Environmental, Spatial and Structural Components in the Composition of Mountain Forest in the Bavarian Alps

Barbara Michler, Jörg Ewald, Hagen Fischer,

University of Applied Sciences, Faculty of Forestry, Freising

14th Meeting of the German Working Group on Vegetation Databases

Oldenburg, **4. – 6. März 2015**

WINALP

Waldinformationssystem Nordalpen

WINALP

Waldinformationssystem Nordalpen

Background

- **WINALP was launched to deliver ecological planning tools for future management of mountain forests.**
- **Knowledge of ecological gradients is crucial in managing mountain forests.**
- **This study aimes to contribute to this task by analysing the variation of species composition and its relationship to site factors .**

Outline

WINALP
Waldinformationssystem Nordalpen

- **Study region**
- **Questions**
- **Sampling design**
- **Data Acquisition**
- **Data Analyses**
- **Results**
- **Conclusion**

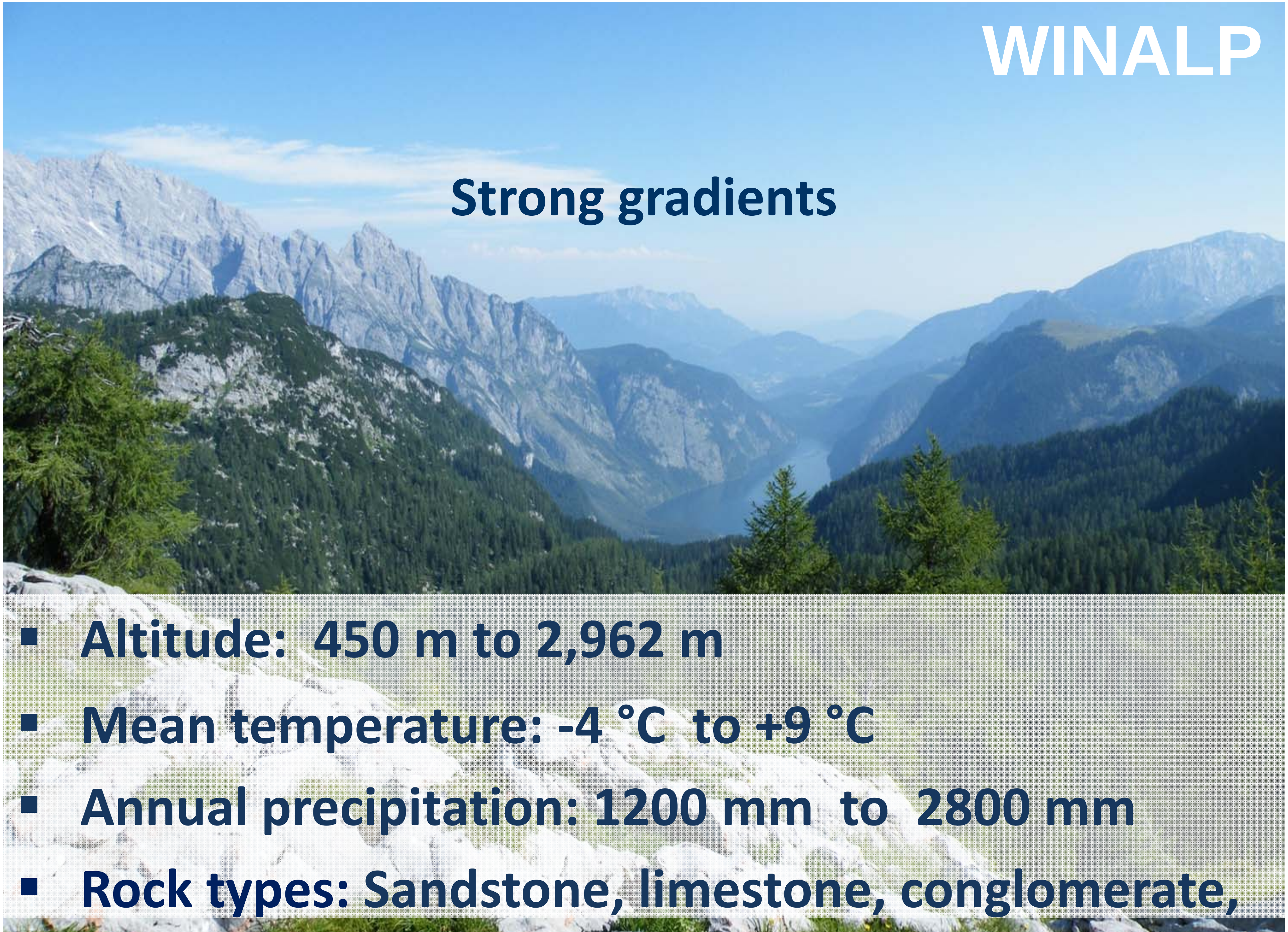
WINALP

Study region

- Mountain range in the Northern Alps (Bavaria)
- Extension 4,600 km²


WINALP
53 % covered by forest
▪ Range from unnaturally structured pure coniferous forests to near-natural stands

WINALP



Strong gradients

- **Altitude: 450 m to 2,962 m**
- **Mean temperature: -4 °C to +9 °C**
- **Annual precipitation: 1200 mm to 2800 mm**
- **Rock types: Sandstone, limestone, conglomerate,**

Questions

- **Which main gradients underline compositional variation in mountain forests of the Bavarian Alps?**
- **How much compositional variation is explained by abiotic: soil, climate, spatial and by biotic predictors: tree layer .**

