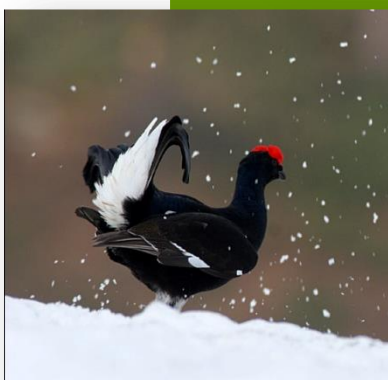


Measurements of biodiversity in north-western Italian Alps

Ramona Viterbi, Cristiana Cerrato, Emanuel Rocchia, Antonello Provenzale

Roma, 3 giugno 2014

Mountain ecosystems

Biodiversity “Hot spot”

- Highly vulnerable
- Very sensitive to climate change
- Provide ecosystems services for lowland

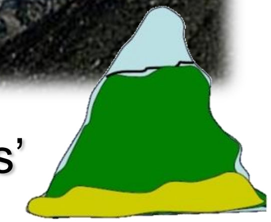
Protected habitats and species

Endemic and rare species

Species with low dispersion potential

Microthermic species

Altitudinal gradients



Natural laboratories to study ecosystem dynamics, biodiversity, and species’ distribution response to climate gradients

Rapp and Silman (2012) Diurnal, seasonal, and altitudinal trends in microclimate across a tropical montane cloud forest. Clim Res; Lomolino (2001) Elevation gradients of species-density: historical and prospective views. Global Ecol Biogeogr 10

“Single species approach”

To analyse the effects of climate parameters on the population dynamic of species that can act as surrogate of biodiversity

Storch (2007) Indicator of the health status of the entire ecosystem

“Multi taxa approach”

To describe alpha and beta diversity variation along altitudinal gradients analysing the factors that influence this distribution

Because of the complexity of biodiversity, surrogates such as subsets of species, species assemblages and habitat types have to be used as measures of biodiversity

Margules and Pressey (2000) Systematic conservation planning. Nature 405

Objectives

1. To describe animal biodiversity along altitudinal gradients and identify the parameters influencing species' distribution

2. To identify the (*group of*) species and the habitat type more sensitive to environmental and climatic changes,
that can be used as biodiversity/ecological indicators

3. To estimate the potential risk of biodiversity loss,
also applying climate change scenarios

4. To set the basis for the development of a long term monitoring scheme, focused on multi-taxa community data

A multi taxa approach to assess pattern of congruence and diversity

- description of alfa and beta diversity variation along altitudinal gradients

- analysis of the relative influence of geographical, environmental and climatic factors on biodiversity structure and community composition

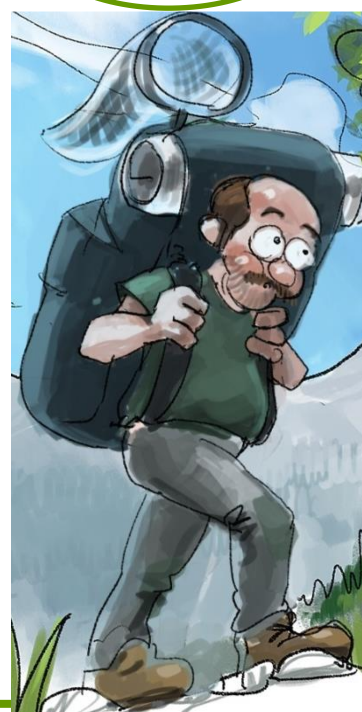
2007-2008

A multi taxa approach to assess pattern of congruence and diversity

- description of alfa and beta diversity variation along altitudinal gradients

- analysis of the relative influence of geographical, environmental and climatic factors on biodiversity structure and community composition

2007-2008 — **4 yrs stop** — **2012-2013**



A multi taxa approach to assess pattern of congruence and diversity

- description of alfa and beta diversity variation along altitudinal gradients

- analysis of the relative influence of geographical, environmental and climatic factors on biodiversity structure and community composition

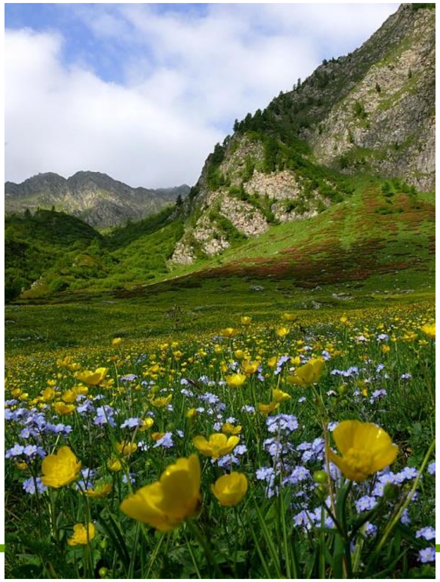
2007-2008 — 4 yrs stop — 2012-2013 — 4 yrs stop — ……………..

Multi taxa approach

Gran Paradiso National Park
5 Transects, **30** Plots

Alpe Veglia Devero Natural Park
3 Transects, **19** Plots

Orsiera Rocciavré Natural Park
4 Transects, **20** Plots

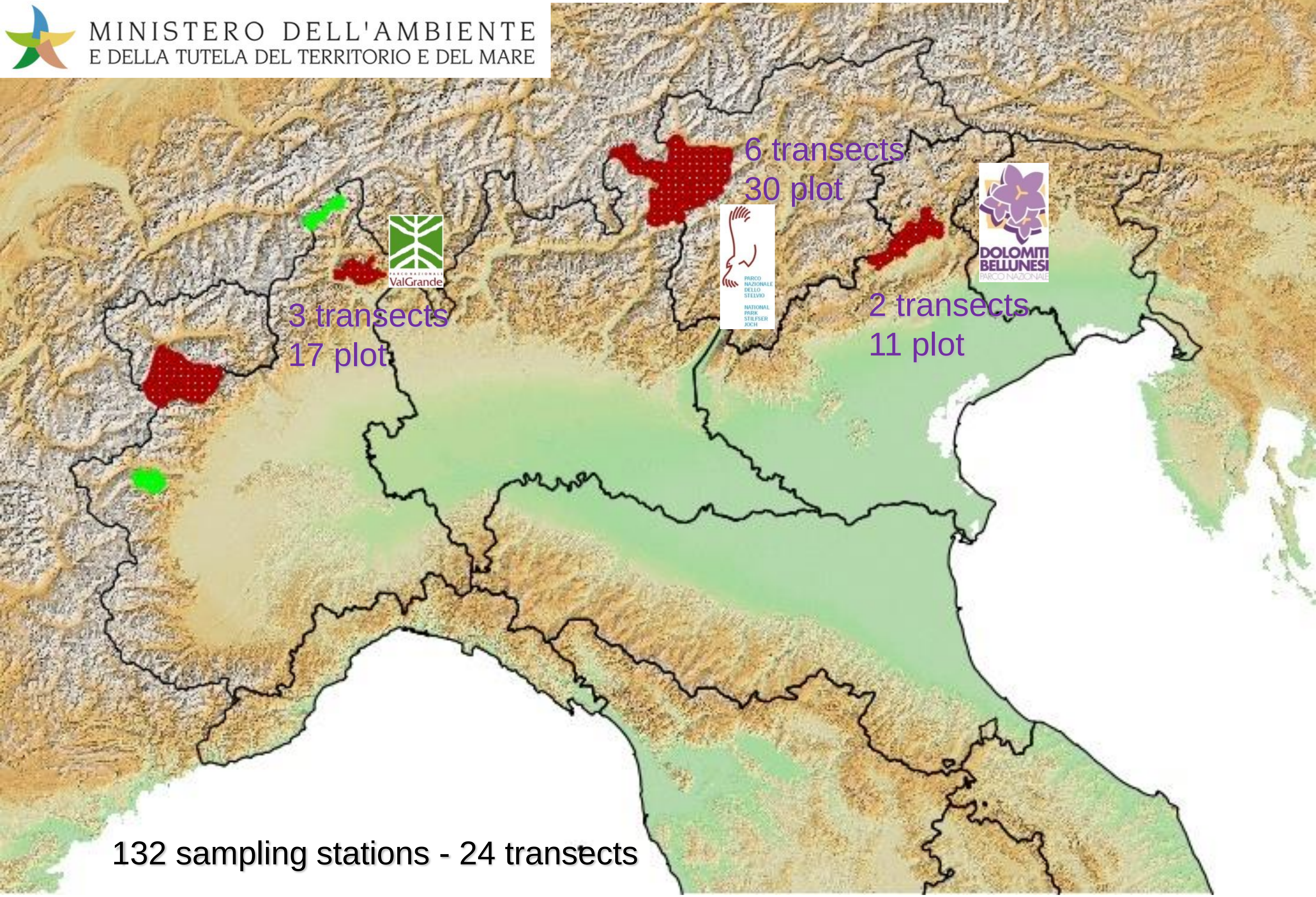


Comparison of elevational trends in diversity among taxa and among mountain ranges is fundamental in order to gain a more comprehensive understanding of patterns of diversity.
Lomolino, 2001. Elevation gradients of species -density: historical and prospective views. Global Ecology and Biogeography

