ALPARC WORKSHOP - Ceresole Reale, 10th of September 2014
"Monitoring biodiversity transformation to document climate change impacts in alpine protected areas"
-

Soil, phyto and Zoocenosis characteristics along two elevational gradients in the Italian Alps: plants and microarthropodes as indicators of temperature change in the alpine area

Enrico Rivella

Arpa Piemonte, Struttura Ambiente e Natura

Con il contributo di:
Andrea Bertola, Nicola Loglisci, Luca Paro, Lucia Pompilio – ARPA Piemonte
Angelo Caimi, Michele Freppaz, Gianluca Filippa – Di.Va.P.R.A. Università di Torino
Danilo Godone – DEIAFA, Università di Torino
Simona Bonelli, Giorgio Buffa, Cristiana Cerrato – DBIOS, Università di Torino

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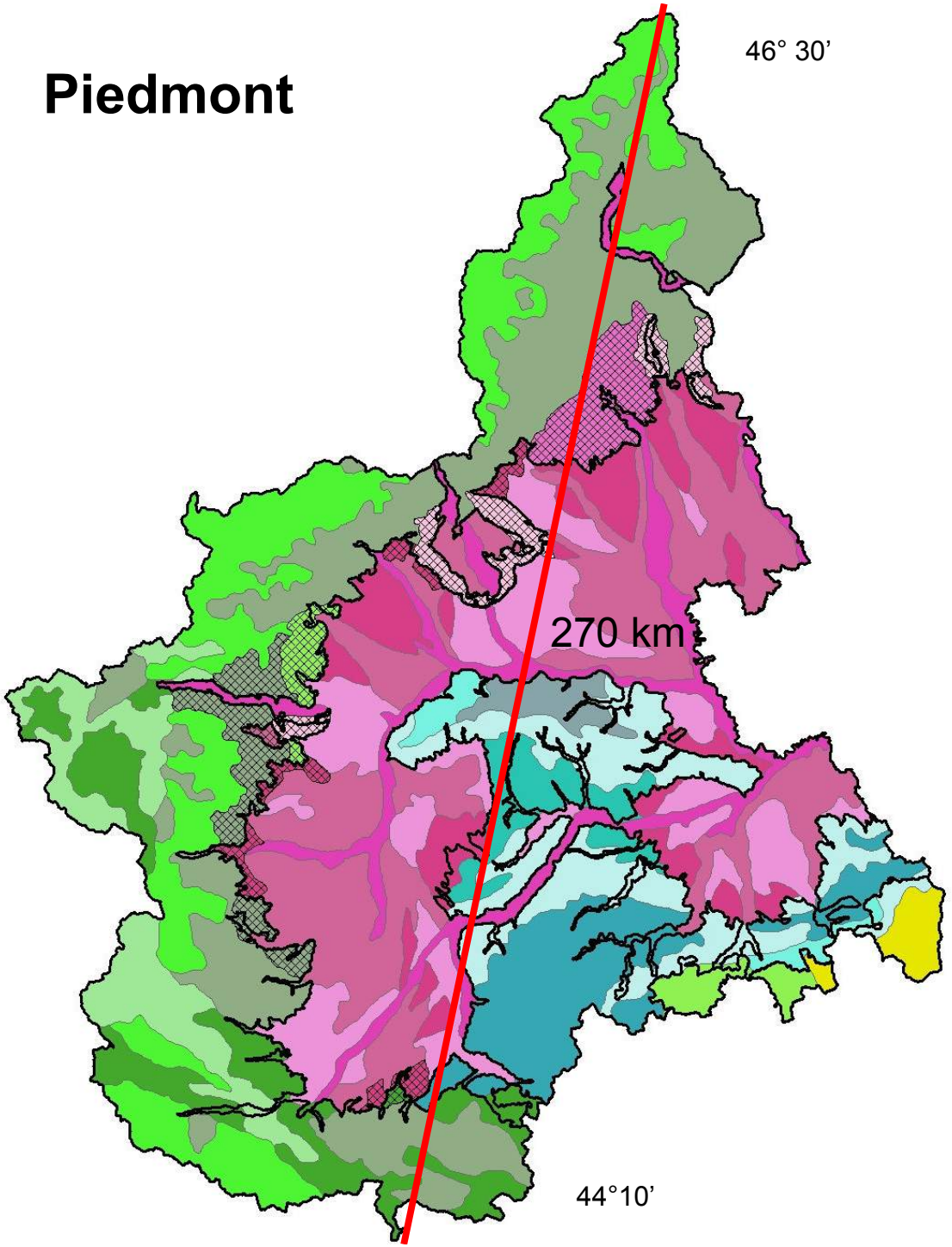
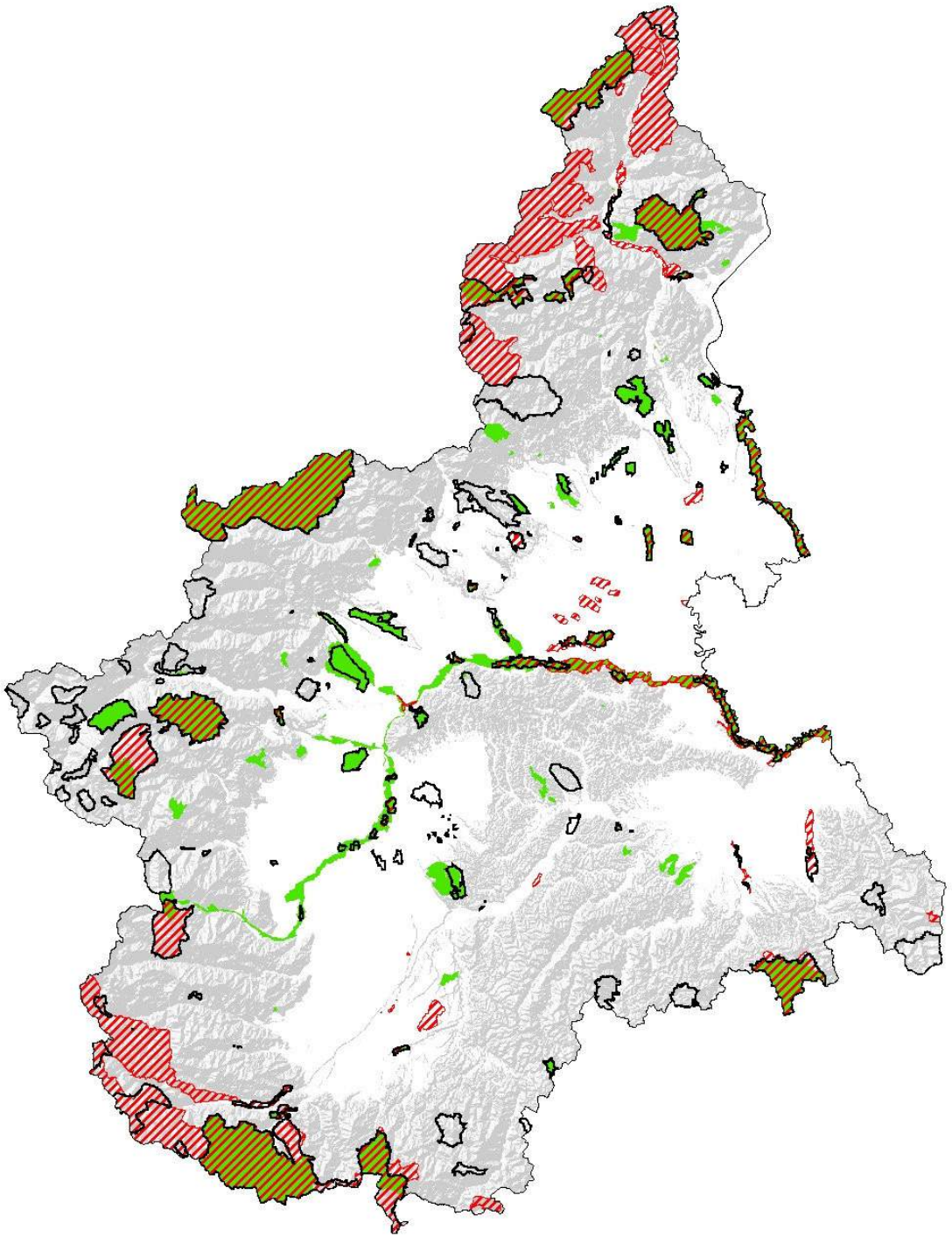
Piedmont