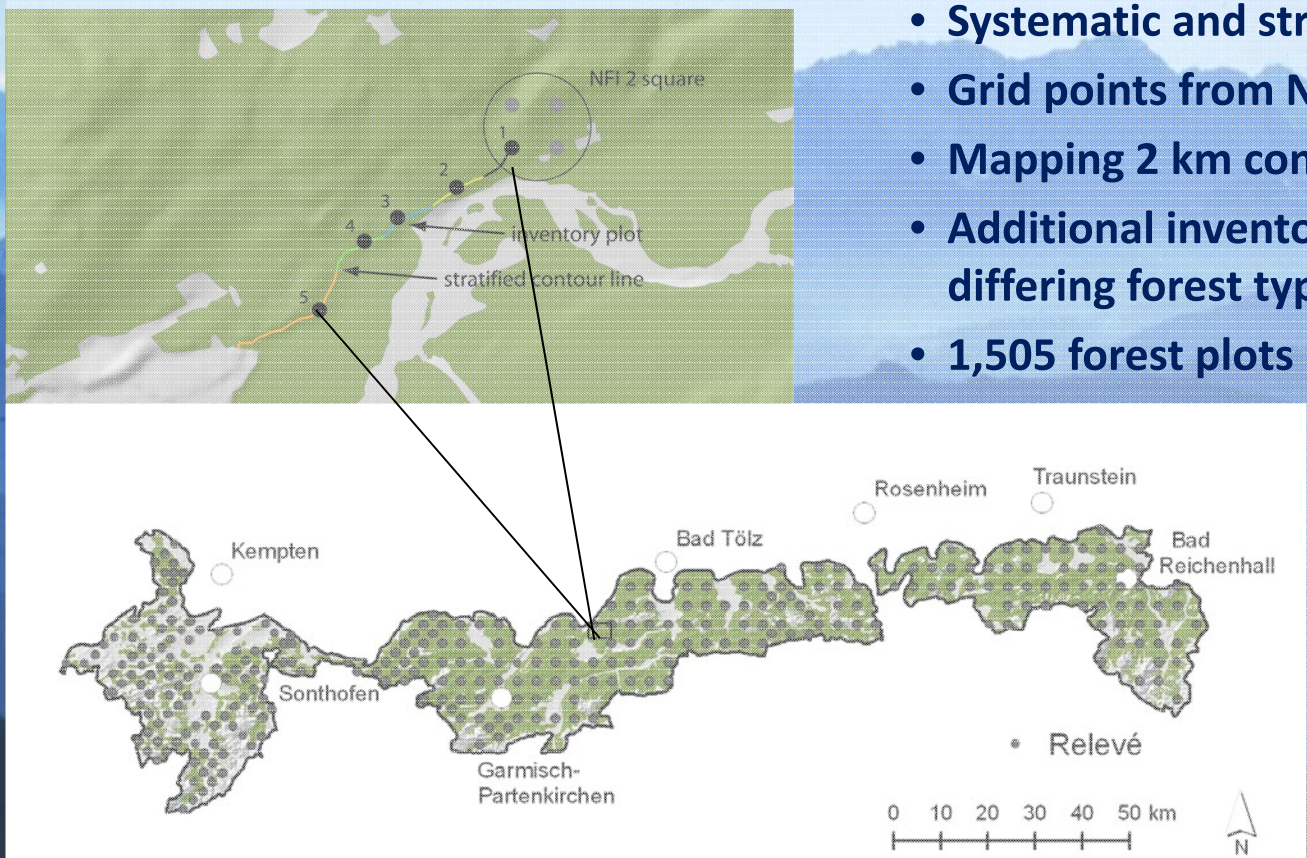
Sampling Design

- Relevés were sampled in in a **combined systematic and stratified** design.
- The **systematic sampling** design was based on the regular 4 km x 4 km squared grid .
- **A first** inventory plot was determined by the grid of the NFI 2.
- Along a 2 km contour line forest types were continuously mapped.
- The **stratified contour line** served as the basis for the placement of **four additional** inventory plots within sections of differing forest types.

Sampling Design

WINALP

Waldinformationssystem Nordalpen



- **Systematic and stratified sampling**
- **Grid points from NFI2 (4km)**
- **Mapping 2 km contour line**
- **Additional inventory plots within sections of differing forest types.**
- **1,505 forest plots**

Modifed from: Reger (2011)

Topographic Data

- **Elevation**
- **Slope**
- **Aspect**

WINALP

Waldinformationssystem Nordalpen

Vegetation Data

- 1505 plots
- 14 m x 14 m
- Vascular plants and horizontal cover
- Six point scale: (+: <1 %, 1: 1-5 %, 2: 6-25 %, 3: >26-50 %, 4: >51-75 %, 5:> 75%)

Forest Types

WINALP
Waldinformationssystem Nordalpen

- **Ewald J, Binner S (2007)** **Werkzeuge zur Bestimmung der Waldtypen im bayerischen Hochgebirge. *Waldökologie online* (5), pp. 25–77**
- **Assessment of the forest types :**
  - **47 forest types**
  - **Ground vegetation, stand , structure, relief and soil**

WINALP

Waldinformationssystem Nordalpen

Soil data

Soil profiles were inspected in auger samples

1505 soil profiles

- **Morphological properties of the horizons**
- **Hydromorphic features**

WINALP

Waldinformationssystem Nordalpen

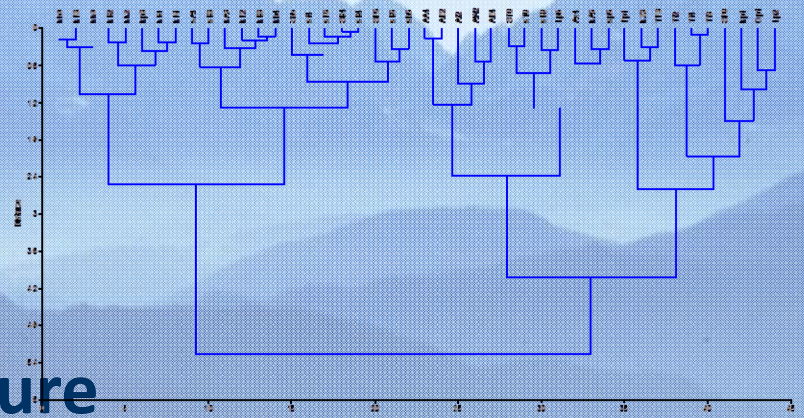
Climatic Data

- **Reger B, Kölling C, Ewald J (2011): Modelling effective thermal climate for mountain forests in the Bavarian Alps: Which is the best model? Journal of Vegetation Science 22 (4), pp. 677–687.**
- **Average monthly sums of precipitation**
- **Average monthly mean temperature**

Available data

WINALP
Waldinformationssystem Nordalpen

- **1505 releves, 910 vascular plants**
- **50 forest types**
- **46 site factors**
  - **Soil**
  - **Relief**
  - **Monthly temperature**
  - **Monthly precipitation**



WINALP

Waldinformationssystem Nordalpen

Tree layer / Understory

- **We hypothesized that tree layer composition has a strong management component due to silviculture, wildlife management and selective game browsing.**
- **In consequence, the analysis were performed separately for tree layer and understory.**

Tree layer / Understory

- **Tree layer influence the understory, e. g. shading, litterquality**
- **Species of the tree layers were treated as predictor variables for the understory**

WINALP

Waldinformationssystem Nordalpen

Data Preprocessing

- **Omitting species occuring only once (645 species left).**
- **Omitting species with negligible variance**
- **Finally 278 species left.**
- **Histogram transformation to dampen the influence of dominant species.**
- **Bulding overstorey (Tree1, Tree2) and understorey (Shrub, Herbs) subsets.**

WINALP

Waldinformationssystem Nordalpen

Data Analysis

To answer the questions we applied constrained ordination (CCA) and variance partitioning.

