementarity mechanisms (e.g., niche partitioning and facilitation) may allow functionally different species to increase productivity in more stressful environments (SR and PD).
- On such poor sites, species more widely distributed on the phylogenetic tree (wider variety in functional attributes) accumulate more biomass (PSC).
- On the best sites, dominant, highly productive species may exclude others, leading to lower diversity-biomass correlation.

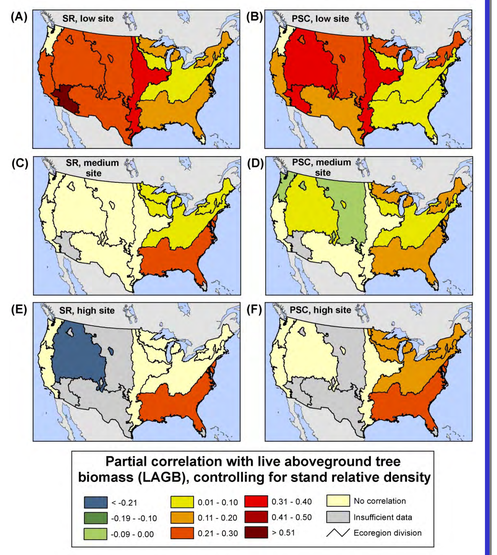


***Figure 2:** Partial correlations within ecoregions (controlling for stand relative density) between LAGB and species richness (SR) and phylogenetic species clustering (PSC) on low-productivity sites (A and B), medium-productivity sites (C and D) and high-productivity sites (E and F).*

Conclusions

- Biodiversity measures may be most critical for evaluating management on low quality and/or poorly stocked sites in areas not previously considered for forest management activities.
- These are the sites where biodiversity is most strongly associated with variation in live aboveground biomass; management of these sites could increase carbon storage and/or biomass for bioenergy.
- In certain situations, evolutionary diversity metrics supply additional information beyond that of species richness counts.

References

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