- pedemonte
- Alvei straordinari
- Morene
- Pianura recente
- Vecchia Pianura
- Terrazzi antichi
- Prealpi
- Appennino
- Rilievi alpini di alta quota su litologie calcaree
- Rilievi alpini di alta quota su litologie silicatiche
- Rilievi alpini di bassa quota su litologie calcaree
- Rilievi alpini di bassa quota su litologie silicatiche
- Rilievi alpini ed appenninici su litologie magnesiache
- Rilievi alto-collinari su litologie prevalentemente conglomeratiche
- Rilievi collinari fortemente sollevati su litologie marnose
- Rilievi collinari su litologie arenacee
- Rilievi collinari su litologie marnose ed argillose
- Rilievi collinari su litologie sabbiose



Siti di interesse comunitario

Zone di protezione speciale

Aree protette

ROLE OF AN ENVIRONMENTAL AGENCY FACE TO CLIMATE CHANGE IN THE ALPINE ECOSYSTEMS

- Finding the right bioindicators to track trends of alpine ecosystems linked to global warming effects
- Implement a long-term monitoring network based on an integrated monitoring protocol (meteorology, pedoloogy, geology, biodiversity)
- Map the territory and model the scenarios for climate change adaptation (planning)

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BIOLOGICAL ANSWERS TO INCREASING TEMPERATURE

- **Altitudinal and longitudinal shift of termo-sensitive species and invasion of clima-adapted or competitive species**
- **Disappearence of vulnerable habitats (pe. bogs)**
- **Different phenological timing of biological rhitmes (vital phases, migration periods, vegetative period)**
- **Mismatch of the interaction between species**
- **Phisiological, behavorioual adaptation**

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Altitudinal shift effects

Elevational shift of vegetation belts

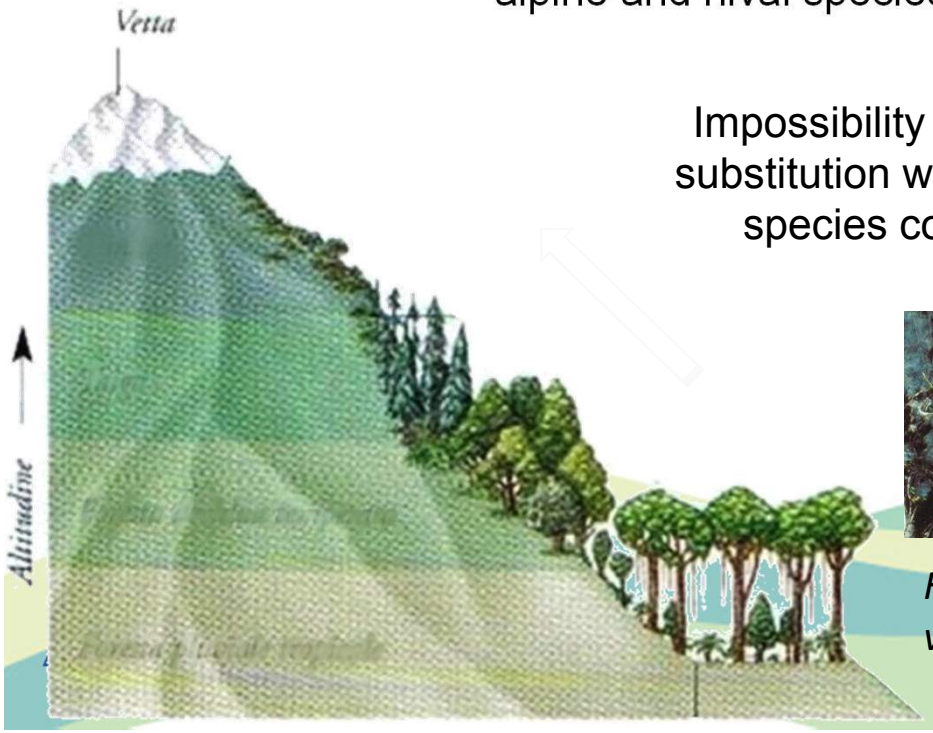
Migration toward summits

Form and extension changements of alpine and nival species habitat

New communities

Impossibility of upward shift and substitution with more competitive species coming from down

