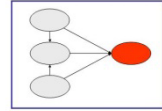


Using structural equation modelling to disentangle the drivers of understory species richness in eutrophic forest patches

Cord Peppler-Lisbach, Linda Beyer, Nadine Menke, Andrea Mentges

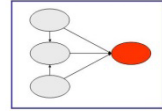
Landscape Ecology Group
Department of Biology and Environmental Sciences
Carl von Ossietzky University Oldenburg

14th Meeting on Vegetation Databases 2015

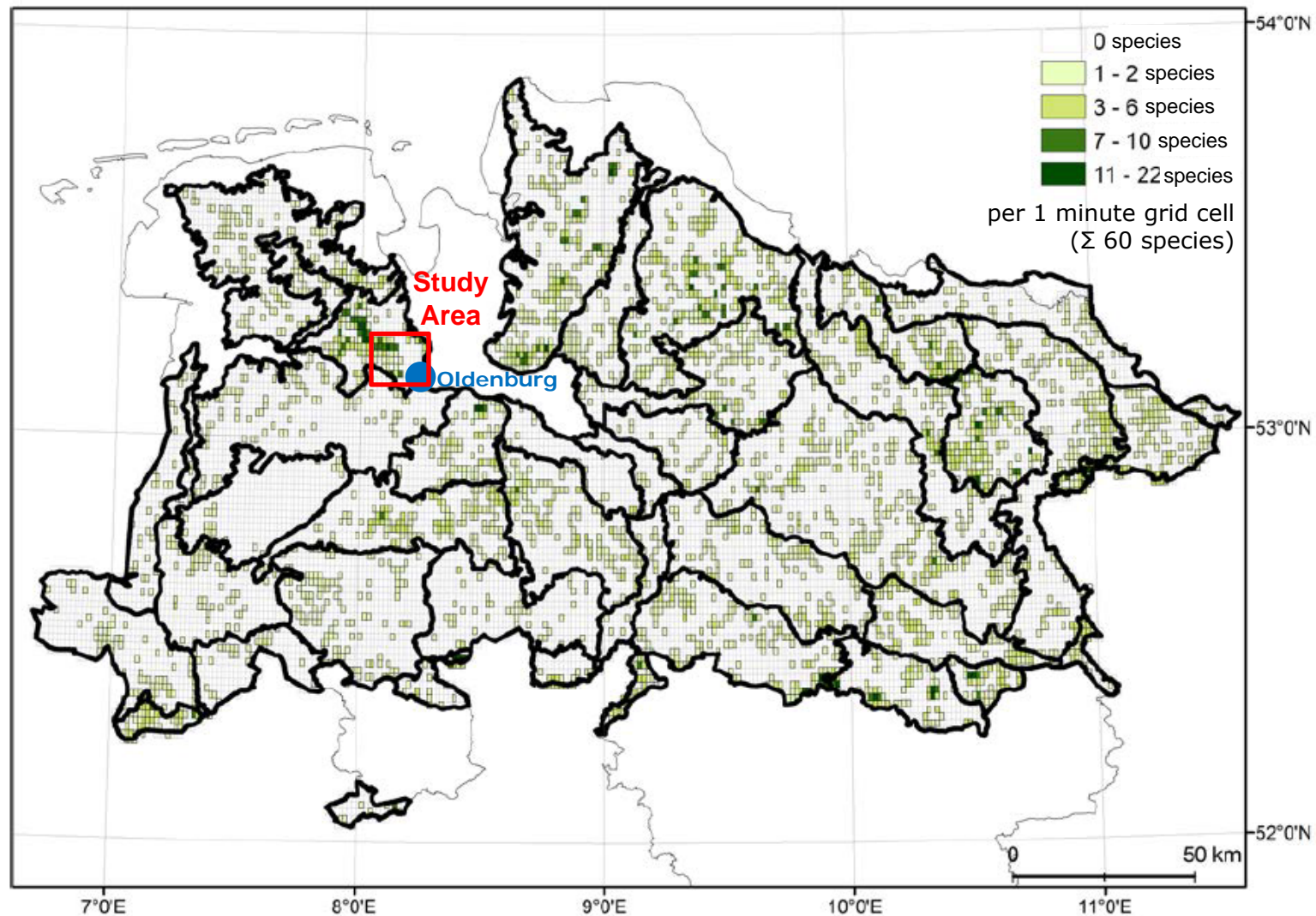


Features of eutrophic forests in NW Germany:

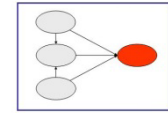
- high species richness of vascular plants
- habitats for specialized, partly endangered vascular plant species, e. g. *Primula elatior*, *Sanicula europaea*, *Phyteuma nigrum*, *Platanthera chlorantha*, *Paris quadrifolia*, *Equisetum hyemale*
- Dominant trees: *Fraxinus*, *Quercus*, *Carpinus*, *Alnus*
- restricted to sites with base-rich and moist soils
- in NW Germany, these sites are rare and isolated



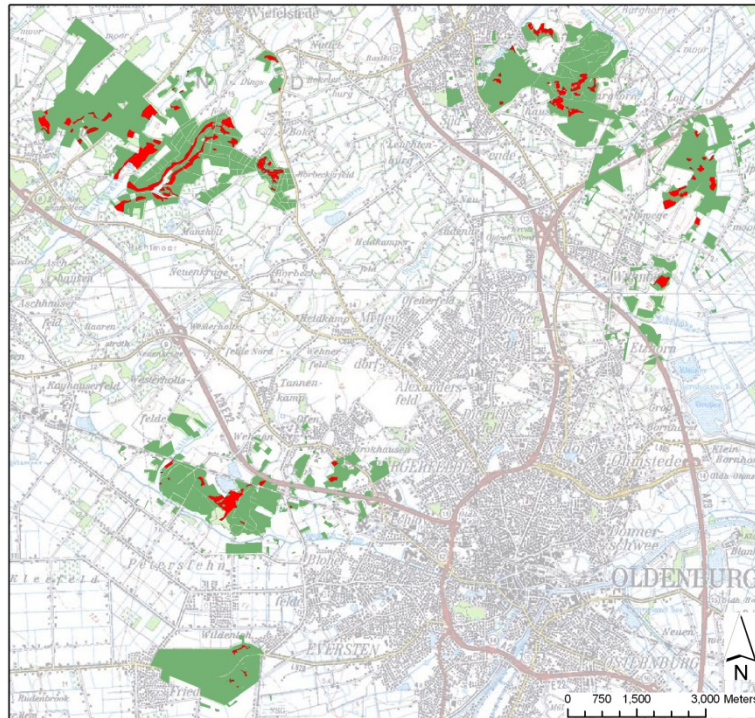
Presence of Red List forest species in lowland Lower Saxony (Culmsee et al. 2011)