WINALP
Waldinformationssystem Nordalpen

Data Analysis

- **Analyses are mainly based on canonical ordination methods using CANOCO software (ter Braak, Šmilauer 2002).**
- **DCA was applied to determine the length of the gradient.**
- **CCA was chosen as length of gradient>>2.**
- **Forward selection was applied to select significant predictor variables.**

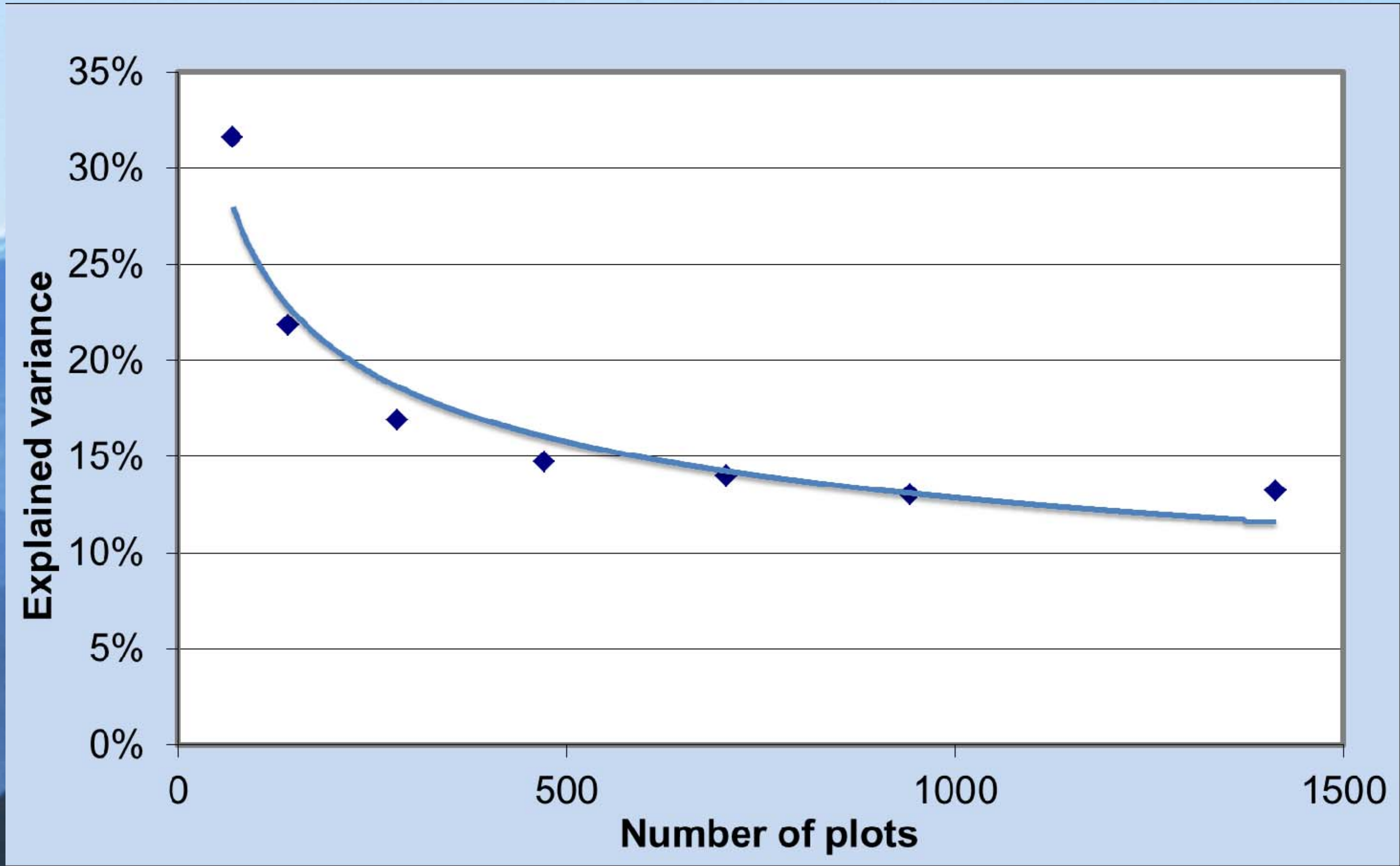
WINALP

Waldinformationssystem Nordalpen

Eigenvalues in large data sets

- **At first glance explained variance seemed to be very low .**
- **We suspected that explained variance may partly depend on sample size.**
- **To test this hypothesis we generated random subsets (10) for 5, 10, 20, 30, 50, 60 % of relevés of the whole data set and analyzed them separately.**
- **In fact, a clear decrease in explained variance with increasing sample size was observed.**

Eigenvalues in large data sets



Forward selection of abiotic explanatory variables: soil, climate, spatial

WINALP
Waldinformationssystem Nordalpen

Code	Explanatory Variable	Unit	IQR	Total	Tree	Unders.
Soil						
Org	**Thickness of organic layer**	cm	[2, 6]	X		X
Ah	**Thickness of A_h-Horizon**	cm	[7, 23]	X	X	X
Depth	**Depth of soil**	cm	[55, 100]	X		X
Earth	**Volume of fine earth**	l/m^2	[230, 755]	X	X	X
Clay	**Volume of clay**	l/m^2	[33, 201]	X		X
Silt	**Volume of silt**	l/m^2	[119, 362]	X	X	X
Sand	**Volume of sand** (collinear with clay and silk)	l/m^2	[20, 126]			
Water	**Depth of waterlogging**	cm	[100, 100]	X	X	X
Decal	**Depth of depletion of lime (Decalcification)**	cm	[0, 59]	X	X	X
UFC	**Useable field capacity**	mm	[64, 152]	X		X
Climate						
P06	**Sum of precipitation falling in June**	mm	[64, 152]		X	
P10	**Sum of precipitation falling in October**	mm	[107, 134]	X		X
T04	**Average temperature in April**	°C	[3, 5]	X		X
T05	**Average temperature in May**	°C	[8, 10]		X	
Alti	**Altitude a.s.l.**	m	[890, 1220]	X	X	X
Asp	**cos (195°-aspect) „southerness“**	./.	[-0.84, 0.64]	X		X
Slo	**Slope**	degree	[15, 35]	X	X	X
Spatial						
Geox	**x-coordinate, Gauß-Krüger coordinate system**	m		X	X	X
Geoy	**y-coordinate, Gauß-Krüger coordinate system**	m		X	X	X