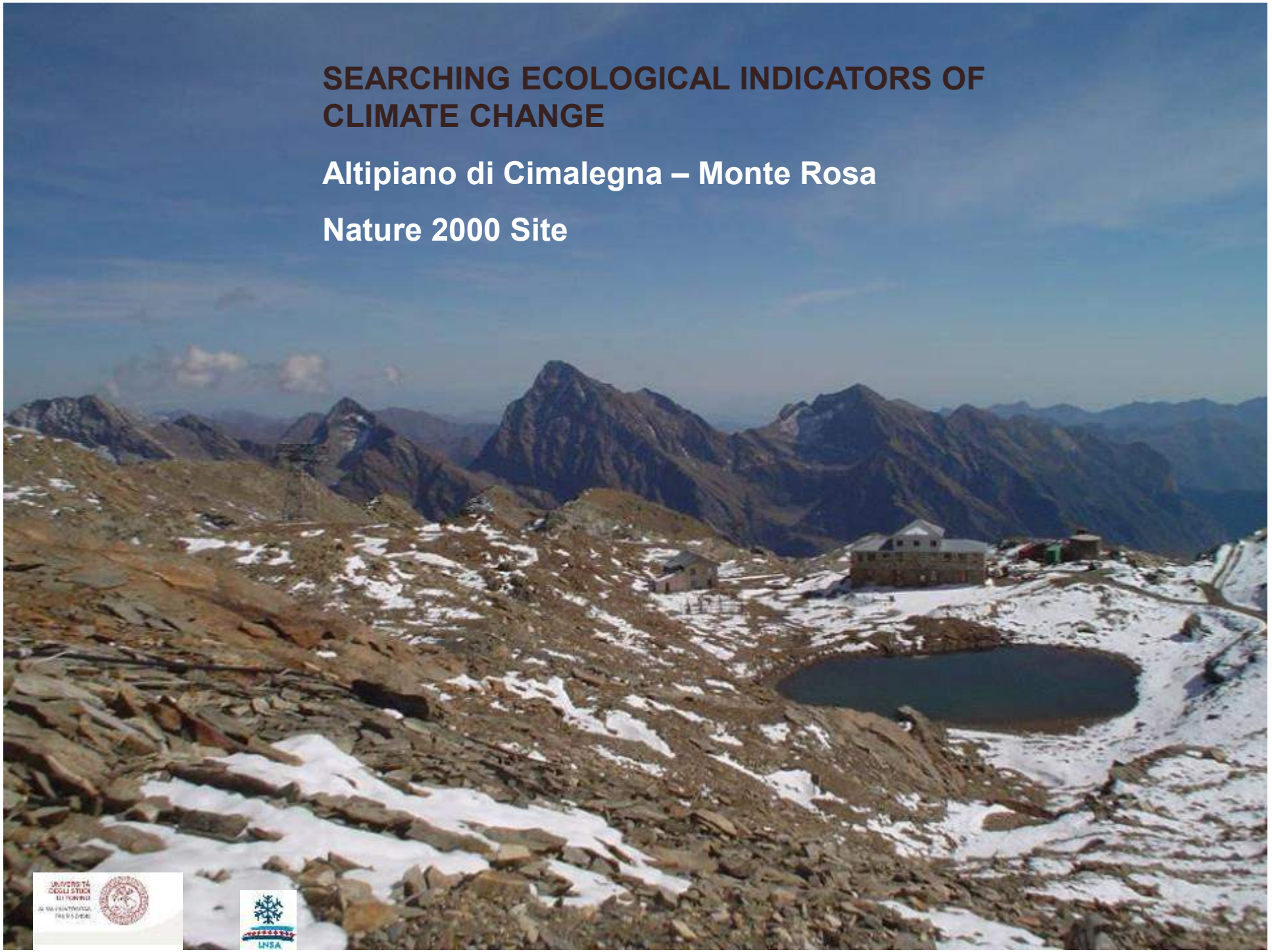
Extinction



Hieracium villosum

Dryas octopetala

Aster alpinus


SEARCHING ECOLOGICAL INDICATORS OF CLIMATE CHANGE
Altipiano di Cimalegna – Monte Rosa
