Stand structure as indicator of forest biodiversity in temperate mixed forest: a multi-taxon approach

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Aims

Investigating many organism groups in forests,

which environmental variables determine their diversity

environmental variables or organism groups are better indicators for general forest biodiversity

Novelty:

Many organism groups

Detailed environmental variables of different spatial and temporal scales

Practical aims

Can we predict forest biodiversity by models based on simple stand level variables?

Potential explanatory variables:

Tree species composition:
    Tree species richness
    Proportion of tree species
 Stand structure:
    Size distribution of trees
    Shrub layer
    Mature trees
    Deadwood
 Light conditions
    Relative diffuse light (mean, heterogeneity)
Litter (amount, chemical properties)
Soil (physical, chemical properties)
Microclimate (temperature, air humidity)
Landscape variables:
    Proportion of landcover types (r=300 m)
    Heterogeneity of landcover types
 Historical variables:
    Proportion of landcover types (r=300 m) in
1853

Organism groups: (abundance, diversity, functional groups)

herbs

 seedlings

bryophytes_ground floor

bryophytes_epiphytes

lichens_epiphytes

fungi_terricolous saprotrophic

fungi_mycorrhiza

fungi_wood-inhabiting

spiders

ground beetles

saproxylic beetles

 birds

???

→

Study area:
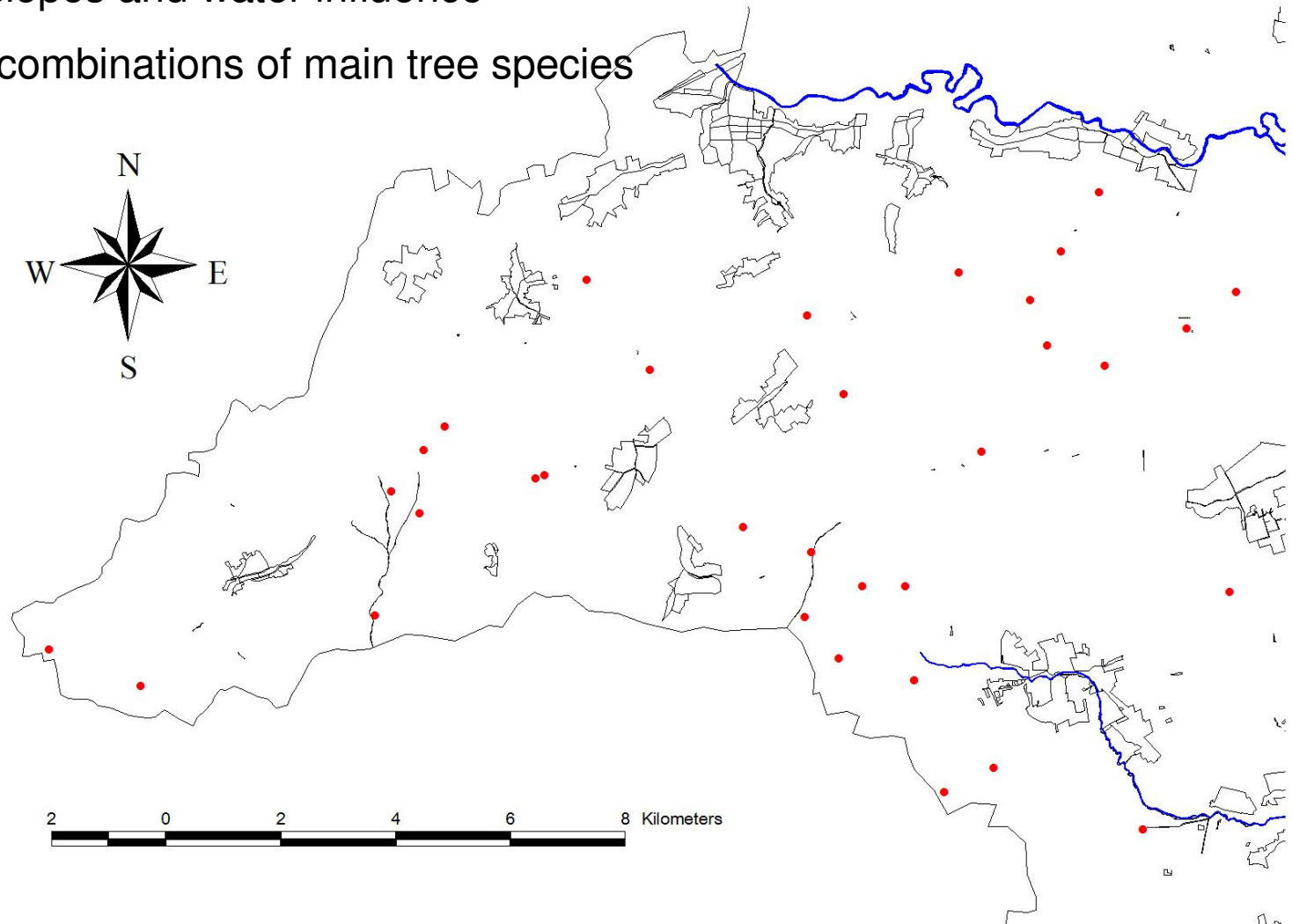
Őrség National Park

35 studied stands

Stand selection by stratified random sampling:

stands older than 70 year

excluding steep slopes and water influence

representing the combinations of main tree species

Field survey

herbs, seedlings, ground floor bryophytes: cover

epiphytic bryophytes and lichens: cover on trees >20 cm DBH

fungi: fruit bodies, 3 occasions
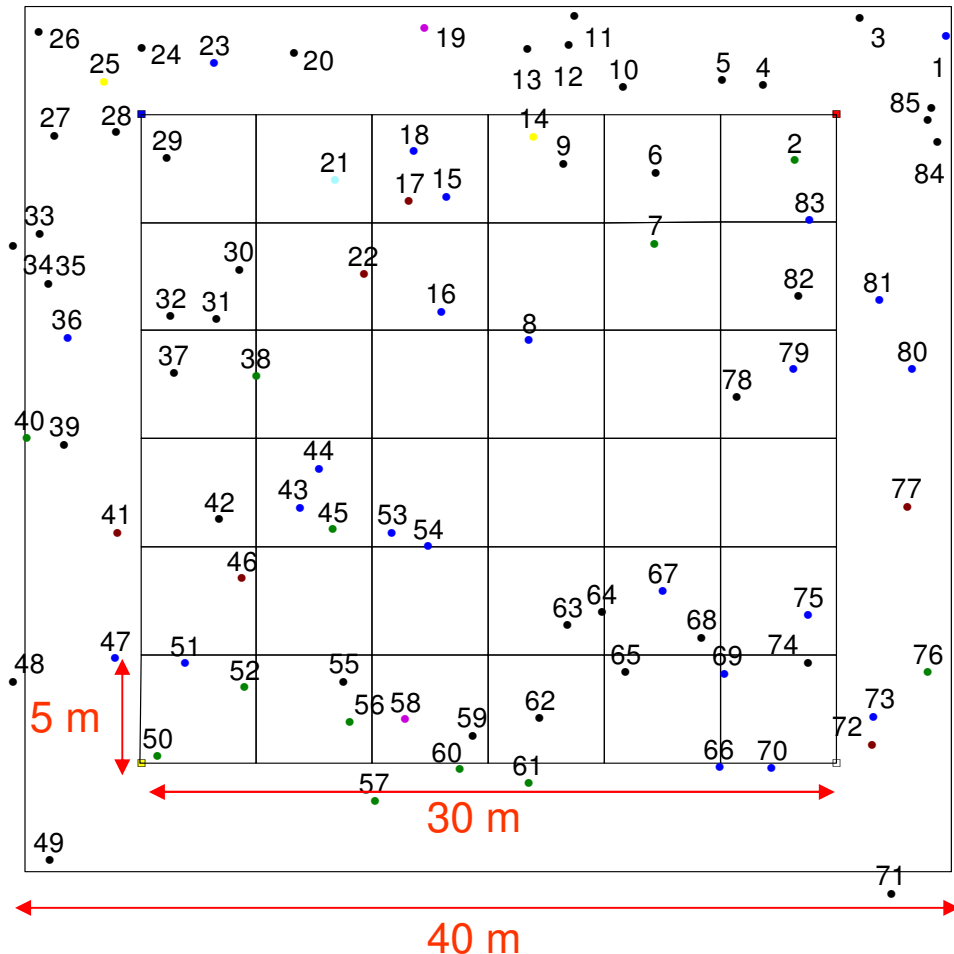
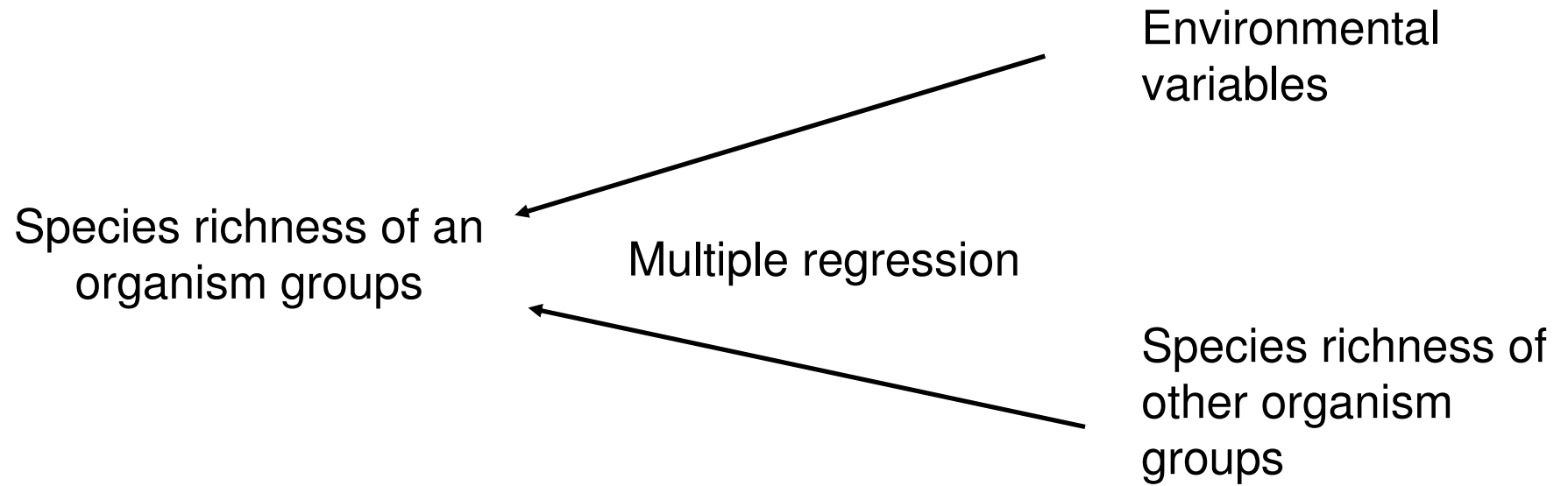spiders: air suction collector, soil traps, 8 occasions