Introduction

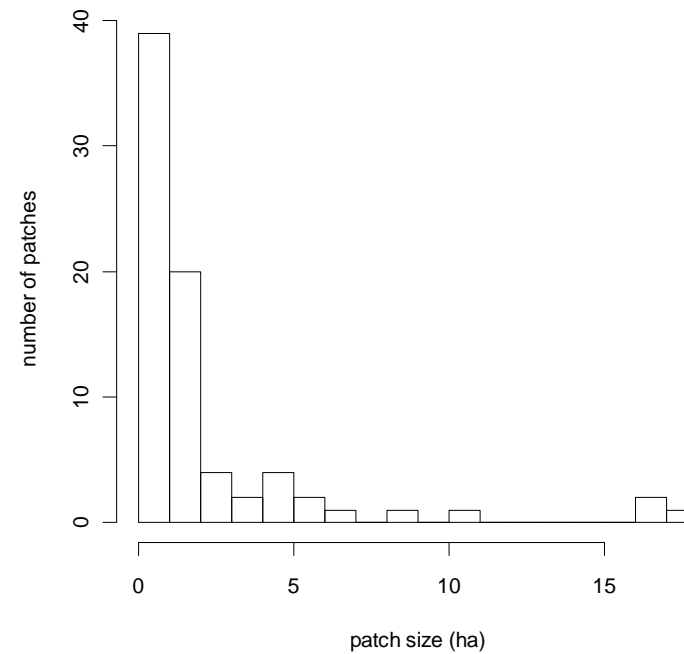


Study area

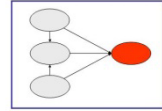


green: forest areas
red: eutrophic forest patches

76 eutrophic forest patches
Patch size 0.06 – 17 ha



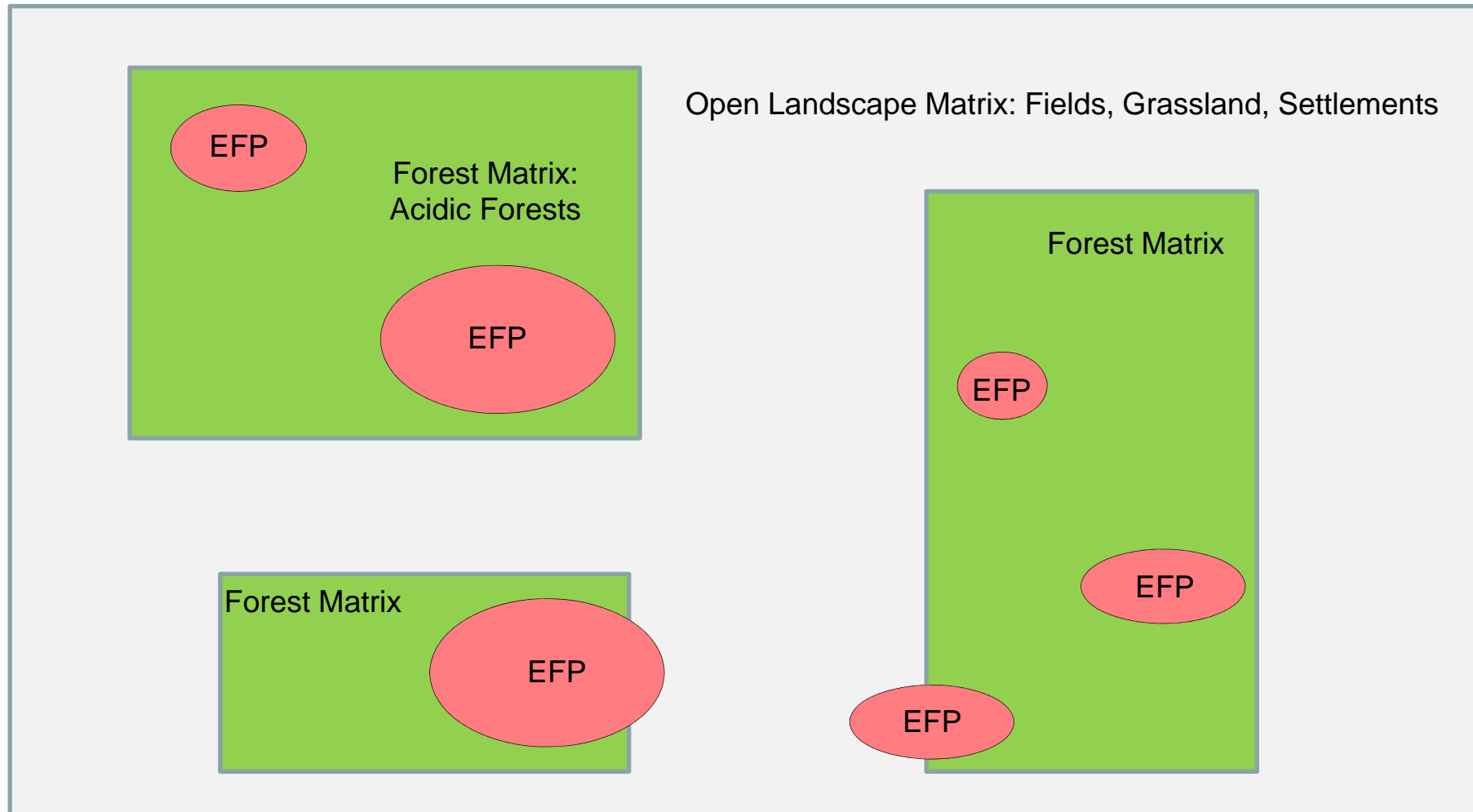
Introduction

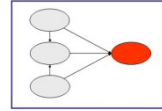


Eutrophic Forest Patches (EFPs):

Habitat islands embedded in different kinds of matrix vegetation

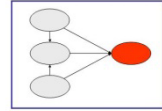
-> principles of island biogeography applicable





1. Data collection

- Plant species survey 2009-2010, two visits (spring/summer)
Complete list of understory herbs for each patch
- Site parameters
(patches \leq 1 ha 5 samples, 1 additional sample/ha)
 - Topsoil pH (CaCl_2)
 - Thickness of humus layer (L+OF)
 - Canopy Openness
(Spherical fisheye photographs, calculation with Gap Analyzer software)
 - Cover of herb layer
- GIS-derived parameters (ArcGIS)
 - patch size
 - path distance to nearest EFP (cost analysis weighted by matrix type)
 - proportion of ancient woodland (historic map 1900)



2. Statistical Analyses

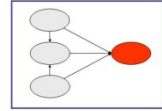
Response variables: Richness of different species groups

- all herb species (total richness) (Σ 202)

Sociological species groups:

- forest species (Σ 70)
- eutrophic forest species* (Σ 47)
- forest matrix species* (Σ 23)
- species of forests + open habitats (generalists) (Σ 73)
- species of open habitats (Σ 59)

(Species groups according to Schmidt et al. 2003, * derived from local database)