Forward selection of biotic explanatory variables, tree species

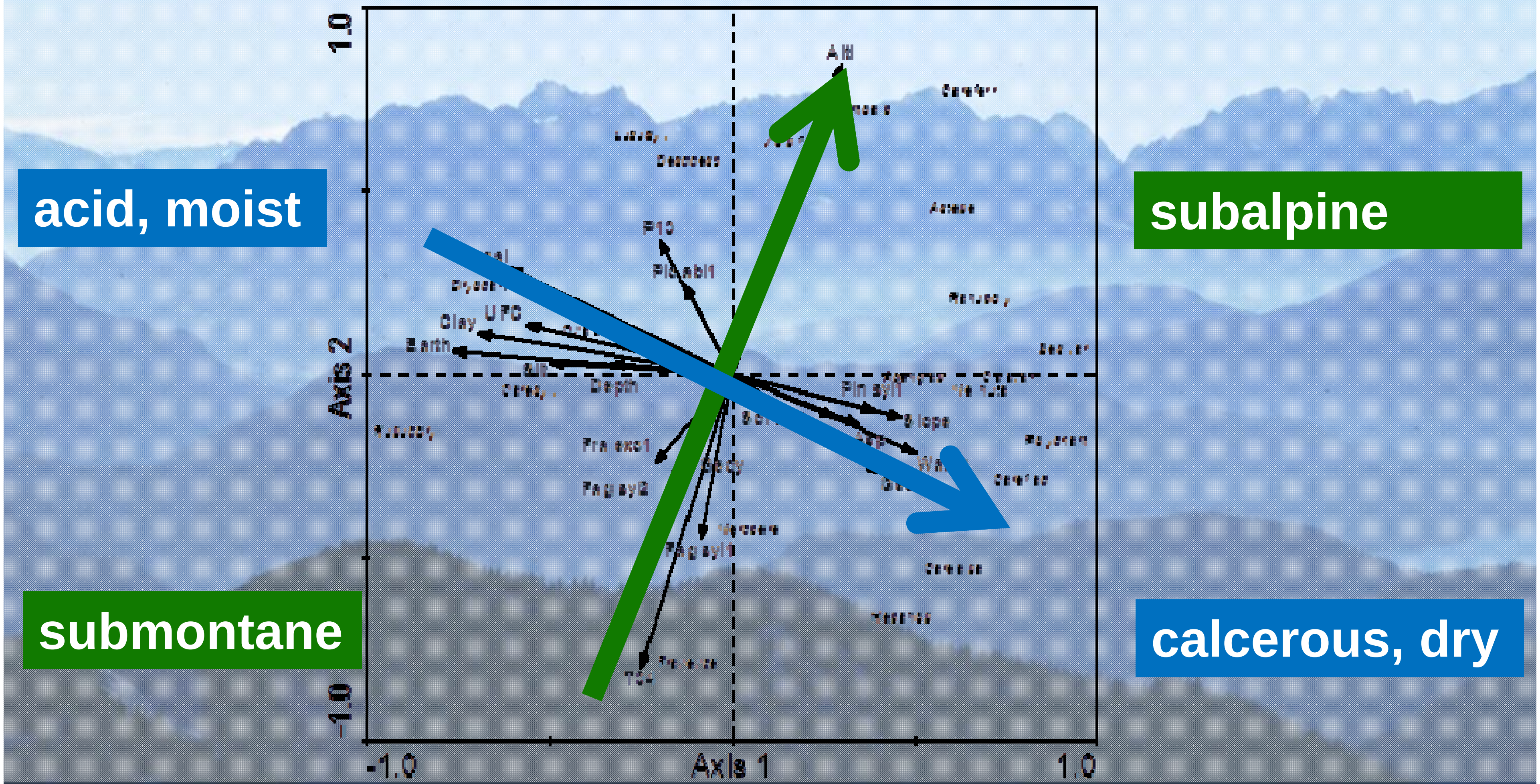
WINALP
Waldinformationssystem Nordalpen

Code	Name	Quantiles [% cover]			Frequency
		Q_{25}	Q_{50}	Q_{75}	
Abialb1	Abies alba, T1	1	5	25	353
Acepse1	Acer pseudoplatanus, T1	1	5	5	314
Aceps2	Acer pseudoplatanus, T2	1	1	5	165
Alnaln1	Alnus alnobetula, T1	26	50	62	3
Alnglu1	Alnus glutinosa, T1	5	15	25	6
Alnglu2	Alnus glutinosa, T2	0	1	1	4
Alninc1	Alnus incana, T1	5	5	25	33
Alninc2	Alnus incana, T2	1	1	5	17
Betpen1	Betula pendula, T1	1	5	5	7
Corave2	Corylus avellana, T2	5	5	5	5
Fagsyl1	Fagus sylvatica, T1	5	25	50	699
Fagsyl2	Fagus sylvatica, T2	1	5	5	484
Fraexc1	Fraxinus excelsior, T1	1	5	25	106
Fraexc2	Fraxinus excelsior, T2	1	5	5	39
Lardec1	Larix decidua, T1	1	1	5	50
Picabi1	Picea abies, T1	5	25	50	1222
Picabi2	Picea abies, T2	1	1	5	550
Pincem1	Pinus cembra, T1	1	1	13	3
Pinmug1	Pinus mugo agg., T1	20	38	50	4
Pinsyl1	Pinus sylvestris, T1	1	5	25	51
Pinsyl2	Pinus sylvestris, T2	1	3	5	12
Poptre1	Populus tremula, T1	1	3	4	2
Prupad2	Prunus padus, T2	5	5	5	2
Querob1	Quercus robur, T1	5	5	5	3
Salapp1	Salix appendiculata agg., T1	2	3	4	2
Salarb1	Salix arbuscula agg., T1	7	13	9	2
Sorari1	Sorbus aria agg., T1	1	1	5	17
Sorari2	Sorbus aria agg., T2	1	1	1	47
Tilpla1	Tilia platyphyllos, T1	5	25	25	5
Ulmgla2	Ulmus glabra, T2	1	1	5	32

Gradients underlining species composition of the understorey

WINALP

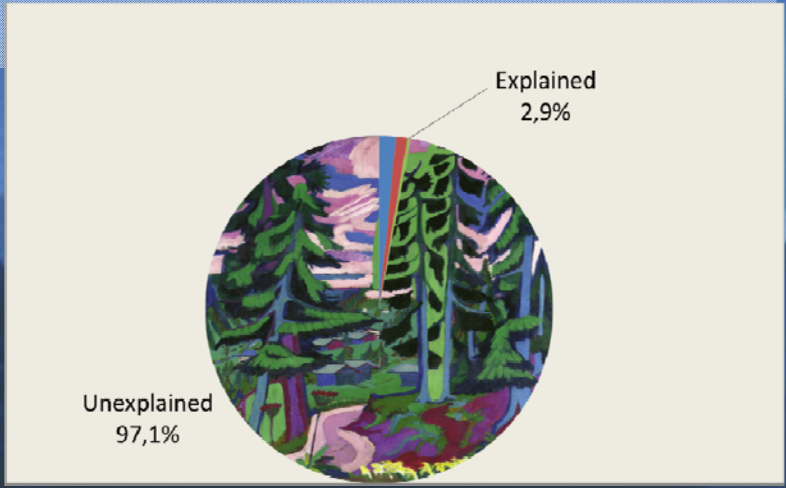
Waldinformationssystem Nordalpen



Variance partitioning

WINALP
Waldinformationssystem Nordalpen

- **Canonical analyses allow partitioning the observed variability of species compositions into a portion that can be explained by the observed environmental variables and into unexplained remains.**