Nature 2000 Site

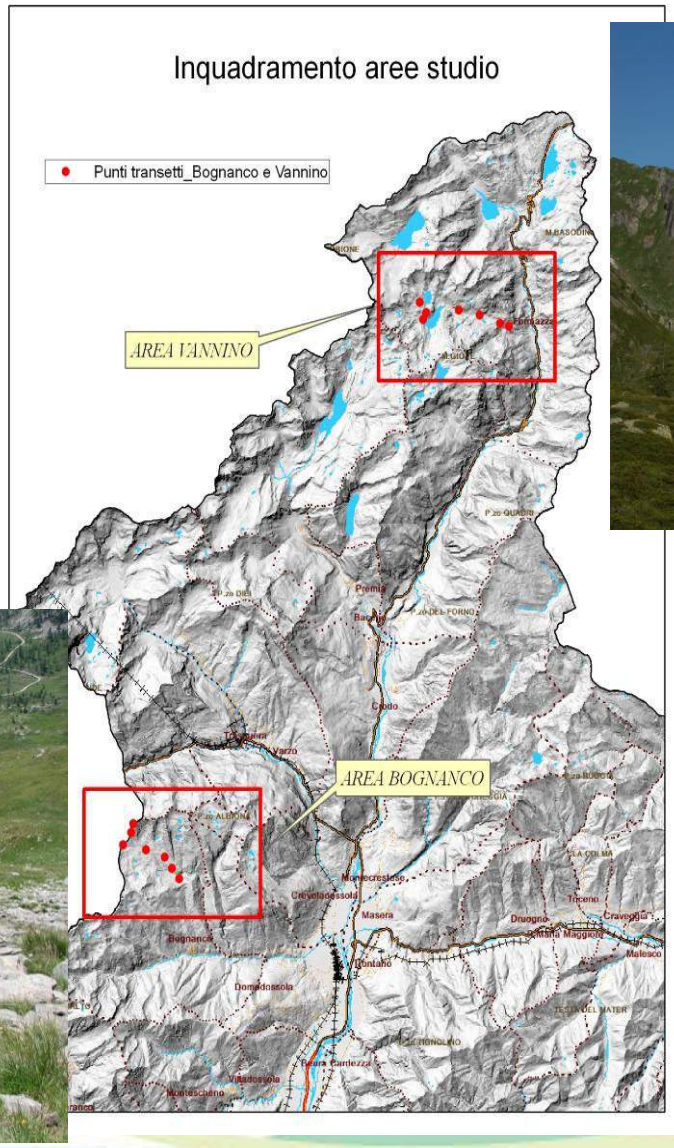
Project EU-INTERREG “BIODIVERSITY’: A RESSOURCE TO CONSERVE”,

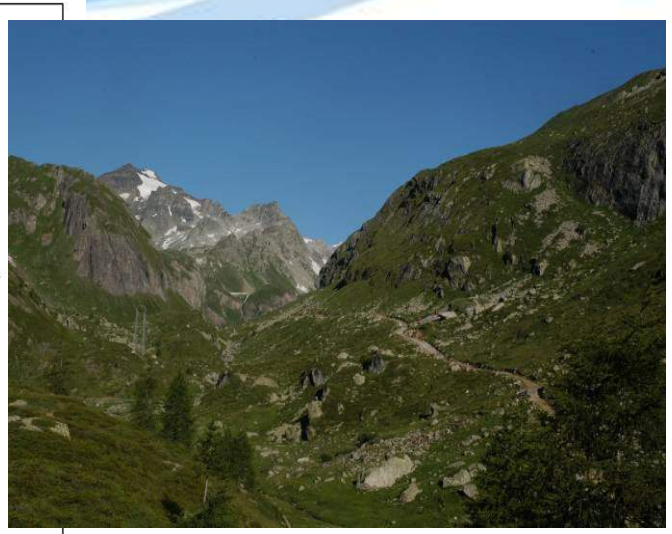
Italy-Switzerland Interreg Prorgamme.