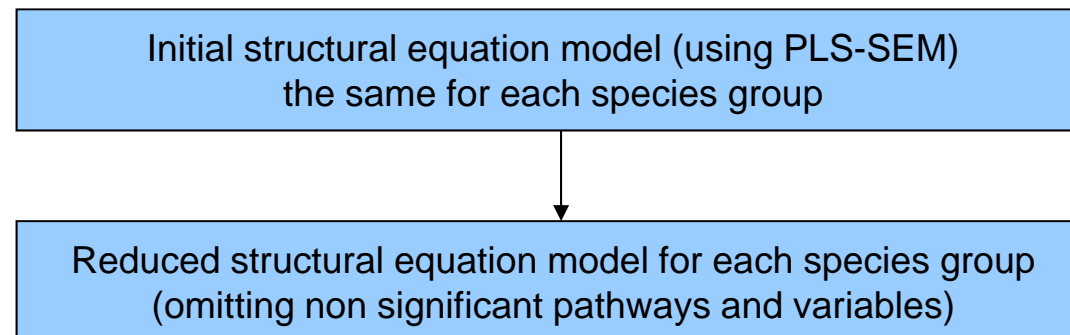


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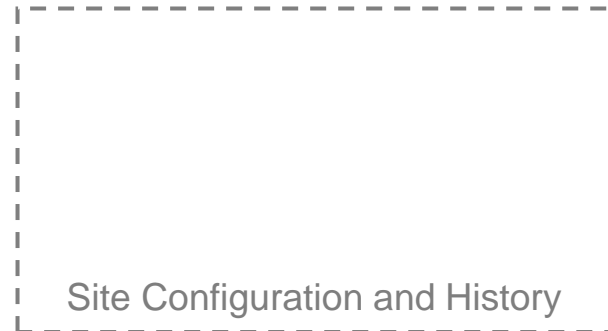
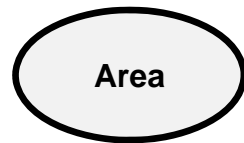
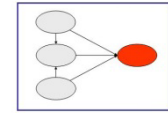
Response variables: Richness of different species groups

other species groups:

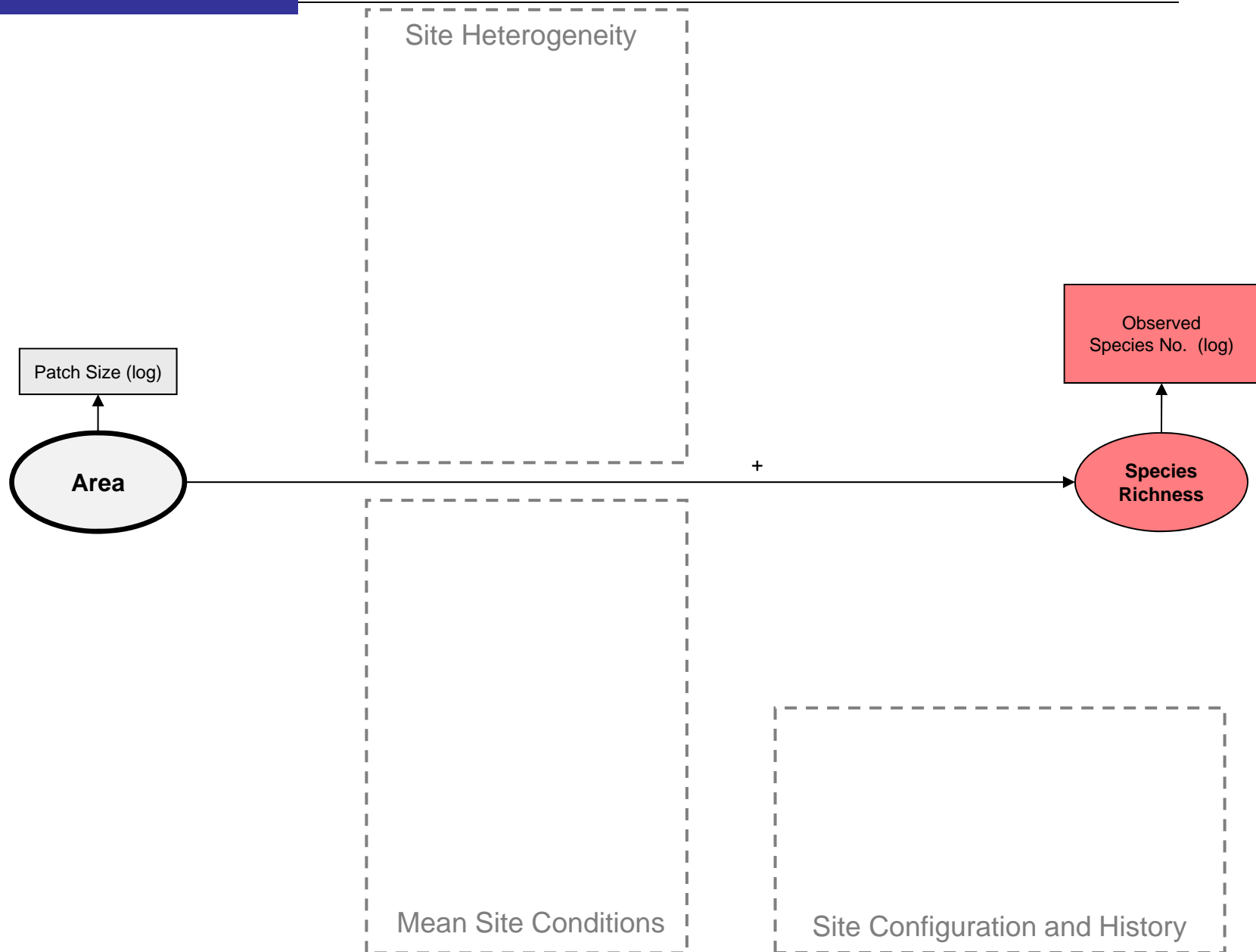
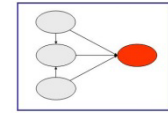
- Functional groups: Competitors, stress tolerators, ruderals
- Ecological groups: Light, moisture, base and nitrogen indicators
- Nature conservation groups: Ancient and recent woodland indicators, Red List species