ground beetles: soil traps, 3 occasions

saproxylic beetles: trapping logs after light eclectors (3 tree species)

birds: point sampling, 2 occasions

5 m

30 m

40 m

Analysis of species richness

Environmental
variables

Species richness of an
organism groups

Multiple regression

Species richness of
other organism
groups

Species richness models using organism groups versus environmental variables as predictors (R^2)

Dependent variable: species richness	Explanatory variables	
	Organism groups	Environmental variables
herbs	0.75 seedlings, lichens	0.51 light, tree diversity
seedlings	0.71 herbs, spiders	0.40 light, tree diversity
bryo_floor	0.47 herbs, spiders	0.53 litter (-), shrub, tree diversity
bryo_epi	0.09 lichens	0.54 shrub, tree diversity, tree size
lichens	0.31 herbs	0.68 oak, shrub, light

	Organism groups	Environmental variables
fungi_tersap	0.45 fungi_wood, herbs	0.58 temperature(-), litter pH
fungi_myc	0.45 spiders, fungi_wood	0.36 temperature (-), litter pH
fungi_wood	0.45 birds, fungi_tersap	0.37 dead wood, litter pH
spiders	0.43 fungi_myc, ground beetles	0.60 dead wood, litter
ground beetles	0.27 spiders, fungi_tersap	0.19 humidity, pine
saproxylic beetles	-	0.27 history, shrub(-)
birds	0.38 fungi_wood	0.40 tree size, floor cover, dead wood