Verbania mountains are located in the North-Western Italian Alps. It is an area of strong climatic variations

Collaboration with University of Turin: DIVAPRA (pedology) and DBIOS (biology)

2 Transects of 7 plots in the range 1600-2600 m





Vallone del Vannino (Val Formazza)

Vallone San Bernardo (Val Bognanco)

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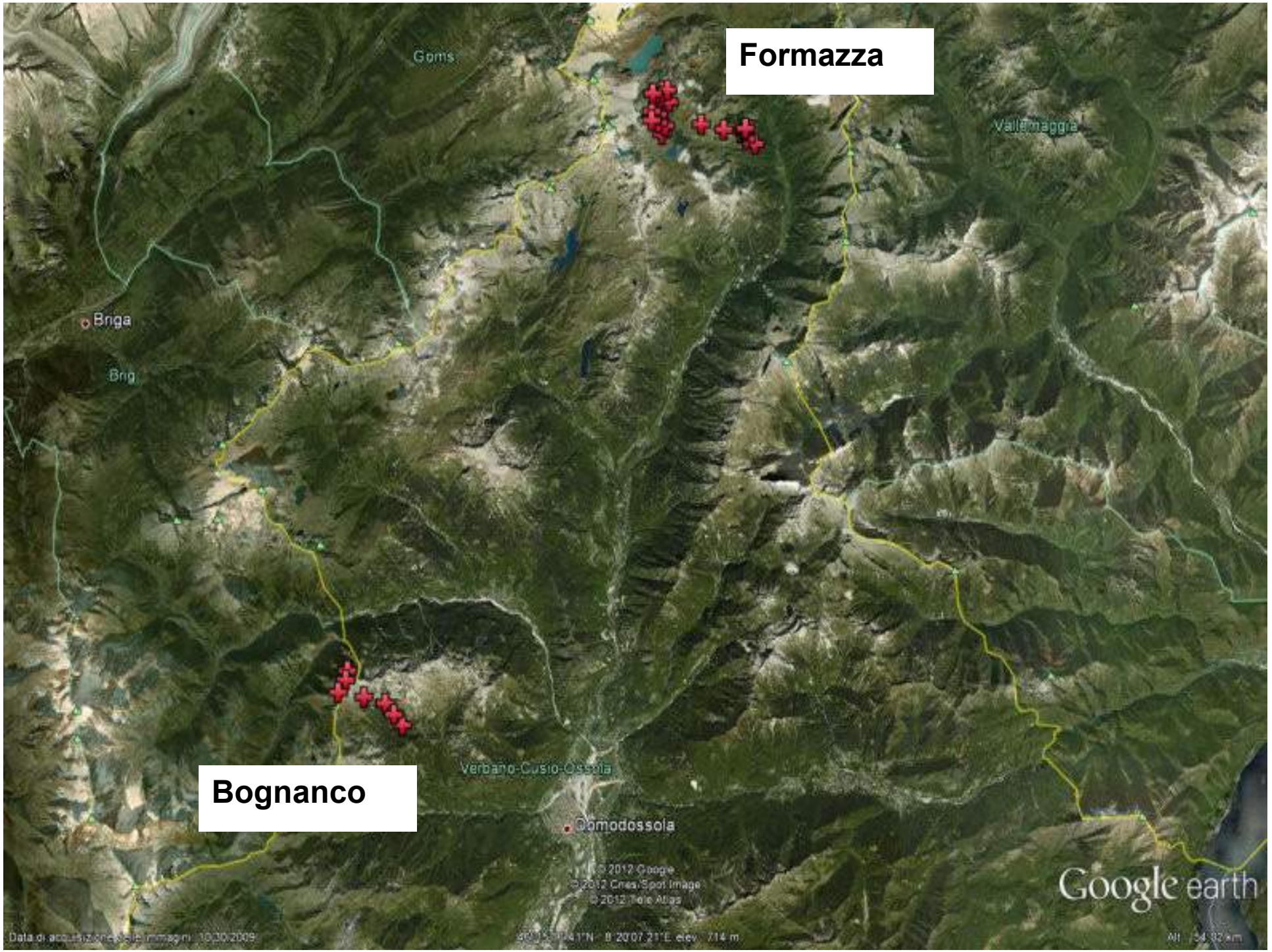
Formazza
Bognanco
Goms
Vallemaggia
Brig
Verbano-Cusio-Ossola
Domodossola
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Google earth