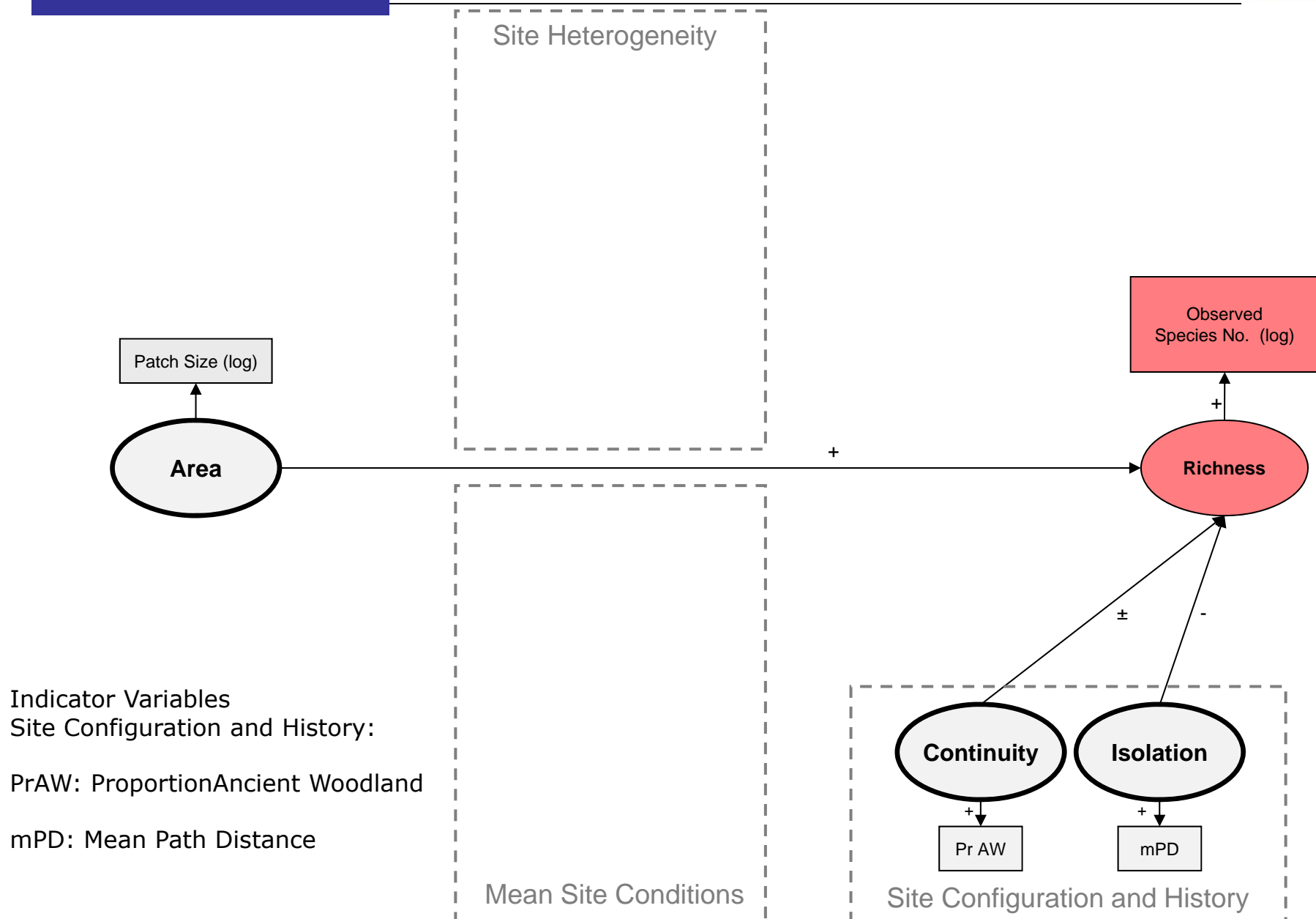
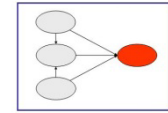
Methods: SEM



Methods: SEM

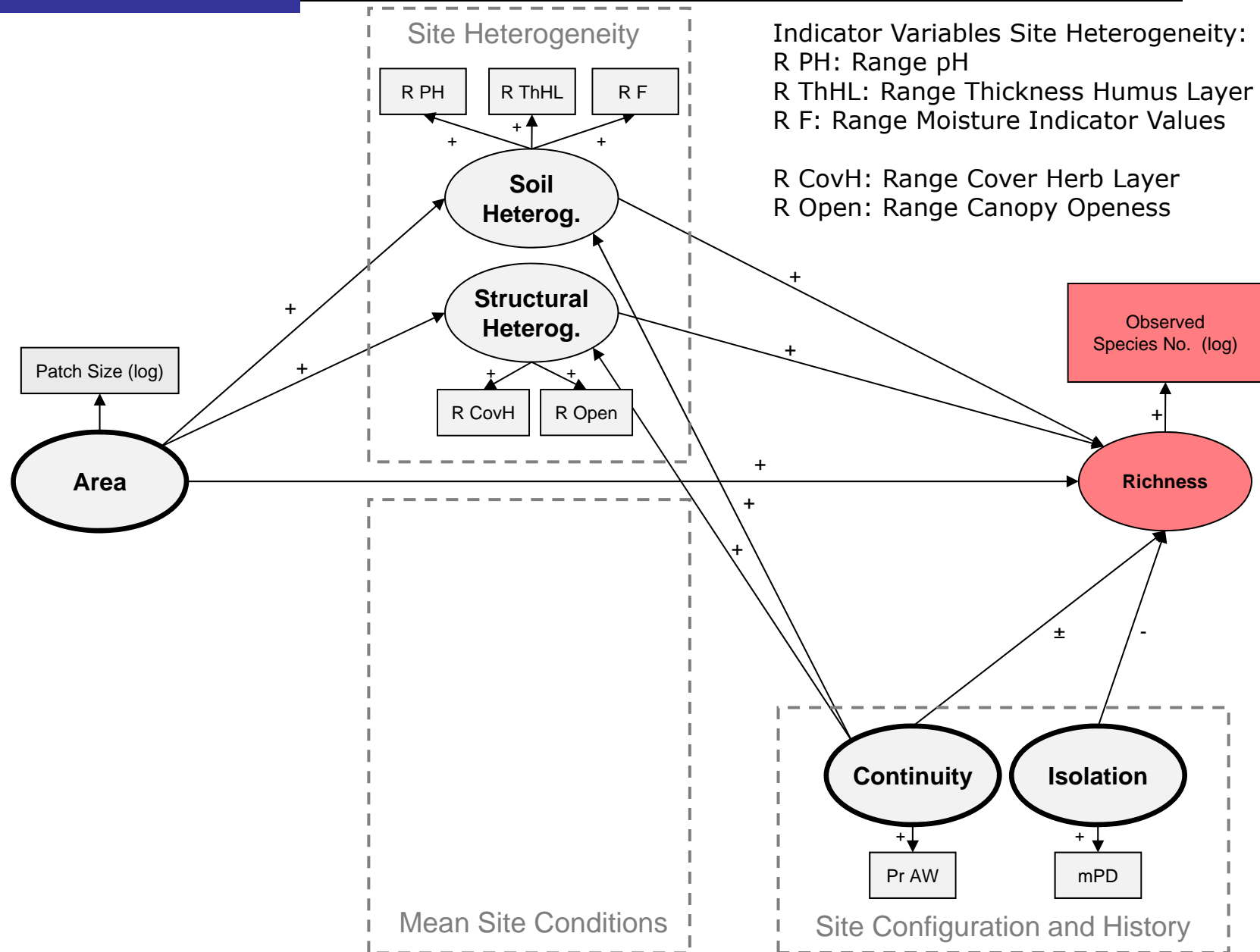
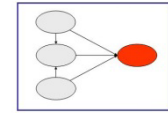