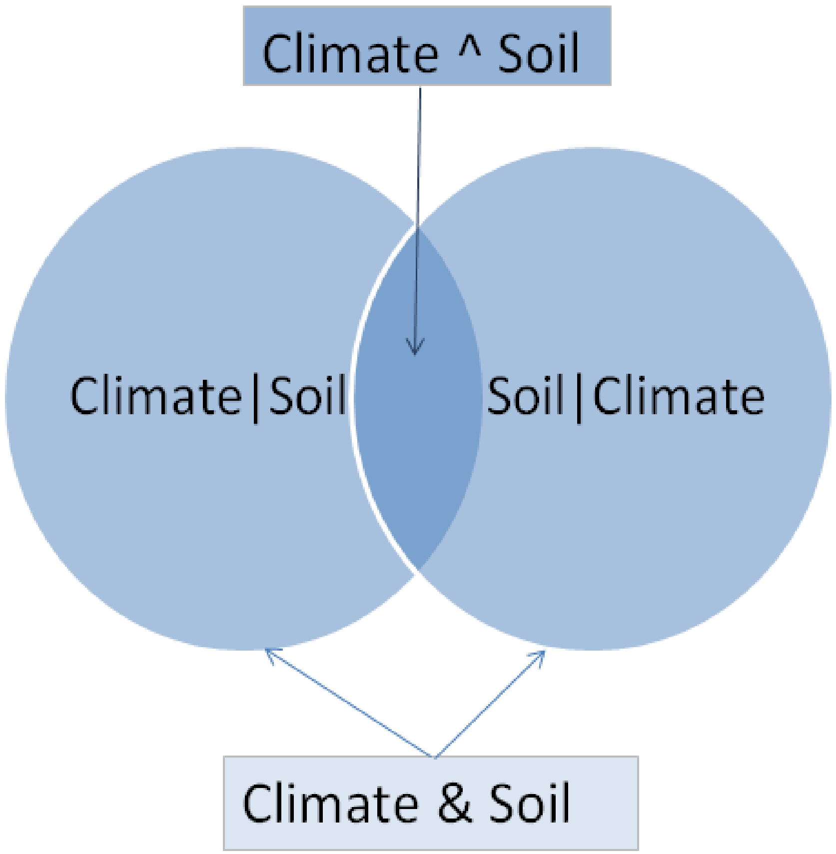


Variance partitioning

- **Using partial ordination, the explained variability can be partitioned according to logical groups of environmental variables.**
- **We grouped the predictor variables into abiotic: “soil”, “climate”, “spatial” and into biotic: “tree layer” .**

Partitioning model

WINALP
Waldinformationssystem Nordalpen



e.g.

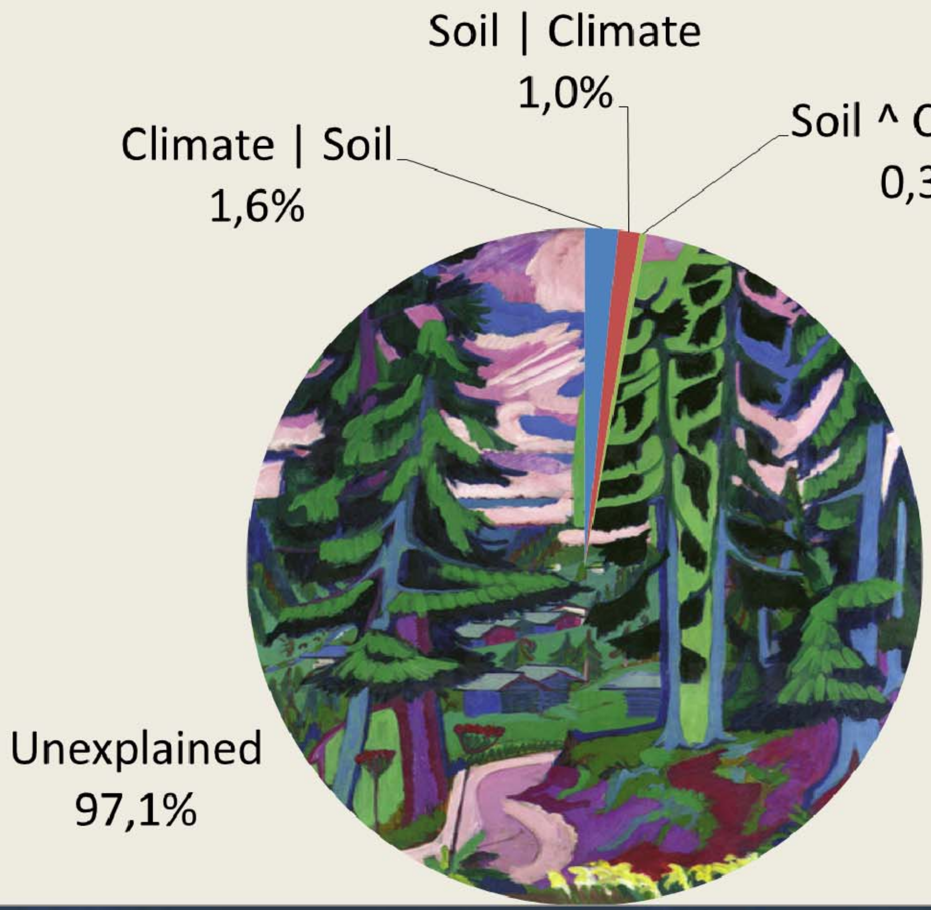
- **Climate & Soil: total variance explaind by both**
- **Climate|Soil: variance explained by climate only**
- **Soil|Climate: variance explained by soil only**
- **Climate ^ Soil: variance explained by soil AND climate**