Specific surveys carried out in a **peatland** for each transect, as the two areas were signalled for hosting termosensitive flora (arctic relicts) and fauna (Odonata and the Lepidopter *Colias palaeno*, whose extinction risk is considered linked to climate change)

La Balma

Formazza

2050 m s.l.m.

San Bernardo
Bognanco 1600 m s.l.m.

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Site 1 Formazza (1786 m slm)

Picea abies, Larix decidua, Sorbus aucuparia, Vaccinium myrtillus, Hepatica nobilis……

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Site 7 Formazza (2515 m slm)

Vaccinium myrtillus, Vaccinium uliginosum, Carex curvula, Carex sempervirens, Geum montanum, Nardus stricta, Nigritella nigra……

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Elevational gradient Bognanco

Site Code	Altitude (m)	Moisture (%)	Environment	Exposition
BoTR1	1.616	105,2	Coniferous wood 85% cover	131° N
BoTR2	1.706	27,9	Coniferous wood 80% cover with *Abies alba*	176° N
BoTR3	1.827	63,3	Coniferous wood 60% cover, with *Larix decidua*	193° N
BoTR4	1.949	36,8	Alpine prairie with shrubs (*Rododendrum f.*)	139° N
BoTR5	2.113	41,2	Alpine prairie with shrubs (Rododendrum f.)	184° N
BoTR6	2.353	23,4	Alpine prairie with stones	178° N
BoTR7	2.590	17,8	Alpine prairie with stones	191° N

Wood
Alpine prairie

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Elevational gradient Formazza (Vannino)

Site Code	Altitude (m)	Moisture (%)	Environment	Exposition
FoTR1	1.795	30,0	Coniferous wood 95% cover with *Picea abies*	182° N
FoTR2	1.910	80,8	Coniferous wood	194° N
FoTR3	2.055	26,4	Shrubs community at the tree-line edge	175° N
FoTR4	2.165	24,3	Alpine prairie with stones	194° N
FoTR5	2.268	50,0	Alpine prairie with stones	177° N
FoTR6	2.394	27,9	Alpine prairie with *Juncus trifidus*	169° N
FoTR7	2.546	62,3	Alpine prairie with stones	187° N