Methods: SEM

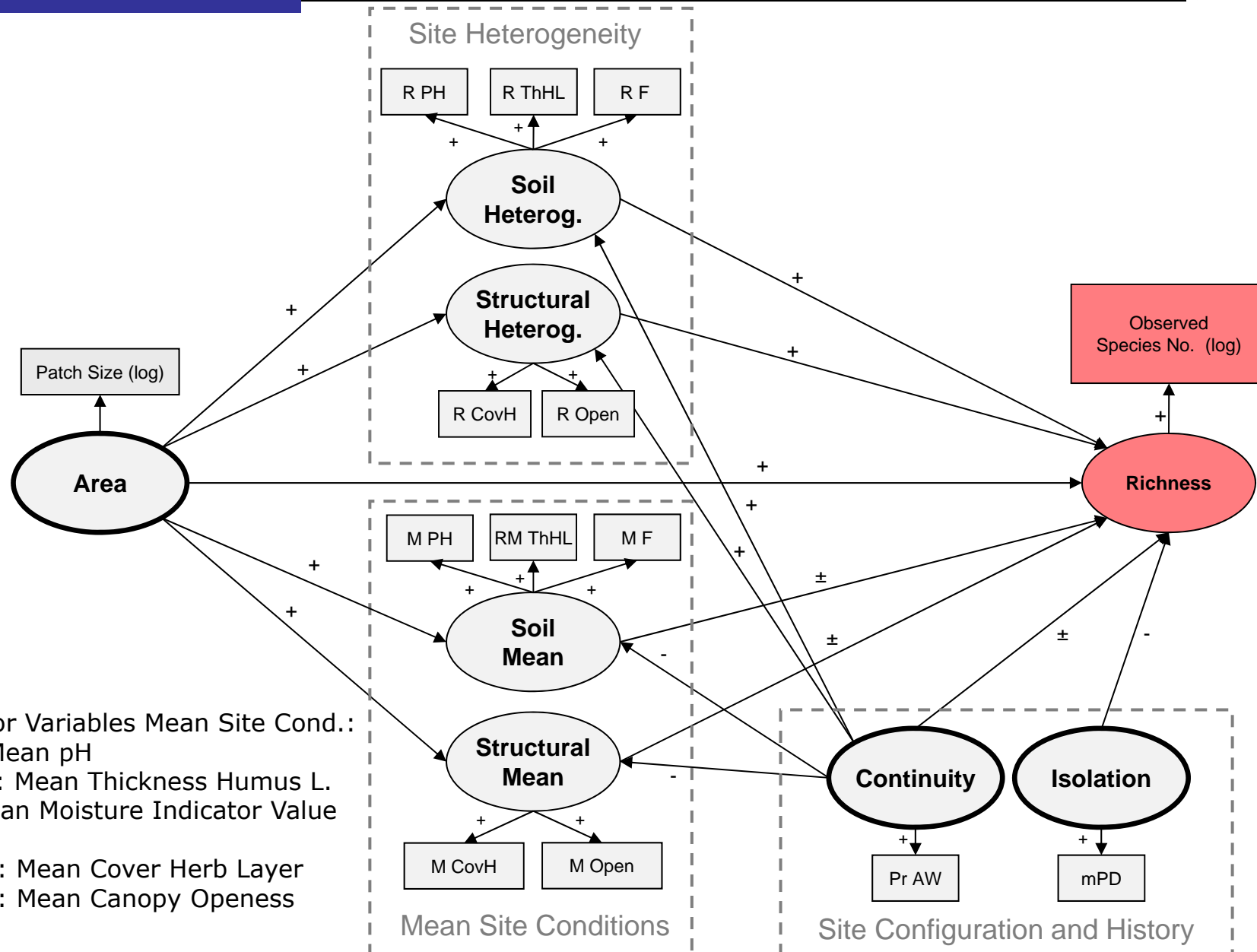
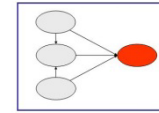


Indicator Variables
 Site Configuration and History:
 PrAW: ProportionAncient Woodland
 mPD: Mean Path Distance

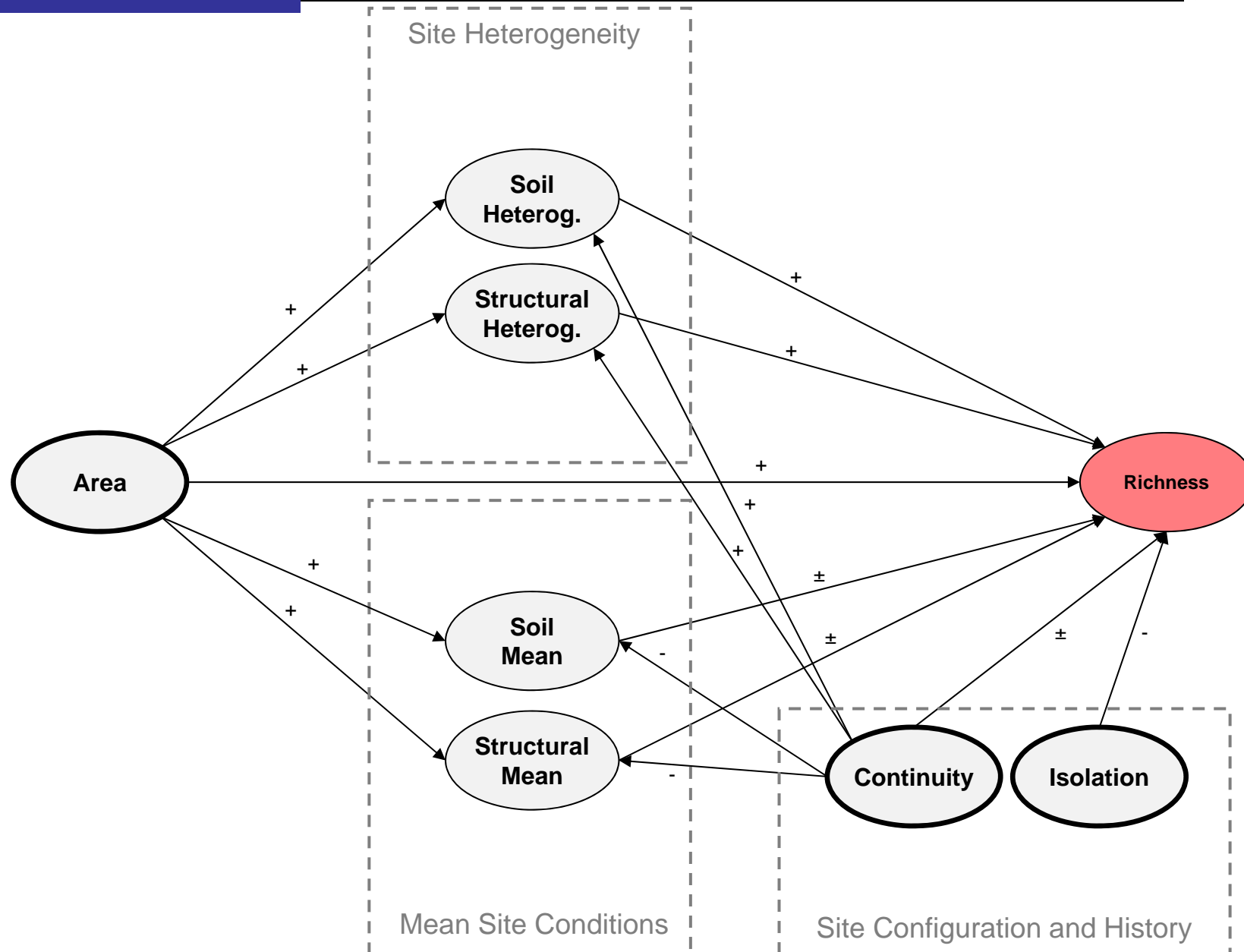
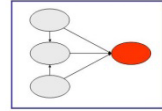
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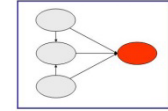