Conclusive evidence for or against the existence of the predicted biological effects of climate change will come from replication of study with additional taxa in other regions.
Parmesan,1996. Climate and species' range. Nature

2012-2014 - Fondi ministeriali ex capitolo 1551 - Azioni di sistema

MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE



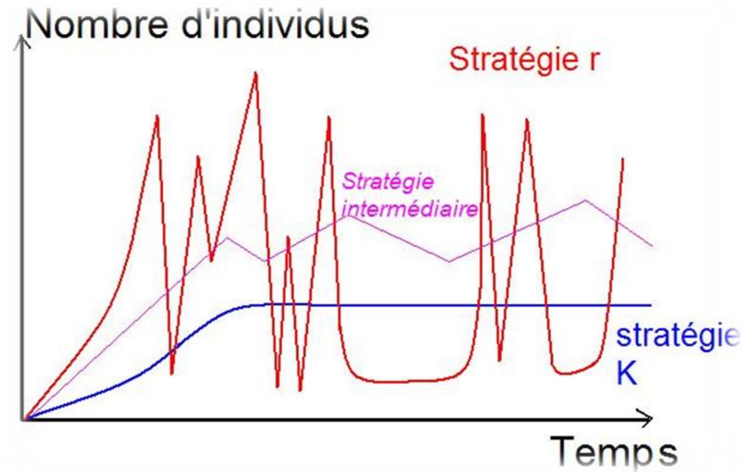
132 sampling stations - 24 transects

Two years of monitoring

Taxa studied

• annual fluctuation

e.g., population dynamic,mostly invertebrates



• lyfecicle

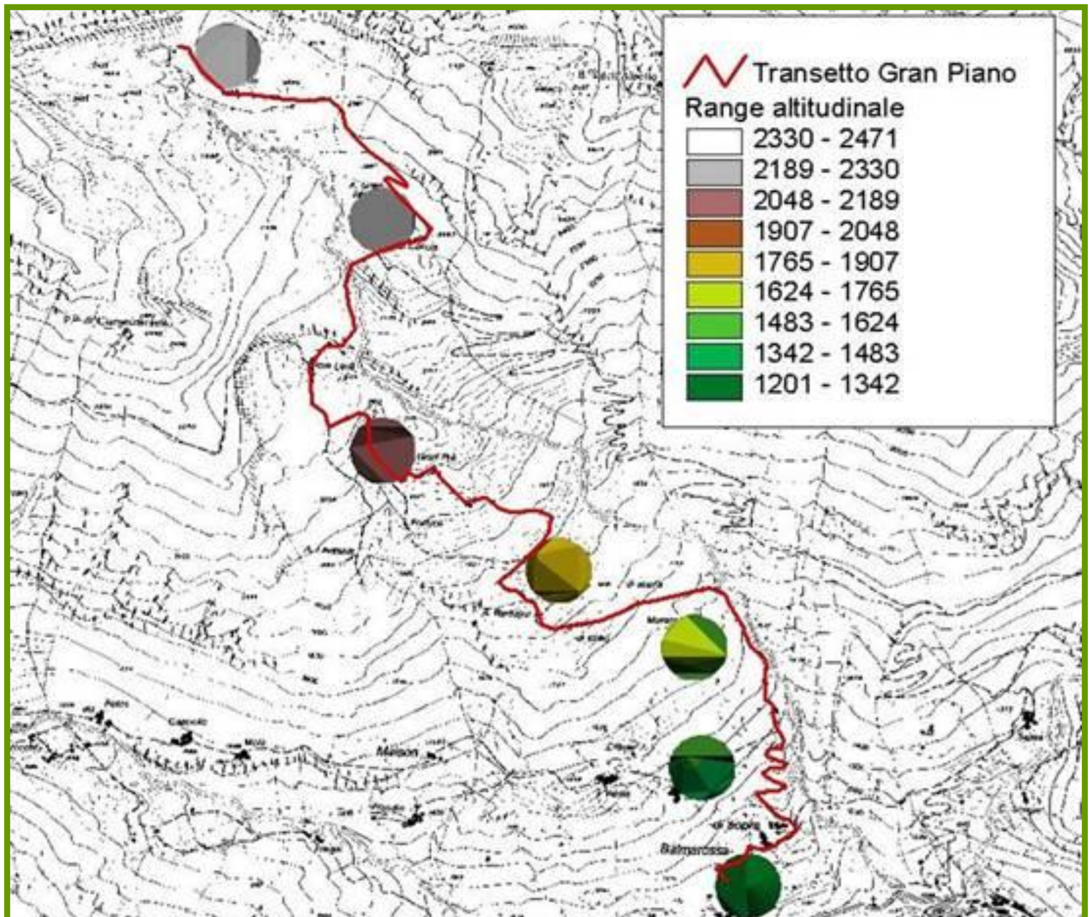
e.g., biennial species

Mountain ecosystems

• harsh environment

• high variability (local and annual)

4-7 plots for every transect
69 plots
Altitudinal range: 500 – 2700 m
3 vegetation belts: Montane, Subalpine, Alpine



Sample unit: plot with a radius of 100 m
One plot every 200 m

Pitfall traps

Point counts

Line transects

Census techniques as much as possible

- Easy to apply
- Standardized
- Cheap

Repeatability over time (4 years) of transects in order to analyse variations

Slide - Exposure
Altitude
→ **Topographic description**

Percentage of vegetation cover (tree, shrub, grass, rock)
Structural diversity
→ **Macro-habitat condition**

Phytosociological surveys
→ **Micro-habitat description**

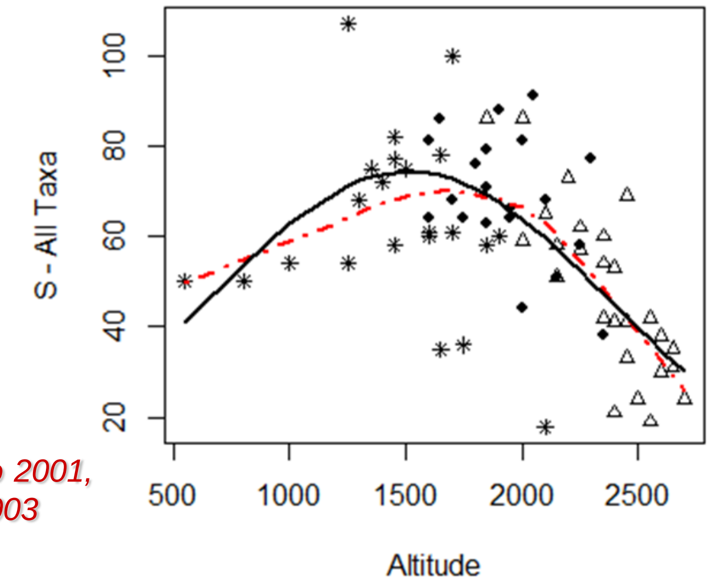
Data-loggers
→ **Microclimatic condition**

Species Richness

Hump-shaped decline

$S = exp\ (2.841 + 0.002\ Alt - 6.420e^{-07}\ Alt^2)$
$D^2_{adj} = 0.425$
$p < 0.0001$

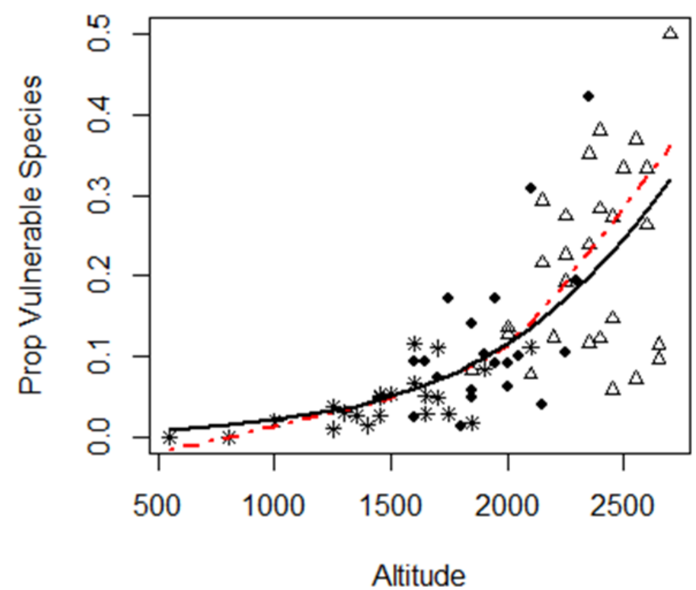
Nor 2001, Sànchez-Cordero 2001, Sheng Li et al. 2003