Summary of the relationships

herbs

bryo_floor — seedlings

bryo_epi

lichens

fungi_tersap

fungi_myc

fungi_wood

birds

spiders

saproxylic
beetles

ground
beetles
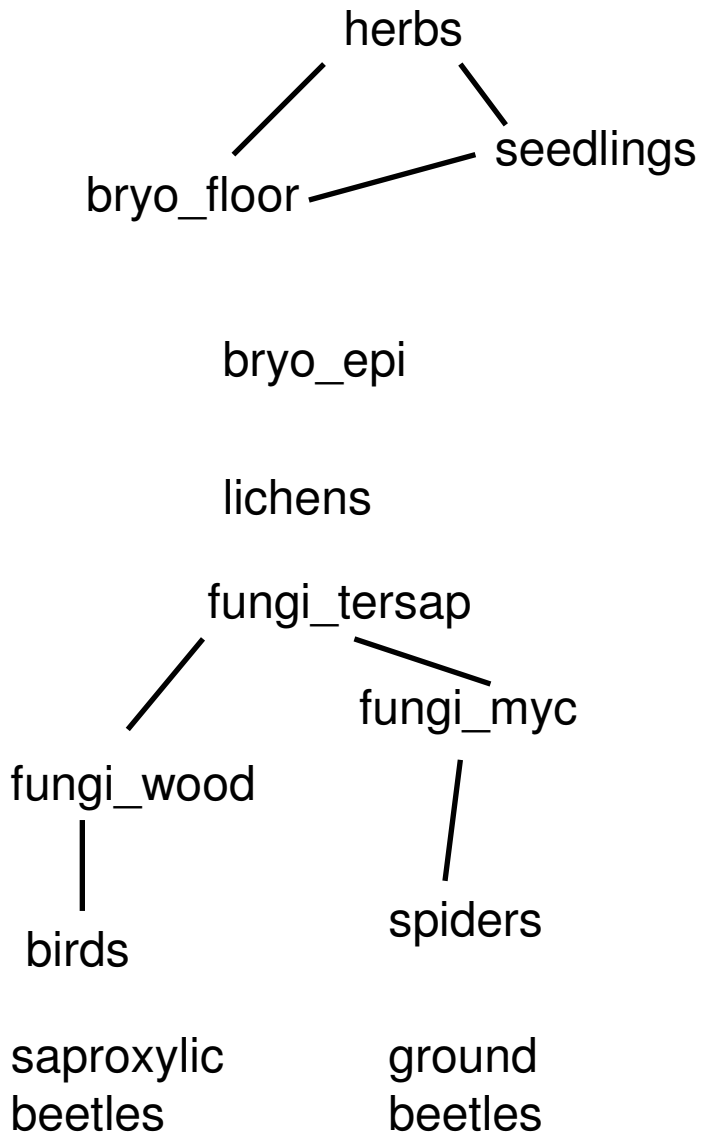
Summary of the relationships
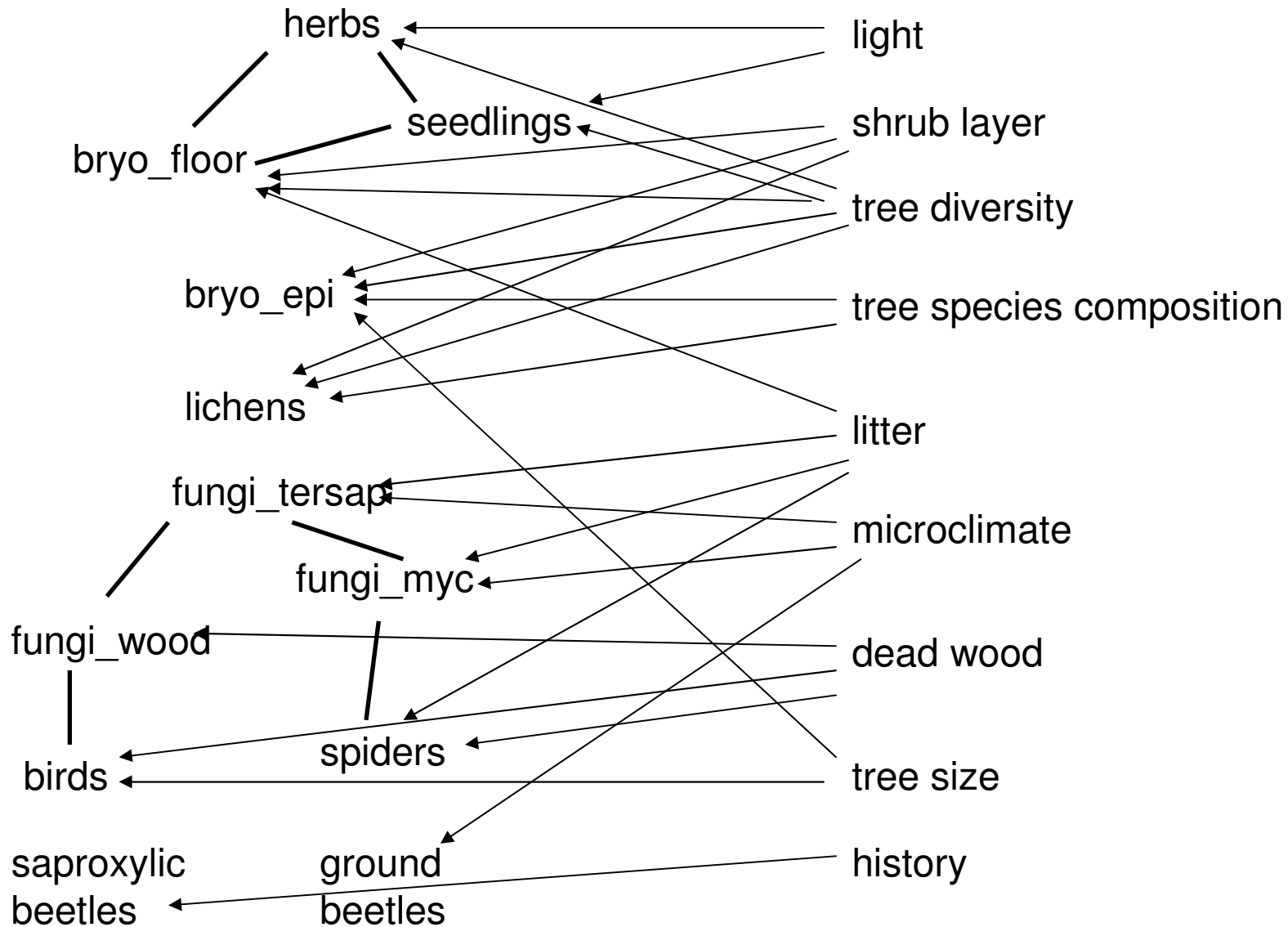
For forest biodiversity the best indicators:

organism groups: herbs, spiders, terricolous saprotrophic fungi

environmental variables: shrub layer, litter, tree species richness, microclimate,

Strong relationships between species richness and environment:

lichens, spiders, terricolous saprotrophic fungi, bryophytes

Direct survey suggested:

herbs, birds

Problematic groups:

saproxylic beetles, ground beetles

Practical considerations

The used models are appropriate for regional prediction of forest biodiversity based on stand structural data

The most important environmental variables of forest biodiversity are related to current, stand level management

Management should be focused on: tree species diversity, shrub layer, heterogeneous light conditions, tree size (age), dead wood

Tree selection (group selection) management is better for biodiversity than shelterwood management

Further questions:

The observed relationships has general or only regional relevances?

Collaboration with other studies

Thank you for your attention!

Species composition

Determinant environmental variables for species composition is selected by Redundancy Analysis

Similarity of species composition

Species (env. variables)

x plot matrices

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Distance matrices between plots

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Correlations between distance matrices

	R^2	environmental variables
herbs	0.32	light, tree species richness, tree density, mixing trees
seedlings	0.51	beech, tree species richness, light, tree density
bryo_floor	0.54	litter, shrub, large trees, acidity
bryo_epi	0.44	oak, temperature, DBH, pine
lichens	0.57	light, pine, oak, hornbeam

	R^2	environmental variables
fungi_tersap	0.46	pine, temperature, deadwood, litter pH
fungi_myc	0.49	beech, DBH, landscape forest, litter pH
fungi_wood	0.44	beech, pine, temperature, hornbeam
spiders	0.43	beech, light, dead wood, soil texture
ground beetles	0.18	hornbeam, humidity, litter N
saproxylic beetles	0.18	dead wood, shrub
birds	0.15	DBH, floor cover, pine

Correlations between distance matrices

	herbs	seedlings	bryo_floor	bryo_epi	lichens	fun_tersap	fun_myc	fun_wood	spiders	gr. beetles	sap. beetles	birds
env				0.30	0.39	0.41			0.32			
herbs	-	0.60	0.54									0.34
seedlings	0.60	-	0.52						0.35		0.17	
bryo_floor	0.54	0.52	-		0.48						0.19	
bryo_epi				-								
lichens				0.35	-							
fun_tersap						-	0.38	0.52		0.33		0.27
fun_myc							-	0.30				
fun_wood						0.52	0.30	-		0.27		
spiders									-			
gr. beetle										-		
sap.beetle											-	
birds												-