Methods: SEM

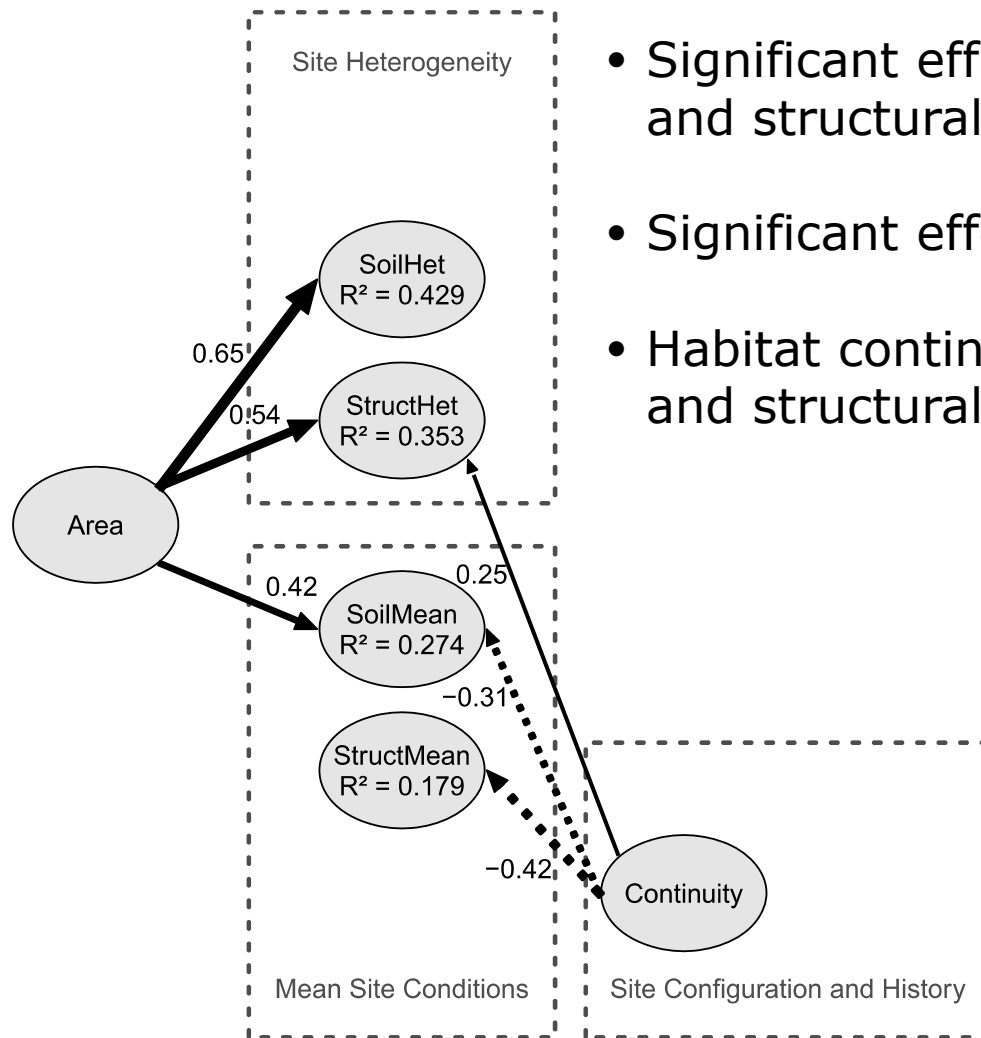


Methods: Initial Model





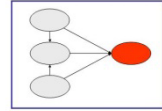
Reduced SEM for predictor relations



- Significant effects of area on soil heterogeneity and structural heterogeneity
- Significant effect of area on mean soil conditions
- Habitat continuity affects mean site conditions and structural heterogeneity

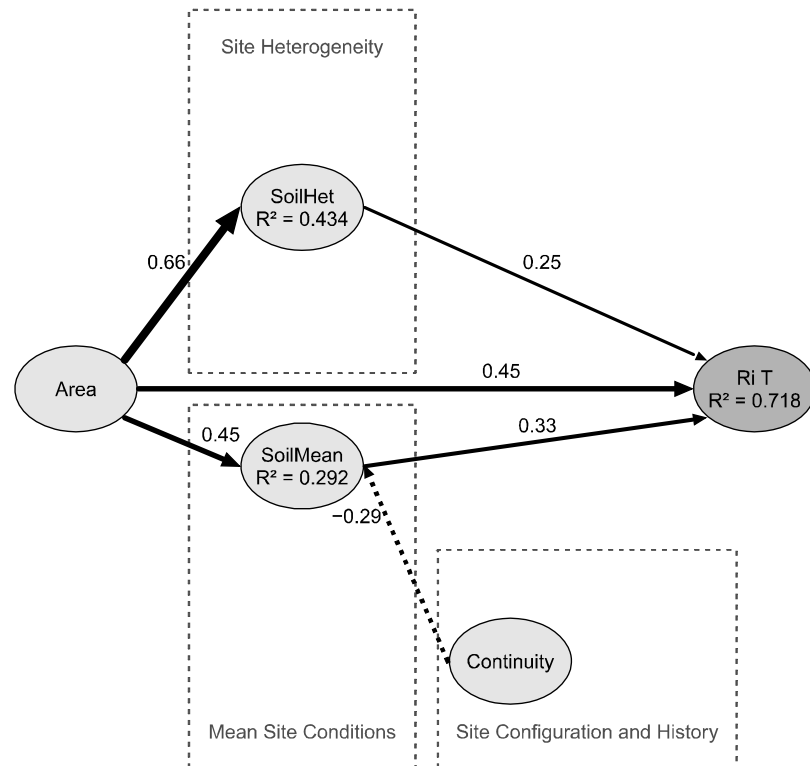
Solid line: positive effect
Dashed line: negative effect