Vulnerable and Endemic Species

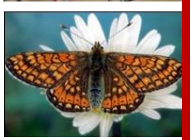
Increase with altitude

logit (proportion of vulnerable species) = $-5.701 + 0.002\ Alt$
$D^2_{adj} = 0.535$
$p < 0.0001$



Viterbi et al., 2013. Patterns of biodiversity in the northwestern Italian Alps: a multi-taxa approach. Community ecology 14: 18-30

Relation among environmental variables and species richness (S)

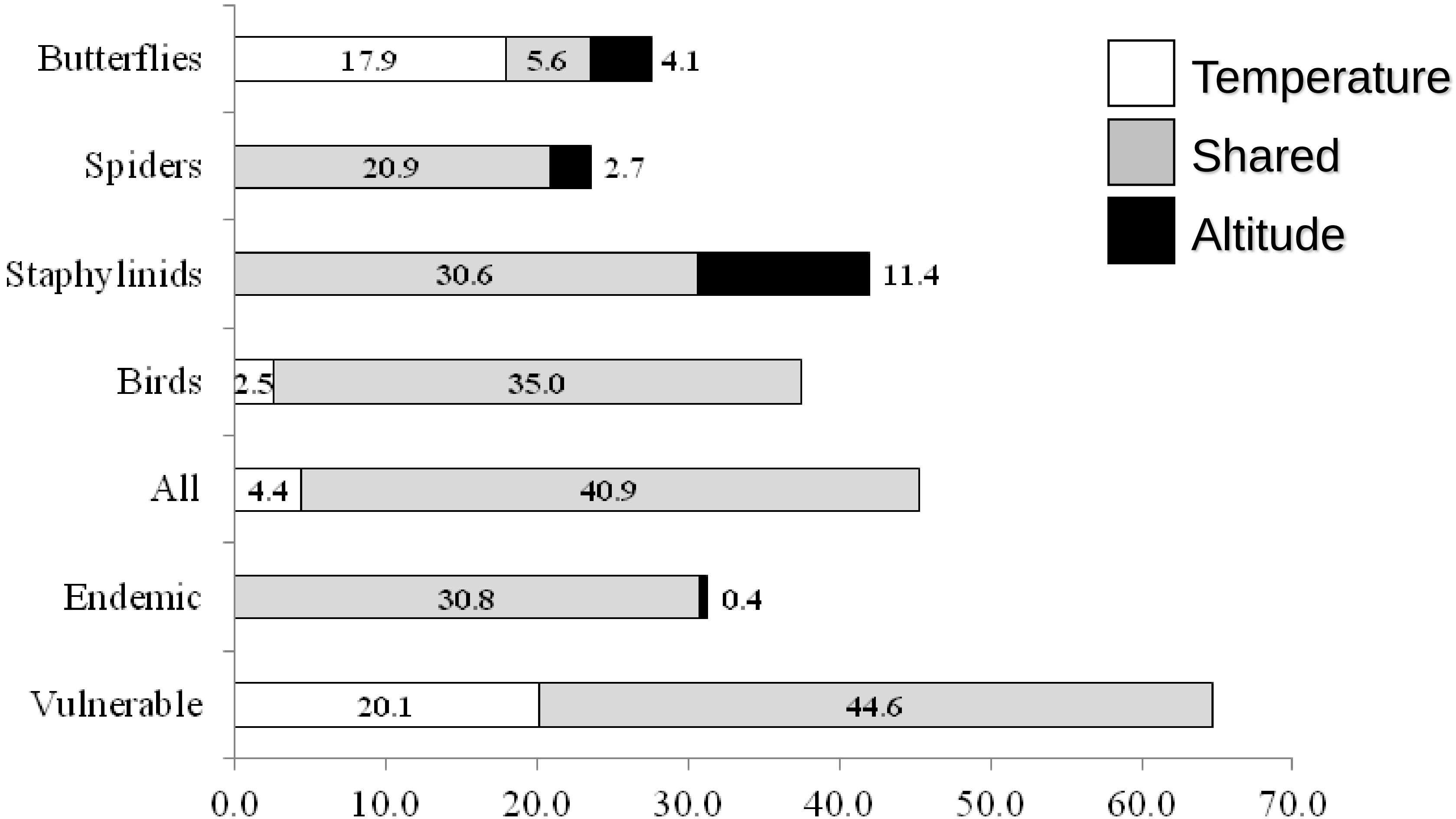
	Alt	Temp	Str Div	Tree%	TShr%	LShr%	HerbL%	Rock%
	-0.435**	0.415*	0.147	0.374	0.154	0.273	0.028	-0.509**
	-0.208	0.198	0.009	-0.232	0.061	-0.145	0.373	-0.225
	-0.566**	0.565**	0.289	0.428**	0.326	0.248	-0.111	-0.367
	-0.409**	0.485**	0.313	0.306	0.386*	0.318	-0.007	-0.054
	-0.449**	0.451**	0.089	0.289	0.246	0.284	0.048	-0.422**
S_{tot}	-0.519**	0.562**	0.192	0.302	0.270	0.272	0.104	-0.406*

StrDiv=Structural Diversity *Tree%*=percentage of tree coverage *TShr%*=percentage of tall shrub coverage *LShr%*=percentage of low shrub coverage *HerbL%*=percentage of herbaceous layer coverage *Rock%*=percentage of rock coverage

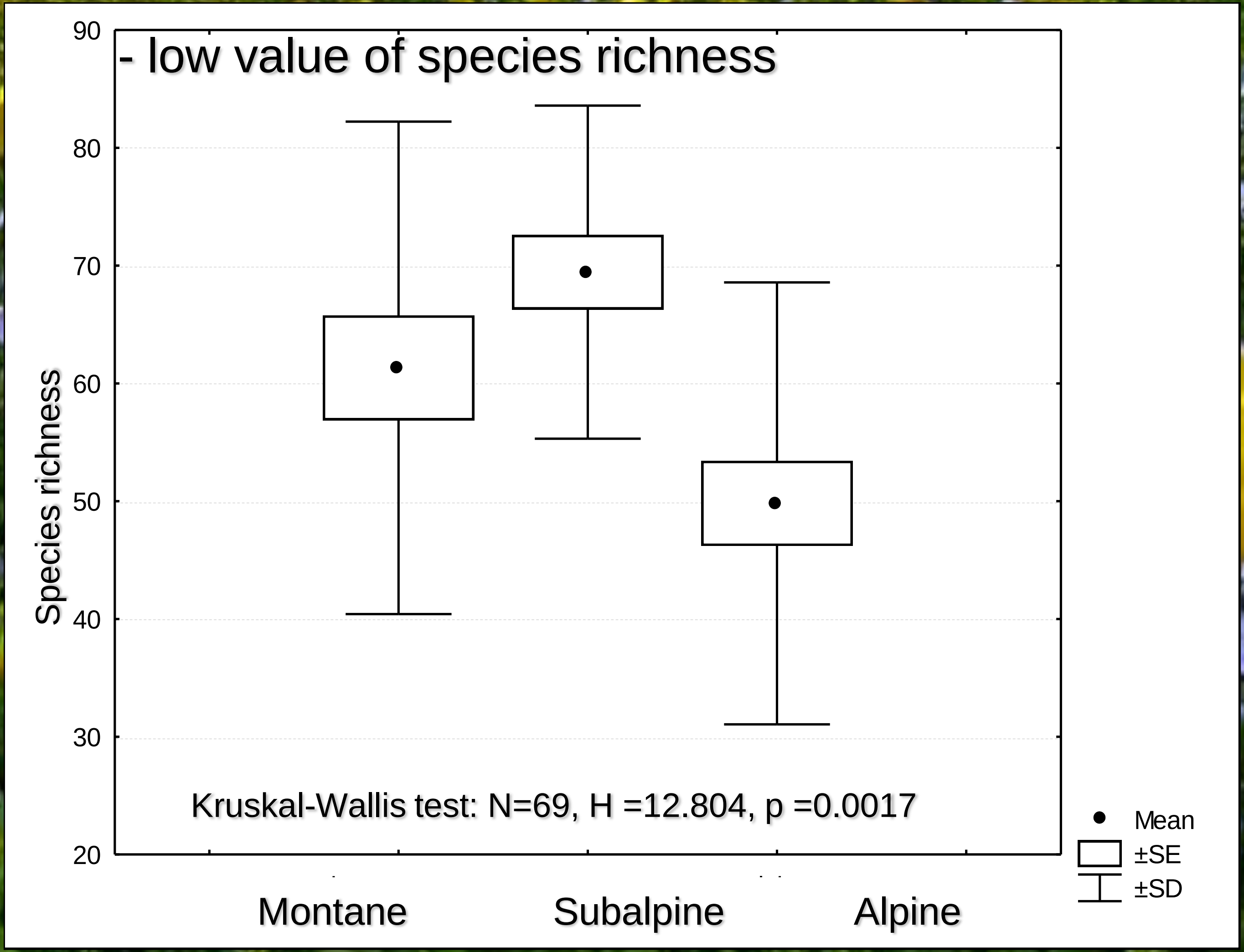
Bonferroni corrected p-values: *p<0.05/48; **p<0.01/48