note

Climate & Soil =

Climate|Soil + Climate^Soil + Soil|Climate

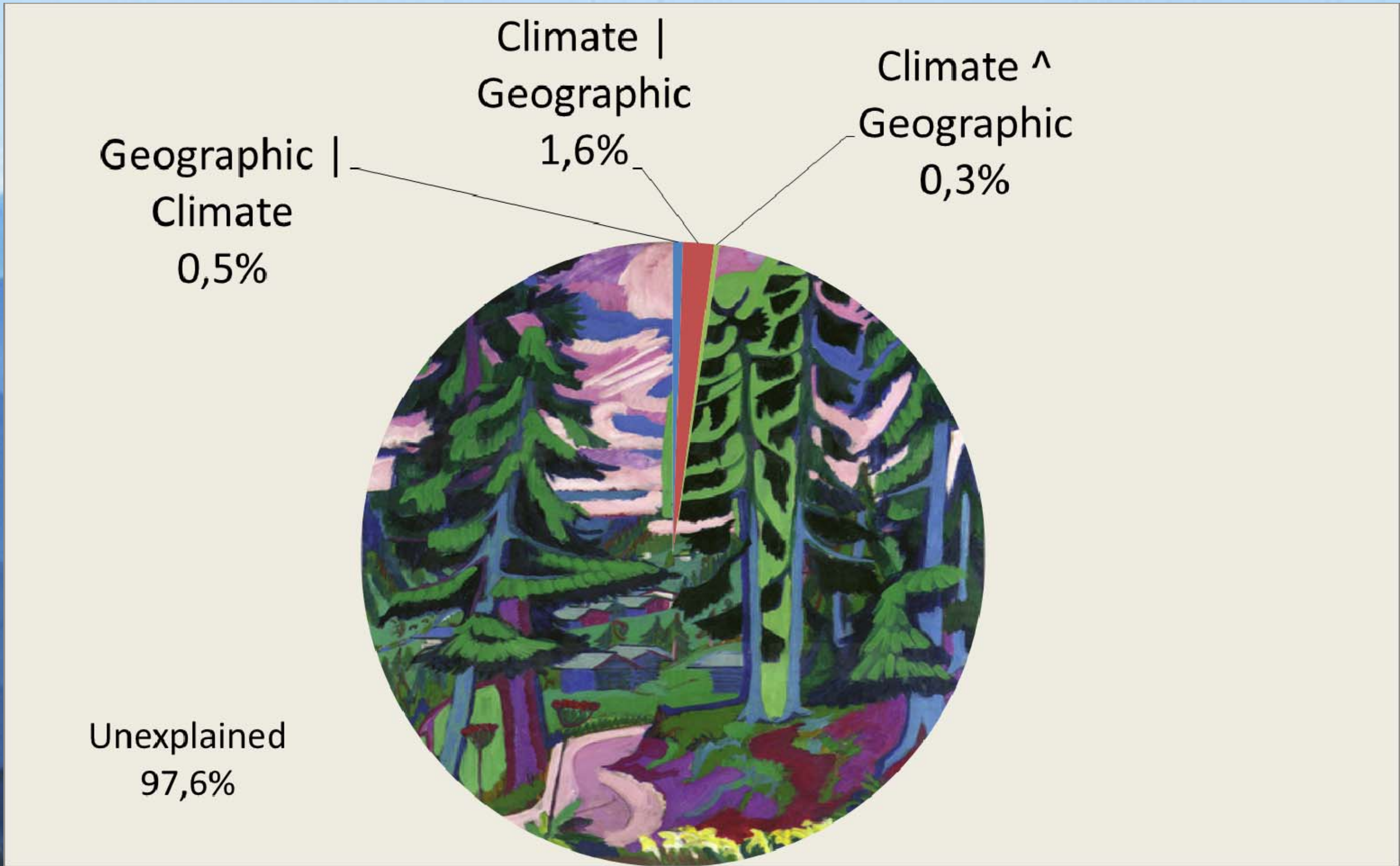
Variance partitioning tree layer: climate and soil



The explanatory power of climate and soil for tree layer species composition was week

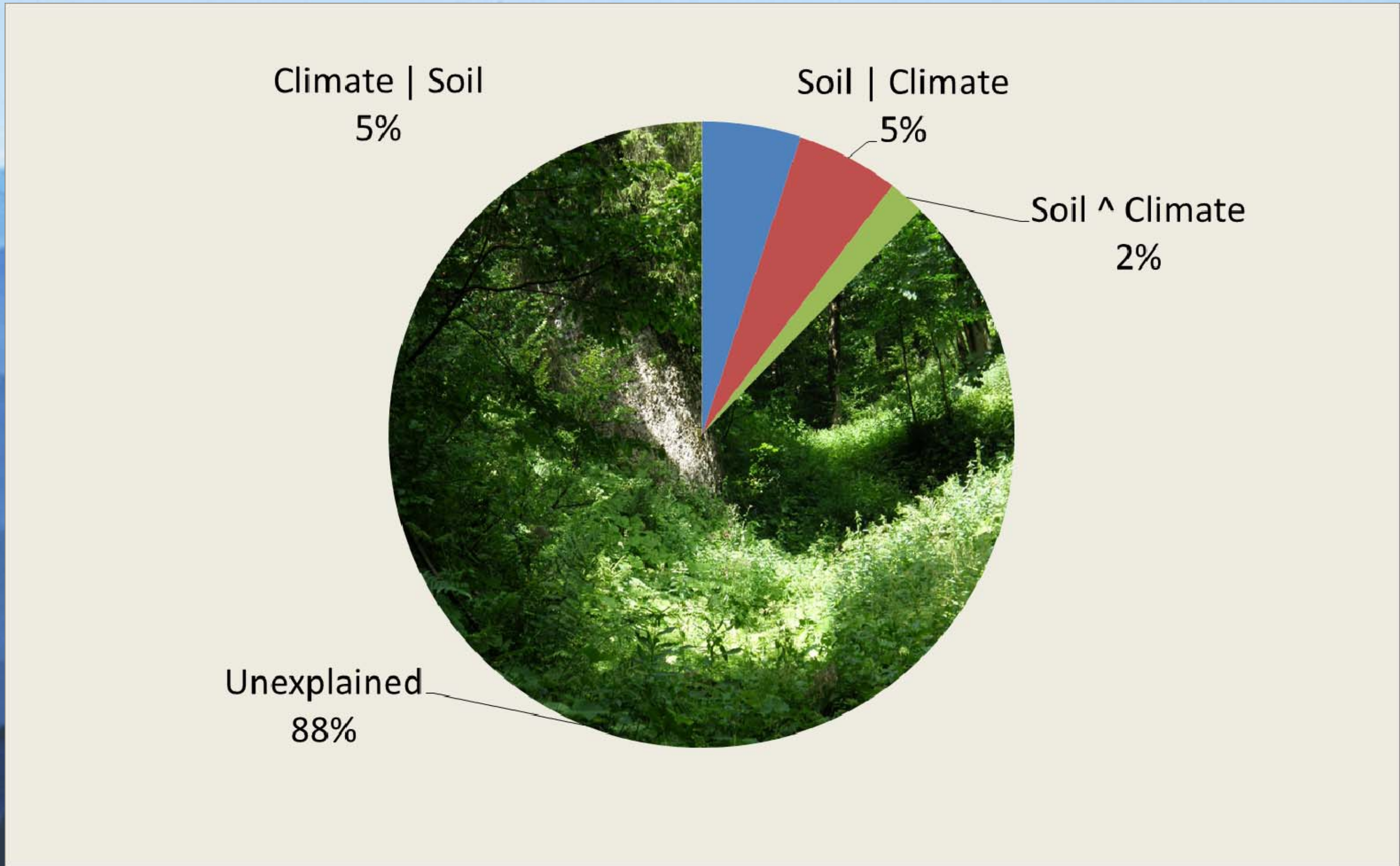
Variance partitioning tree layer: geographic and climate