Results

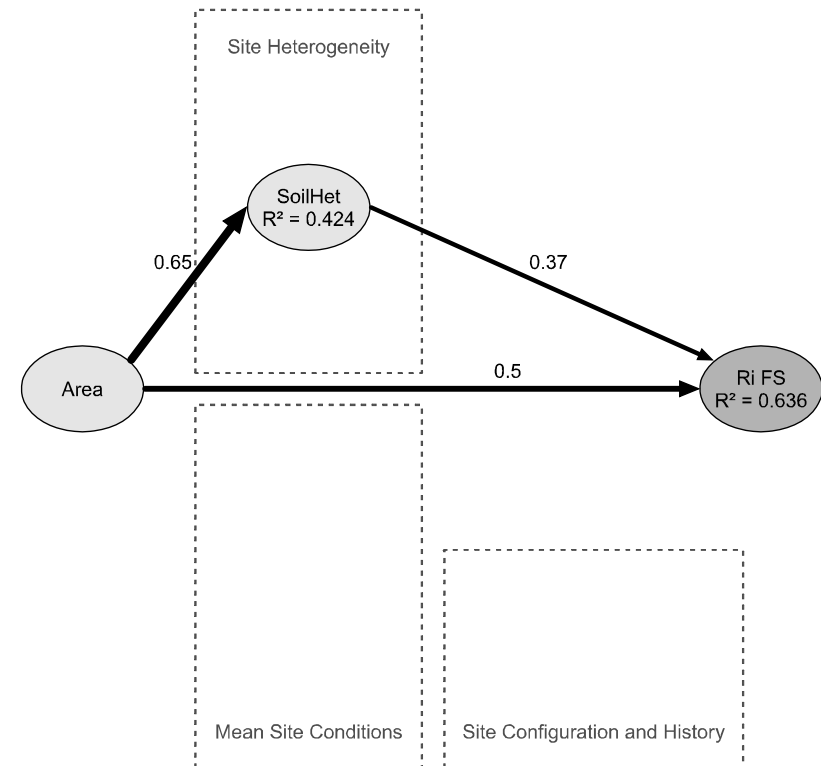


Reduced SEM for total richness and forest species richness

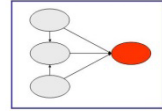
a) Total Richness



b) Richness Forest Species

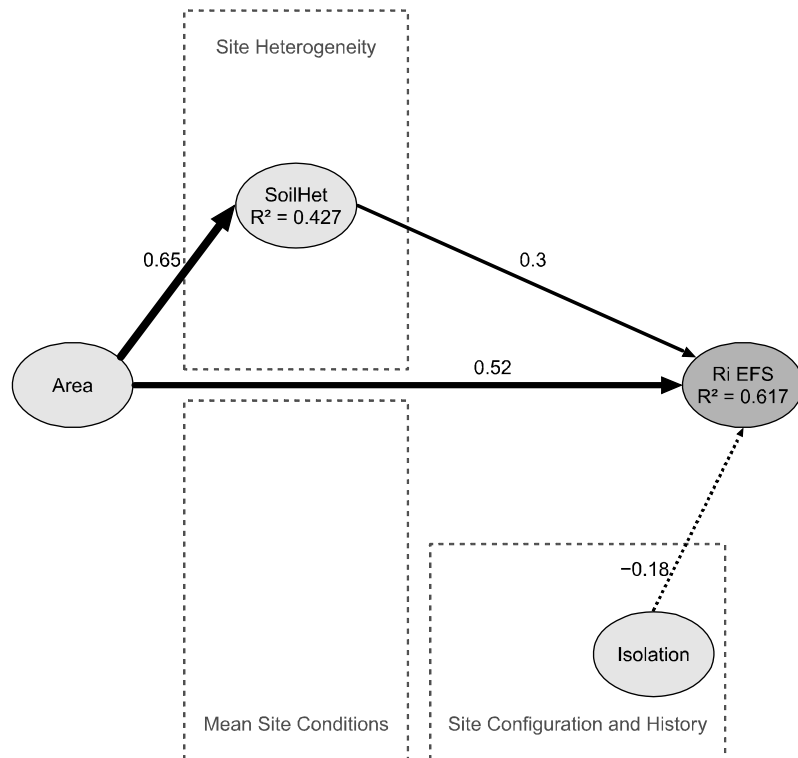


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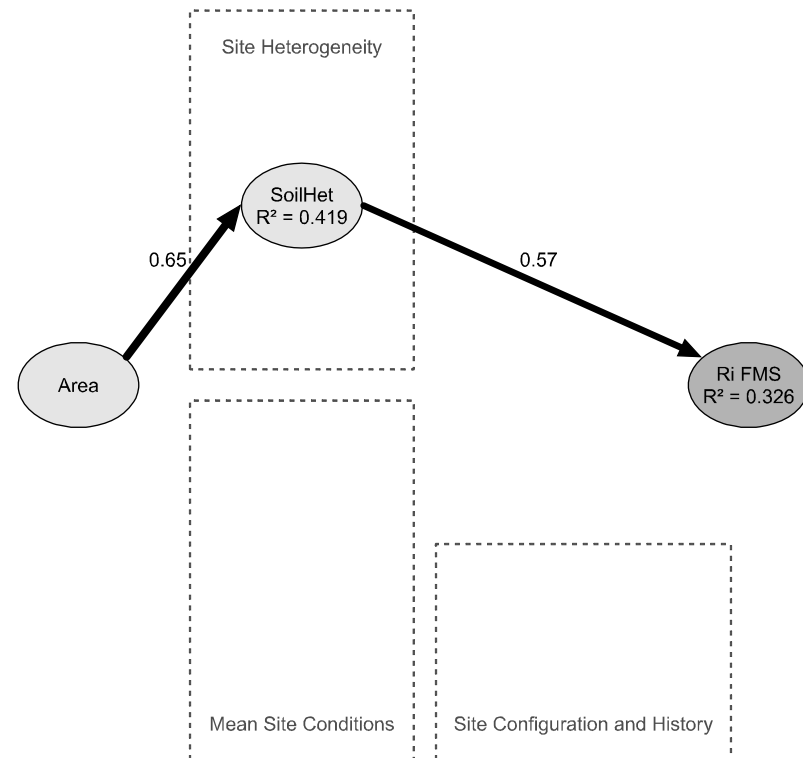