Variation Partitioning on Species Richness

Shared and pure effect of ***temperature*** and ***altitude***

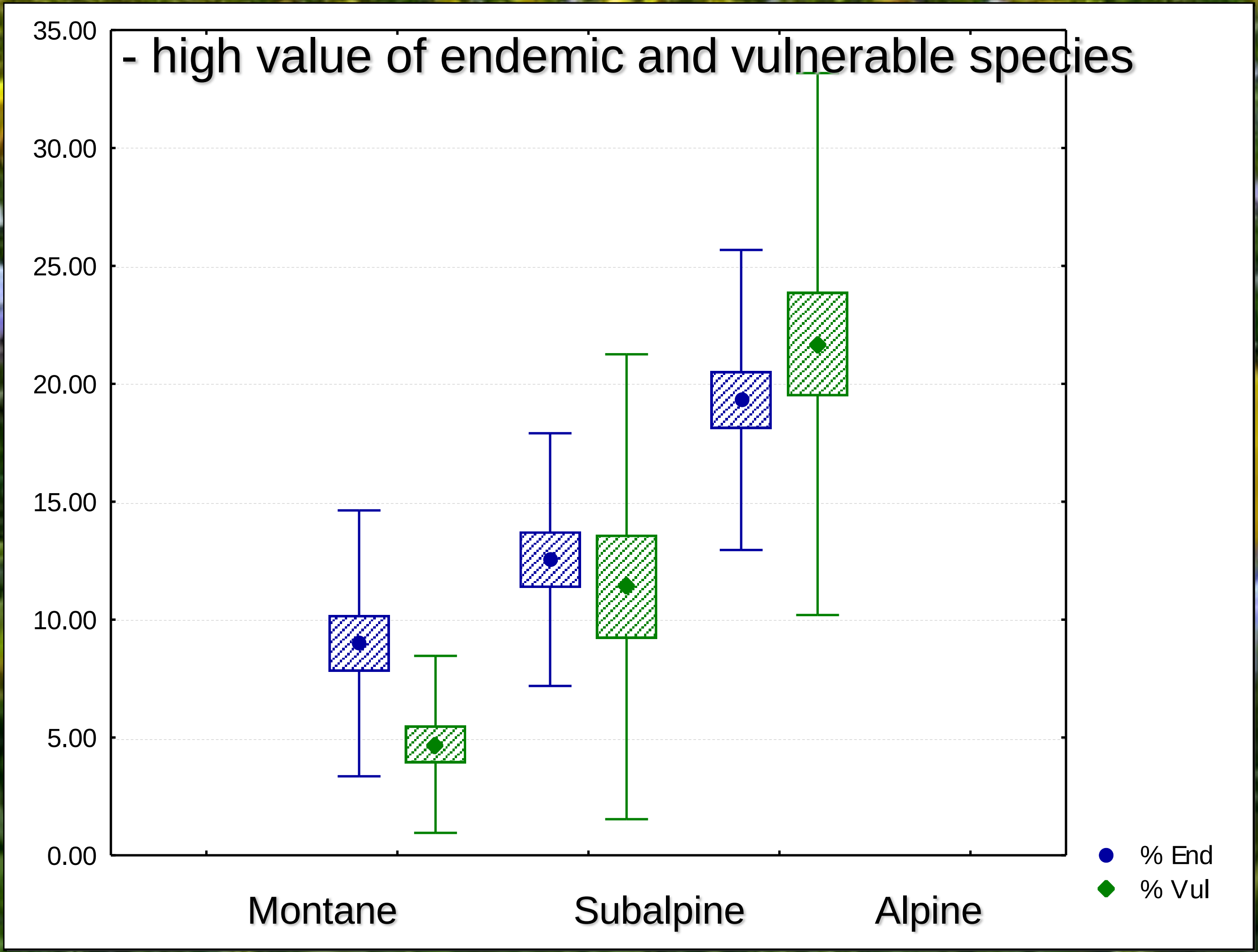


Peculiarities of the alpine belt:



Peculiarities of the alpine belt:

- high value of endemic and vulnerable species



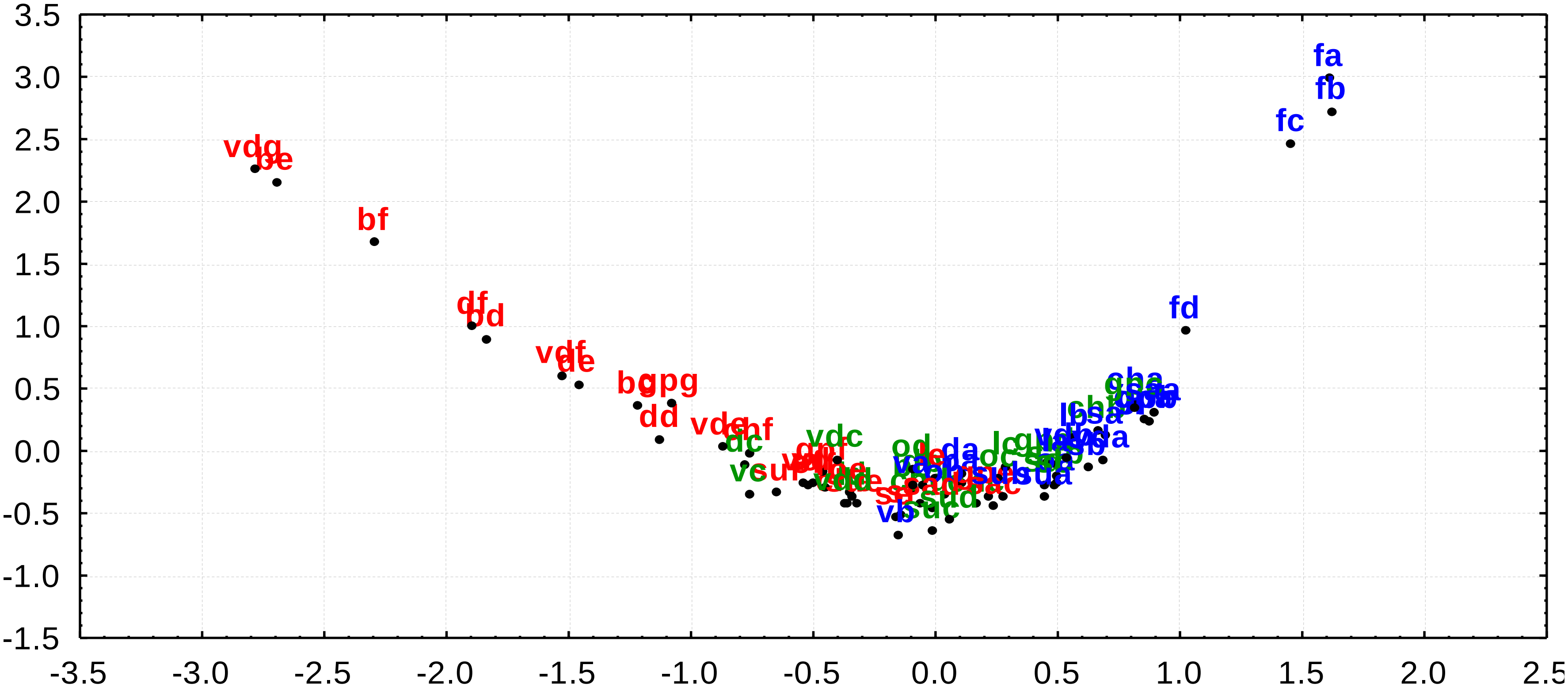
Endemic-Kruskal-Wallis test: N=69, H=25.057, p=0.0000

Vulnerable-Kruskal-Wallis test: N=69, H=33.771, p=0.0000

Community Composition

Correspondence Analysis

Montane
Subalpine
Alpine



	Alt	Temp	Str Div	Tree%	TShr%	LShr%	HerbL%	Rock%
	-0.567**	0.657**	0.328	0.232	0.326	-0.049	0.037	0.058
	-0.574**	0.623**	0.293	0.328	0.418*	0.261	-0.112	-0.026
	0.911**	-0.852**	-0.430**	-0.800**	-0.674**	-0.377*	0.388*	0.234
	0.860**	-0.882**	-0.353	-0.610**	-0.612**	-0.191	0.276	0.043
	-0.818**	0.849**	0.400**	0.500**	0.581**	0.171	-0.158	-0.117
$ScoreAx1_{tot}$	**-0.889****	**0.918****	**0.399***	**0.569****	**0.600****	**0.214**	**-0.212**	**-0.138**