WINALP
Waldinformationssystem Nordalpen



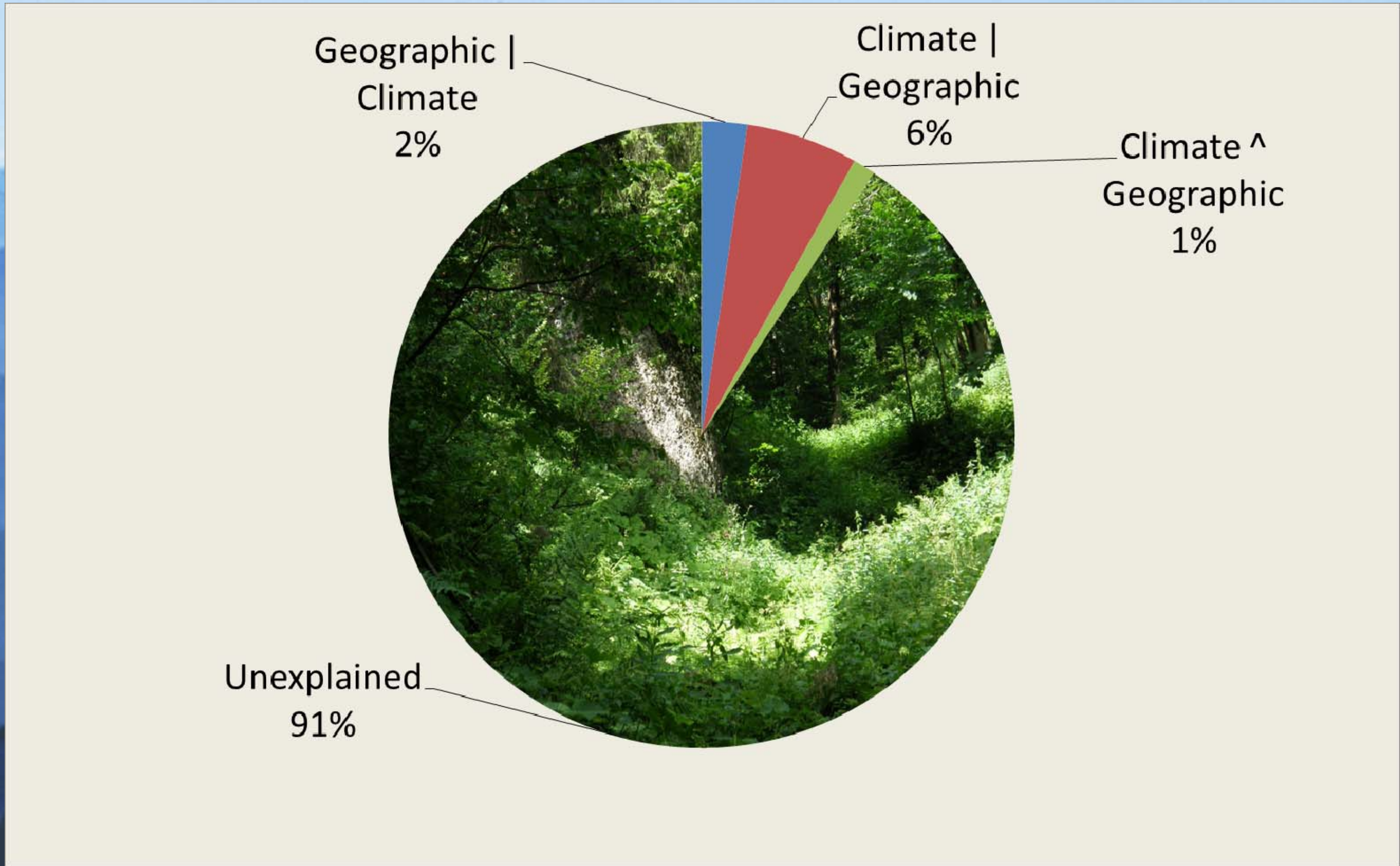
Variance partitioning understory: climate and soil

WINALP
Waldinformationssystem Nordalpen



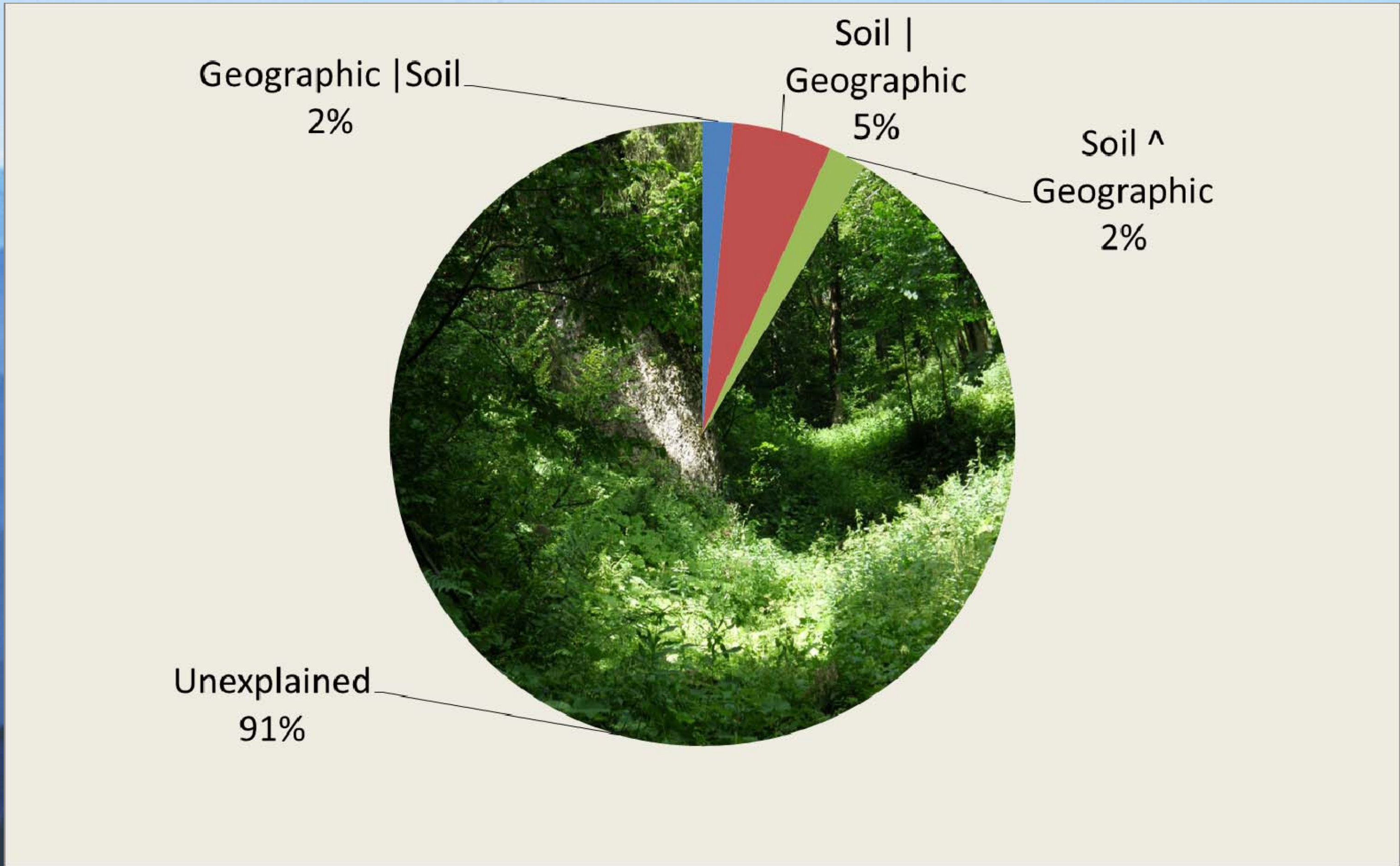
Variance partitioning understory: geographic and climate