Reduced SEM for richness of eutrophic forest species and forest matrix species

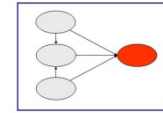
c) Richness Eutrophic Forest Species



d) Richness Forest Matrix Species

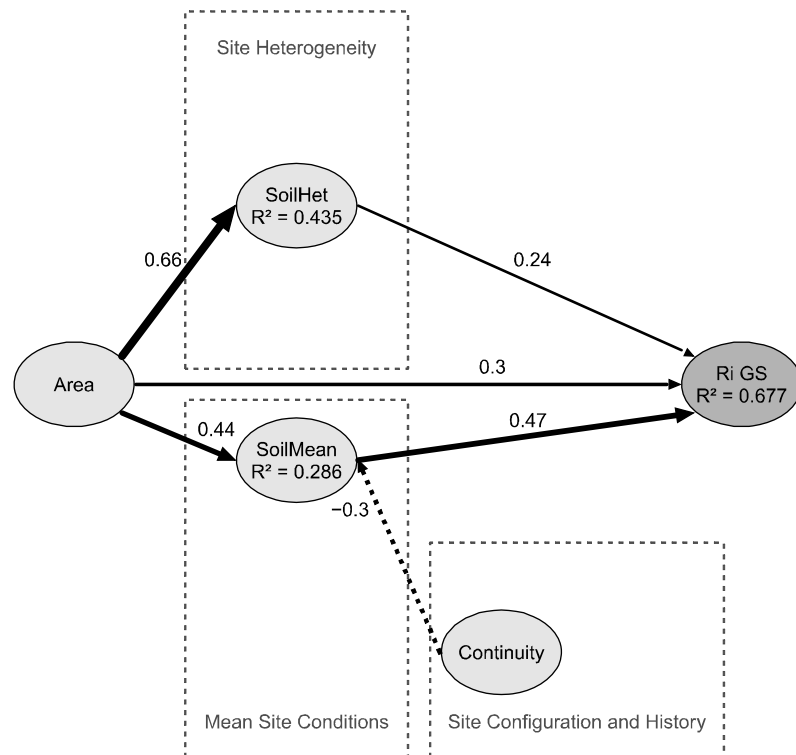


Solid line: positive effect
Dashed line: negative effect

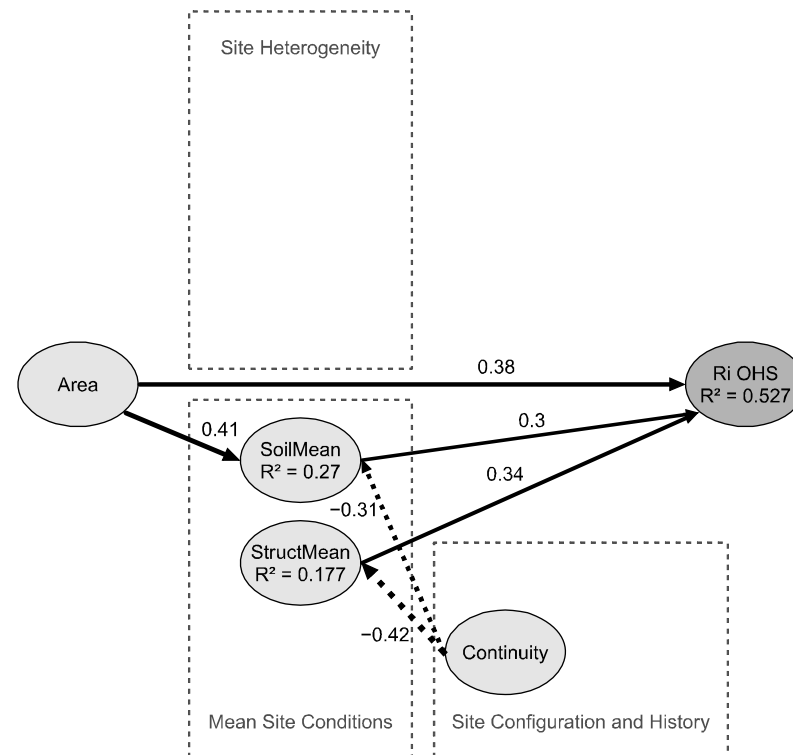


Reduced SEM for richness of generalists and open habitat species

e) Richness Generalist Species

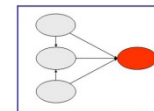


f) Richness Open Habitat Species



Solid line: positive effect
Dashed line: negative effect

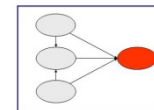
Results



Reduced SEM: other species groups Standardized total and direct effects on richness

Model	Model R ²	Area Total Effect	Area Direct Effect	Continuity Total Effect	Continuity Direct Effect	Isolation	Soil Heterog.	Mean Soil Cond.	Mean Struct. Cond.
Functional groups									
Richness Competitors	0.55	0.62	0.40					0.46	
Richness Stress Tolerators	0.54	0.58	0.33	0.31	0.31		0.38		
Richness Ruderals	0.48	0.69	0.69						
Ecological Groups									
Richness Light Indicator Species	0.65	0.62	0.24	-0.15			0.25	0.51	
Richness Moisture Indicator Species	0.77	0.73	0.38	-0.14			0.18	0.05	
Richness Base Indicator Species	0.67	0.75	0.44	-0.08			0.27	0.29	
Richness Nitrogen Indicator Species	0.55	0.65	0.47	-0.12				0.40	
Nature Conservation Groups									
Richness Ancient Woodland Indicators	0.49	0.64	0.41				0.37		
Richness Specialist Ancient Woodland Indicators	0.51	0.63	0.43			-0.18	0.31		
Richness Recent Woodland Species	0.54	0.60	0.30	-0.21	-0.21		0.24	0.30	
Richness Red List Species	0.50	0.67	0.46				0.31		

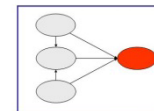
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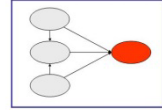
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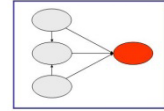
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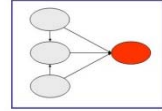
Summary

- Area
 - Dominant driver of species richness of eutrophic forest patches
 - Affects specialists and endangered species directly more than others, low or no direct effect on matrix species
- Heterogeneity
 - Soil and structural heterogeneity increase significantly with patch size however, only soil heterogeneity has an effect on species richness
 - Strong effects on forest species in general
 - No effects on open habitat species, N-indicators and competitors
- Mean site conditions
 - Especially important for richness of generalists, open habitat species, L-, R-, N- and recent woodland indicators
 - No effect on forest species
- Habitat continuity
 - Direct effects only on stress tolerators (+) and recent woodland indicators (-)
 - Indirect effect mediated by mean site conditions
- Isolation
 - Only important for richness of specialists



Conclusions: **Inference of ecological processes (?)**

- Direct area effects
 - Results suggest importance of large patches for habitat specialists and endangered species.
 - Causal background for direct area effects?
Lower extinction risk? Sampling effect? Unaccounted heterogeneity?
- Effects of site heterogeneity
 - Forest species richness supported by niche diversity (habitat filter)
 - Unaccounted effects of habitat continuity?
- Effects of mean site conditions
 - Richness of non-forest species supported by increasing size of species pool with increasing nutrient and light availability (habitat filter)
 - Indirect (and partly unaccounted) effects of patch history
 - No effect on weak competitors. No competition filter at the patch scale
- Effects of habitat isolation
 - Dispersal limitation of habitat specialists
 - Ongoing dispersal processes? Effects of fragmentation history?



Thanks to
AK Floristik Oldenburg, especially A. Hilbich, T. Homm, N. Kinder,
N. Könitz, R. Lühken, C. Neugart, A. Rath, D. Schabelreiter, J.
Schwienheer, H. Timmermann

Thank you for your attention!

Peppler-Lisbach, C., Beyer, L., Menke, N. & Mentges, A. (2014) Disentangling the drivers of understory species richness in eutrophic forest patches. *Journal of Vegetation Science*. DOI: 10.1111/jvs.12249