Gradient is mostly determined by:

- Altitude
- Microclimatic conditions

	Temperature	Altitude	Belt	Geography	
Carabidae	0.228***	(n.s.)	*	***	**Controlling for Temperature**
Lepidoptera	0.390***	*	***	***	
Araneae	0.316***	(n.s.)	**	***	
Staphylinidae	0.245***	(n.s.)	*	***	
Aves	0.398***	***	***	(n.s.)	
Carabidae	***	0.178***	(n.s)	***	**Controlling for Altitude**
Lepidoptera	***	0.350***	***	***	
Araneae	***	0.255***	*	***	
Staphylinidae	***	0.204***	(n.s)	***	
Aves	(n.s.)	0.523***	***	**	
Carabidae	***	**	0.149***	***	**Controlling for Belt**
Lepidoptera	***	***	0.354***	***	
Araneae	***	**	0.221***	***	
Staphylinidae	***	**	0.149***	***	
Aves	***	***	0.594***	**	
Carabidae	***	***	***	0.305***	**Controlling for Geography**
Lepidoptera	***	***	***	0.285***	
Araneae	***	***	***	0.237***	
Staphylinidae	***	***	***	0.164***	
Aves	***	***	***	0.110*	

Bonferroni corrected p-values:*= p<0.01;**= p<0.001;***= p<0.0001;n.s. = not significant

Controlling for temperature altitude lost importance

Mantel test; Partial Mantel test
Jaccard Estimator index Chao et al. 2005

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Controlling for temperature altitude lost importance

Strong link of community composition of invertebrates to temperature

Birds show a different pattern

↓

Endothermic

Mantel test; Partial Mantel test

Jaccard Estimator index Chao et al. 2005

	Temperature	Altitude	Belt	Geography	
Carabidae	0.228***	(n.s.)	*	***	**Controlling for Temperature**
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Controlling for temperature altitude lost importance

Strong link of community composition of invertebrates to temperature

Birds show a different pattern

↓

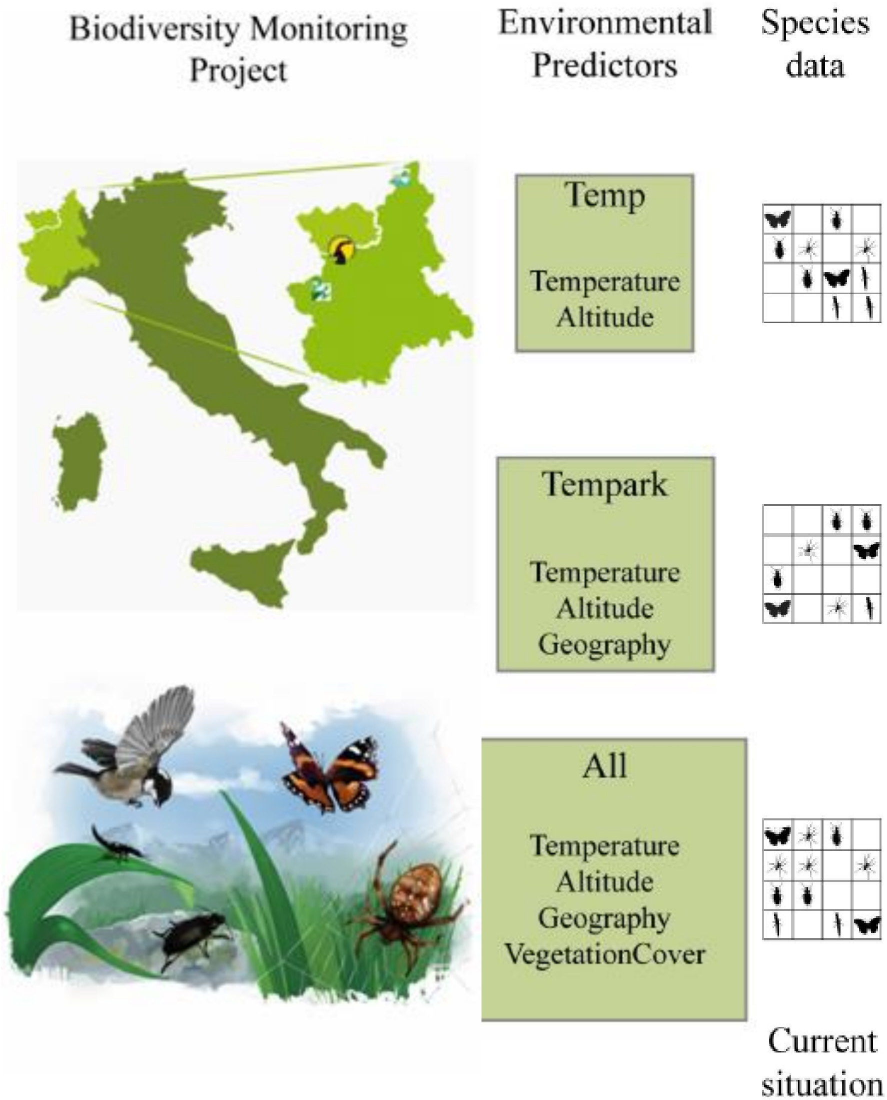
Endothermic

The variance explained by geographic distance cannot be attributable to any other factor

Effects of temperature increase scenarios on multitaxa distribution in mountain ecosystems

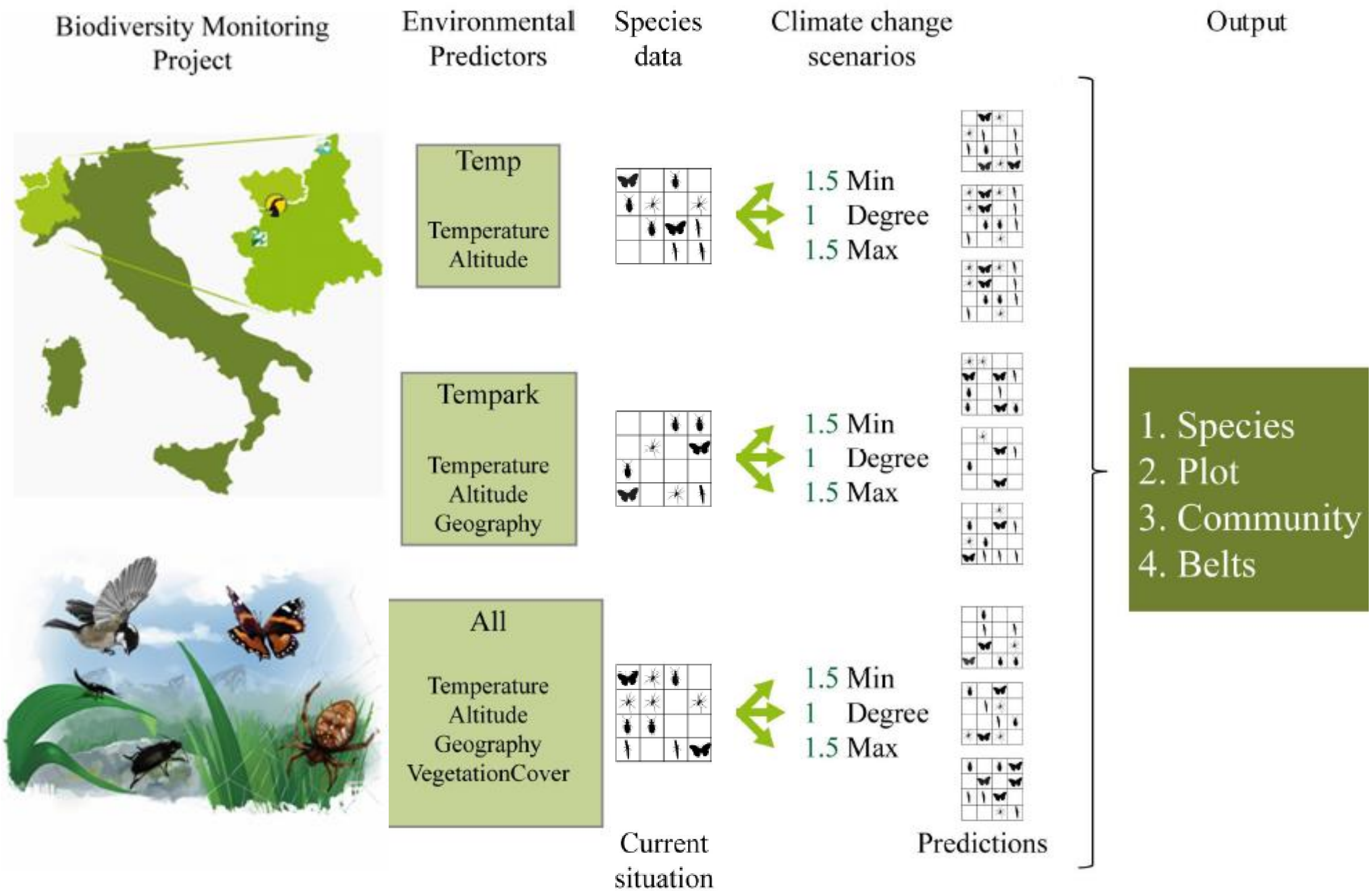
Assess the risk of alpine biodiversity modification in relation to climate change