WINALP
Waldinformationssystem Nordalpen



Variance partitioning understory: geographic and soil

WINALP
Waldinformationssystem Nordalpen



Variance partitioning understory: abiotic and trees

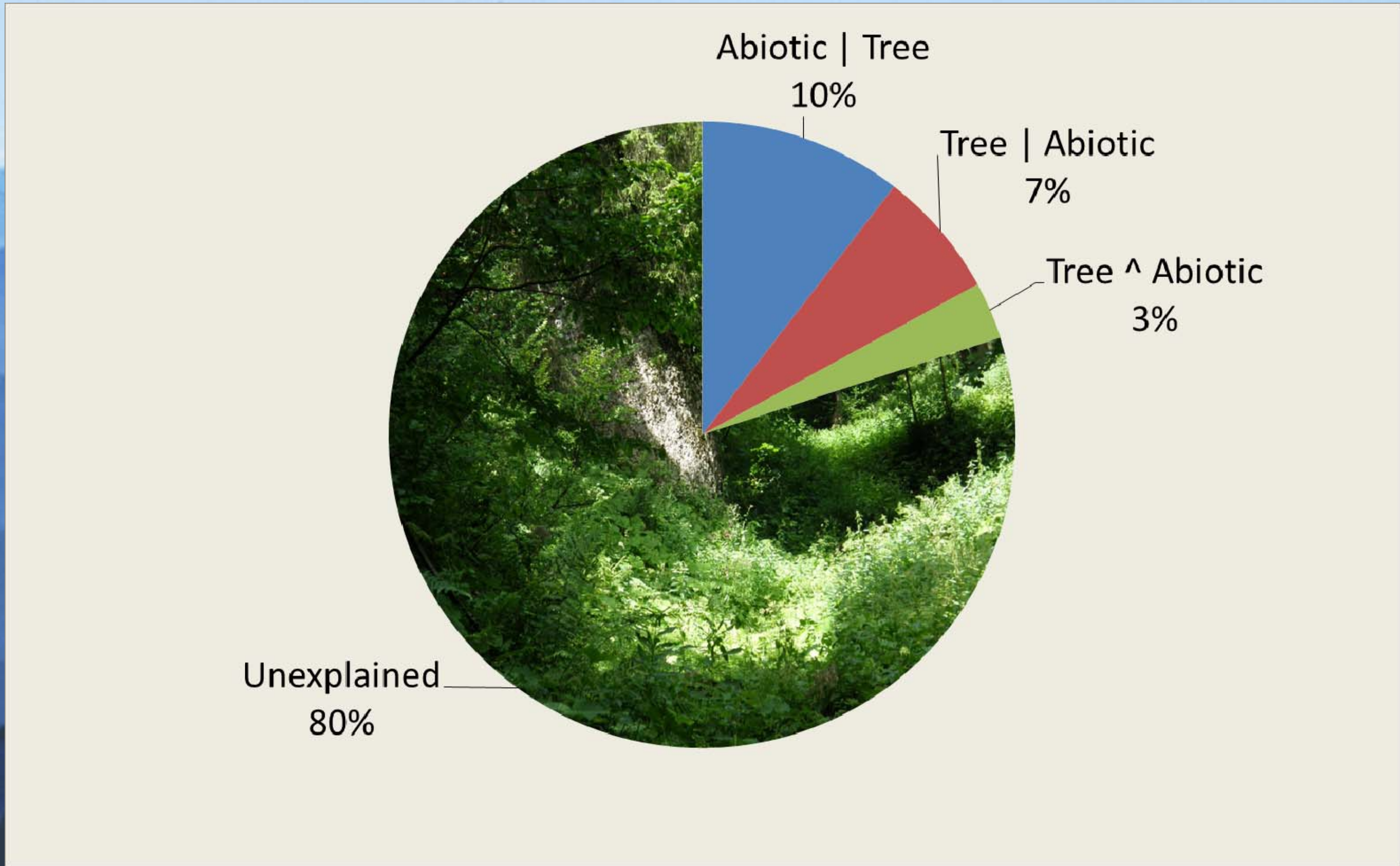
WINALP

Waldinformationssystem Nordalpen

- **We hypothesized that the tree layer influences the environment of understory vegetation.**
- **Therefore we tested tree species as one set of predictor variables against all abiotic variables.**
- **The largest portion of explained variability (10 %) was associated with the abiotic environmental variables.**
- **But tree layer had an additional explanatory power of 7 %.**

Variance partitioning understory: abiotic and trees

WINALP
Waldinformationssystem Nordalpen



WINALP

Waldinformationssystem Nordalpen

Conclusion

- **Understory and tree layer react different to environmental variables.**
- **Understory is better explained by choosen environmental variables than tree layer.**
- **Understory: Climate and soil explain nearly equal portion of variance.**
- **Understory: Tree species (Biotic) explain huge part (7%) of the variability of the understorey species composition.**

Analysing a large, comprehensive dataset of plant species composition and environmental predictors allowed us to synthesize knowledge on the dependence of species composition on different groups of environmental predictors.

We would like to express our great appreciation to

WINALP

Waldinformationssystem Nordalpen

WINALP-Project-team and

- Bayerische Vermessungsverwaltung (LVG)
- Landesamt für Umwelt (LfU)
- Deutscher Wetterdienst (DWD)
- Landesanstalt für Wald und Forstwirtschaft (LWF)

www.winalp.info


WINALP
Thank you for your attention!