Viterbi et al., 2013. Effects of temperature rise on multi-taxa distribution in mountain ecosystems. Submitted to Oecologia



> increase of *__minimum temperature__* Beniston (2006)

> increase of *__maximum temperature__* Ciccarelli et al (2008)



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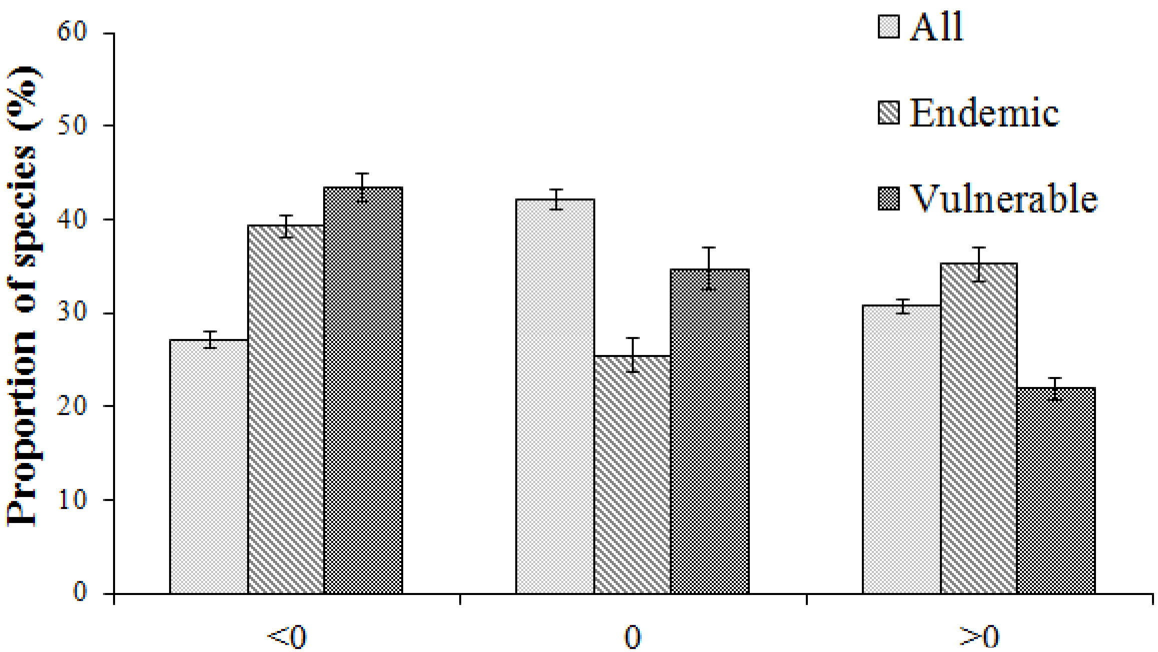
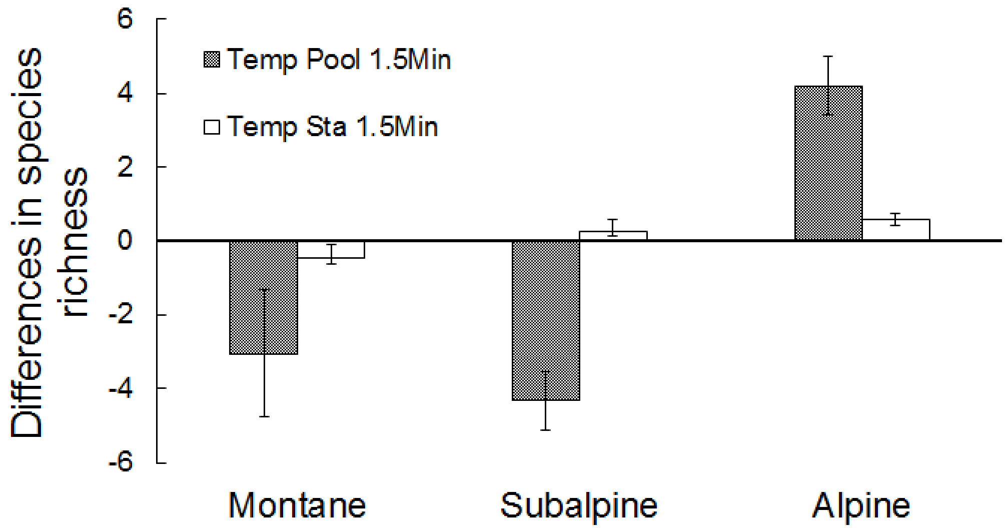
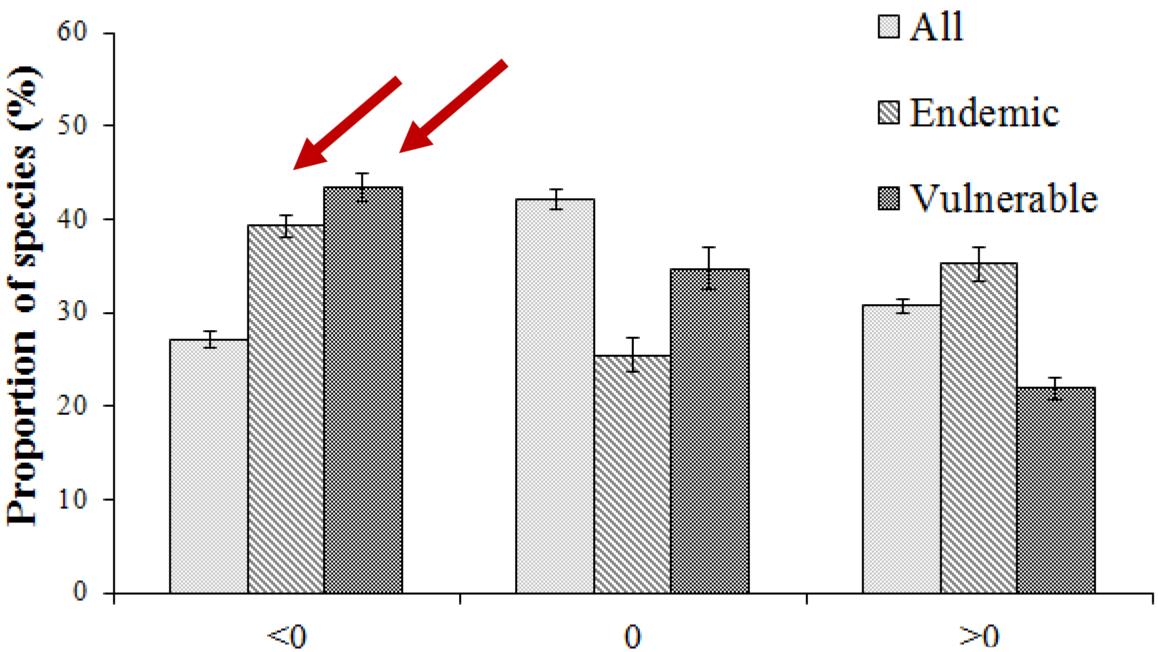


Proportion of species (%)
0
10
20
30
40
50
60
<0
0
>0
All
Endemic
Vulnerable

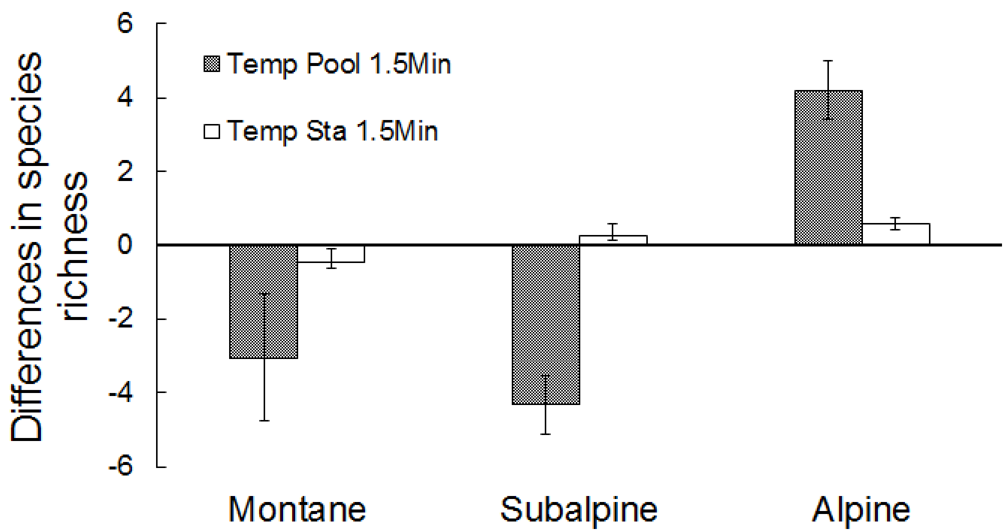


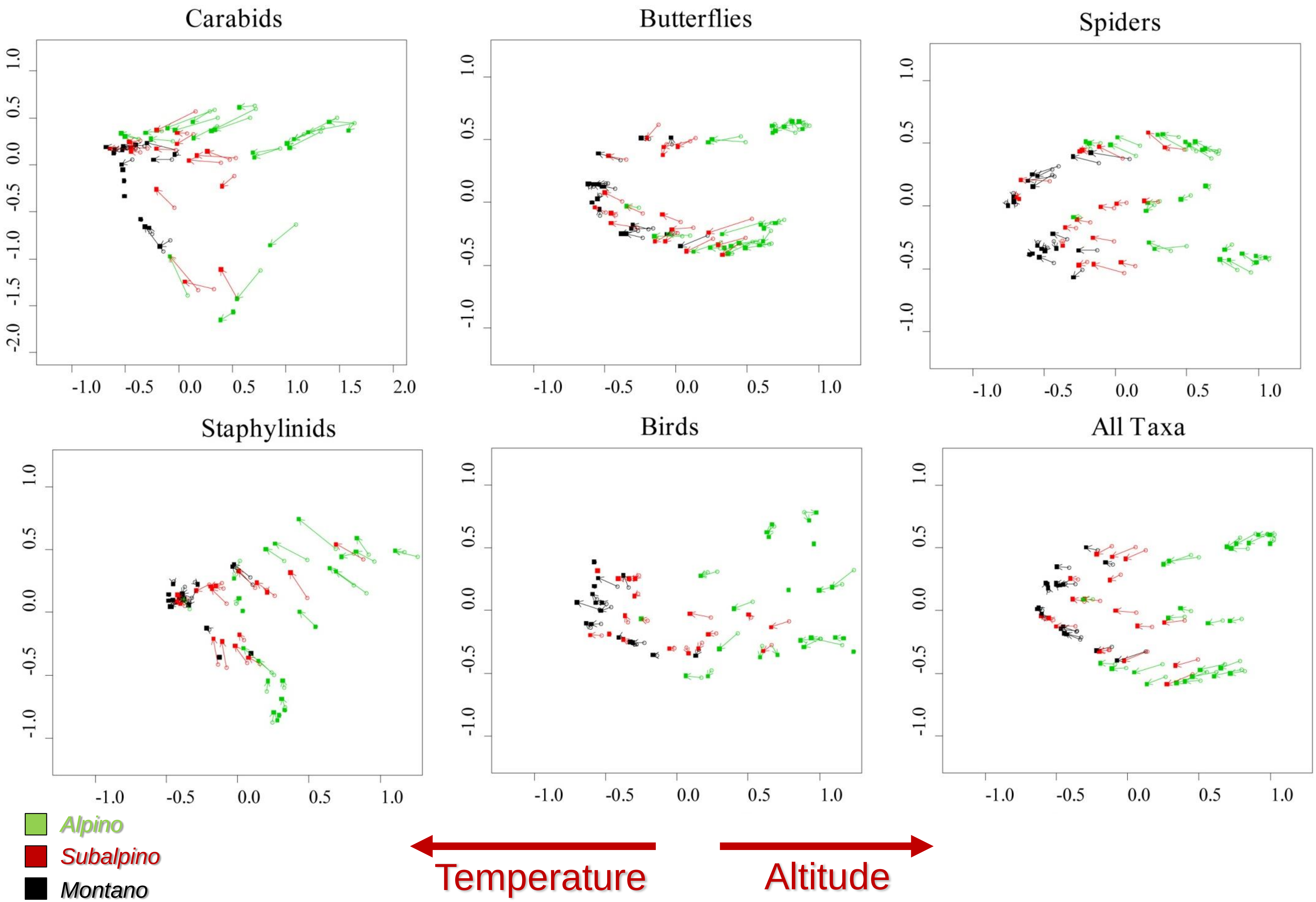
Differences in species richness
6
4
2
0
-2
-4
-6
Temp Pool 1.5Min
Temp Sta 1.5Min
Montane
Subalpine
Alpine



For endemic and vulnerable species decreased the number of occupied plots

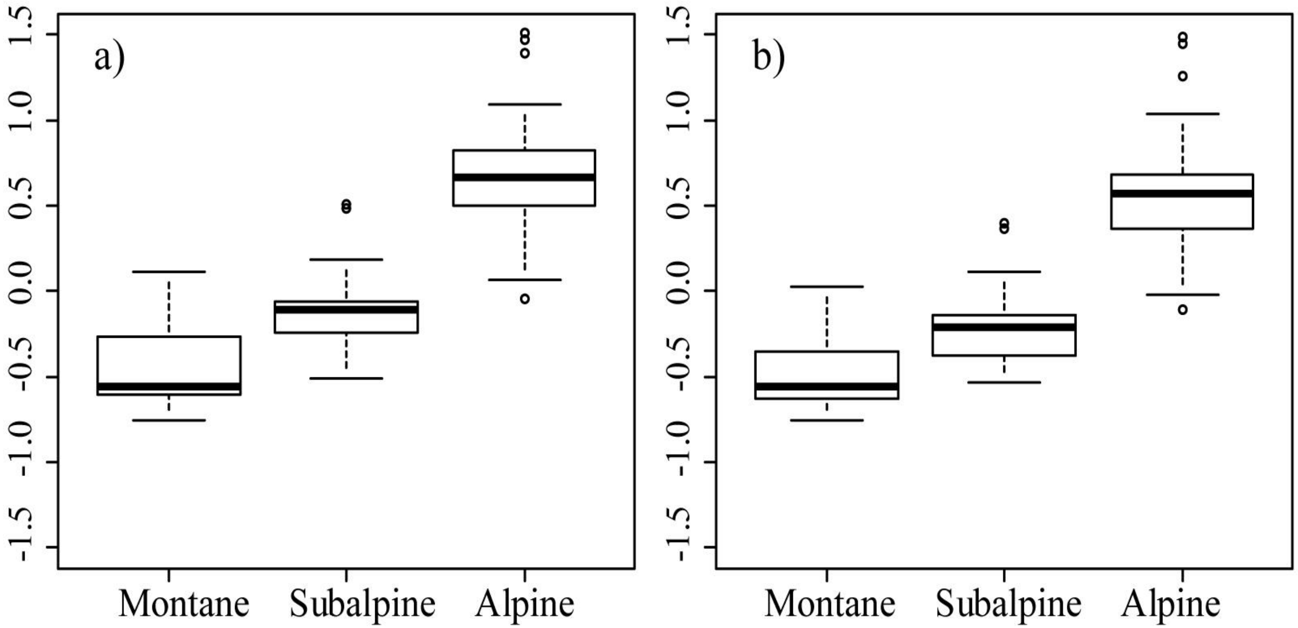
Species richness increased in the alpine belt





Carabids
Butterflies
Spiders
Staphylinids
Birds
All Taxa
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Alpino
Subalpino
Montano
Temperature
Altitude

Present   Model

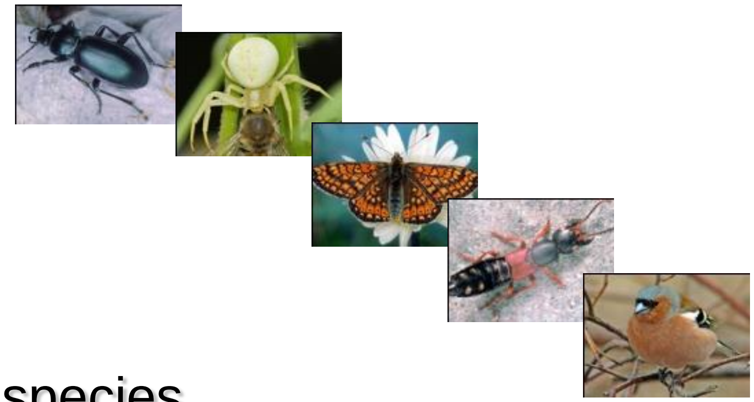


Climate-  -Biodiversity

Species richness and community composition are mostly determined by:

- Altitude

- Microclimatic conditions



Peculiarities of Alpine belt :

- Low values of species richness

- High percentage of endemic and vulnerable species

Strong link of invertebrates' community to temperature:

- Potential sensitivity to climatic variation

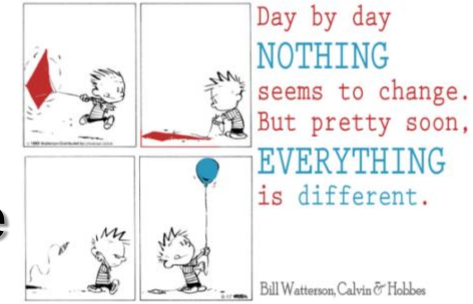
Moderate temperature increase scenarios:

- Influence species richness and community composition

- Affect mostly endemic and vulnerable species

- Increase alpine belt species richness, decrease the one in the subalpine

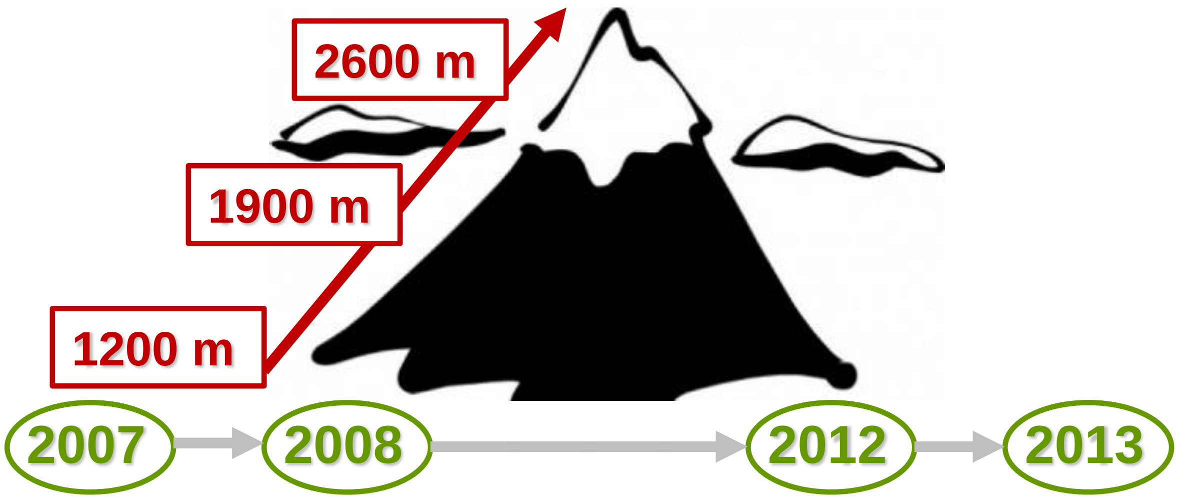
In progress…



Temporal and Spatial β-diversity

Change in community structure through space and time

Species or functional groups responsible of change



- ***Turnover***: replacement of some species by others from site to site
- ***Nestdness***: non-random process of species loss

Variation: multivariate dispersion or variance in community structure

Loss of variation at different altitude (***biotic homogenization***)

Anderson et al. (2011) Navigating the multiple meaning of β-diversity: a roadmap for the practicing ecologist. Ecol Lett 14: 19-28
Baselga (2012) The relationship between species replacement, dissimilarity derived from nestedness, and nestedness. Global Ecol Biogeogr 21: 1223-1232

Time Series: Butterfly

Respond quickly and faster than other groups
Can act as indicators of changes in other taxa

Parmesan (2003) University of Chicago Press; Thomas et al. (2004) Nature; Devictor et al. (2012) Nat Clim Change
Hellmann (2002) Island Press; Thomas (2005) Phil Trans R Soc B

Butterfly Monitoring Scheme
In many European countries, but lacking in Italy

e.g. Roy et al. (2001) J Animal Ecol; Franco et al. (2006) Glob Change Biol; Pöyry et al. (2009) Glob Change Biol; Stefanescu et al. (2011) Glob Change Biol; WallisDeVries et al. (2011) Oecologia

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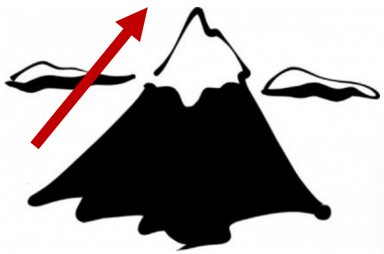
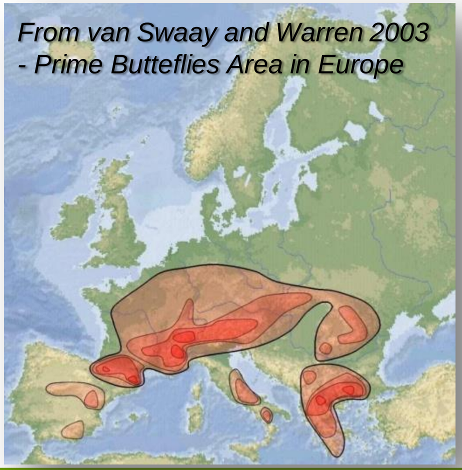
2 altitudinal gradients *Valle Orco and Valle Soana*

Altitudinal range: 1200-2400 m



Sampling stations: 13

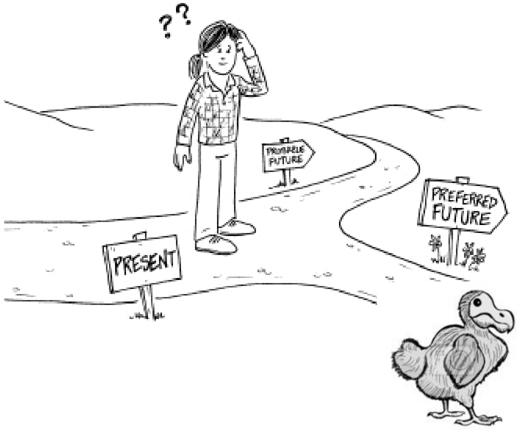
9 monitoring years: 2006-2014



Time-series analysis

Continuous *vs* interupted monitoring
9 years vs *2 years monitoring-4 years stop-2 years monitoring*

Indicator of Climate Change



Climate change scenarios

Key *indicator species*, for each taxon, selected from the field surveys

- Different functional groups
- Altitudinal specialists *vs* generalists

Data on ***bioclimatic limits*** obtained from primary literature and confirmed by expert opinion

Maximum Entropy Model
Philips et al. (2006) Maximum entropy modeling of species geographic distribution. Ecol Mod 190: 231-259

Boosted Regression Trees
Elith et al. (2008) A working guide to boosted regression trees. J Animal Ecol 77: 802-813

Hierarchical Bayes Models
Kery and Royle (2008) Hierarchical Bayes estimation of species richness and occupancy in spatially replicated surveys

Increasing the number of scenarios to identify the temperature threshold beyond which the risk of biodiversity loss will be extremely elevated

Summers et al. (2012) Species vulnerability to climate change: impacts on spatial conservation priorities and species representation. Global Change Biol 18: 2335-2348; McMahon et al. (2011) Improving assessment and modelling of climate change impacts on global terrestrial biodiversity. Trend Ecol Evol 26: 249-259:

Body-size along Altitudinal gradient

Body size
- thermoregulation
- energy and mass acquisition
- life-history
- fecundity

Resilience in the face of climate change
Fluctuating Asymmetry

Chown and Gaston (2010) Body size variation in insects: a macroecological perspective

Understanding the mechanistic links between body size and environmental heterogeneity will identify key traits that shape the potential of a species to respond to climate change and provide insights into thermal tolerances, information that is currently lacking for most species

Gardner et al. (2011) Declining body size: a third universal response to warming? Trends Ecol Evol 26

Body-size along Altitudinal gradient

Body size
- thermoregulation
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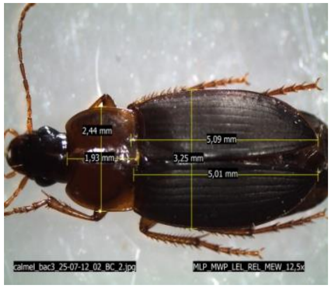
Resilience in the face of climate change
Fluctuating Asymmetry

Chown and Gaston (2010) Body size variation in insects: a macroecological perspective

Understanding the mechanistic links between body size and environmental heterogeneity will identify key traits that shape the potential of a species to respond to climate change and provide insights into thermal tolerances, information that is currently lacking for most species

Gardner et al. (2011) Declining body size: a third universal response to warming? Trends Ecol Evol 26



Coleoptera Carabidae
5 species (200-500 specimens per species)
11 parameters

Widespread along the altitudinal gradient (1200-2600 m) and the 3 areas

Relative role of

Abiotic Factors Altitude, Temperature, Rainfall

Biotic Factors Nutrition/Food availability, Competition/Facilitation

Vegetation surveys, Macro-invertebrates sampling

Thanks for your attention!