Wood
Alpine prairie

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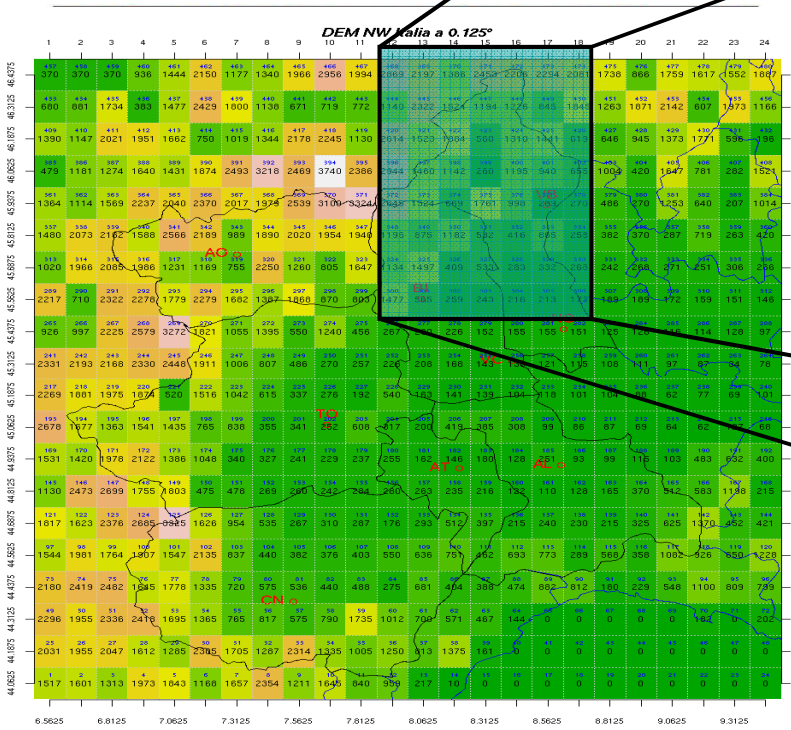
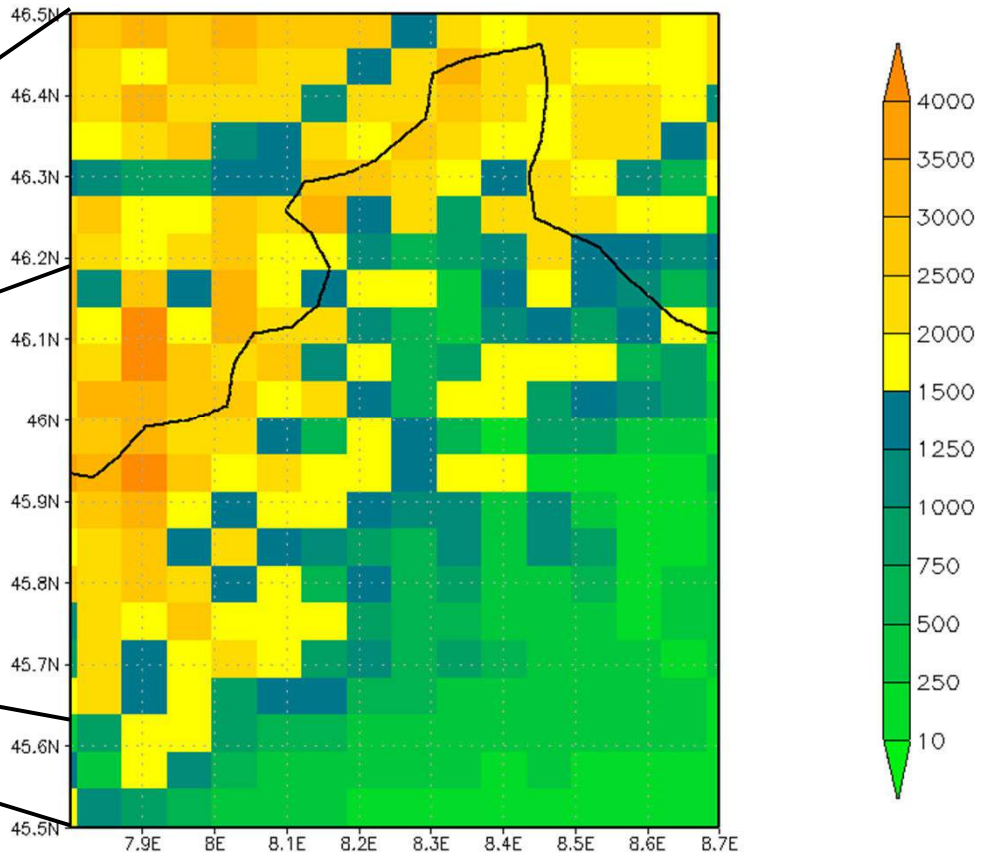
Climatic data coming from automatic weather stations spread over the study area were set on a 7 km resolution grid, applying the Optimal Interpolation methodology.

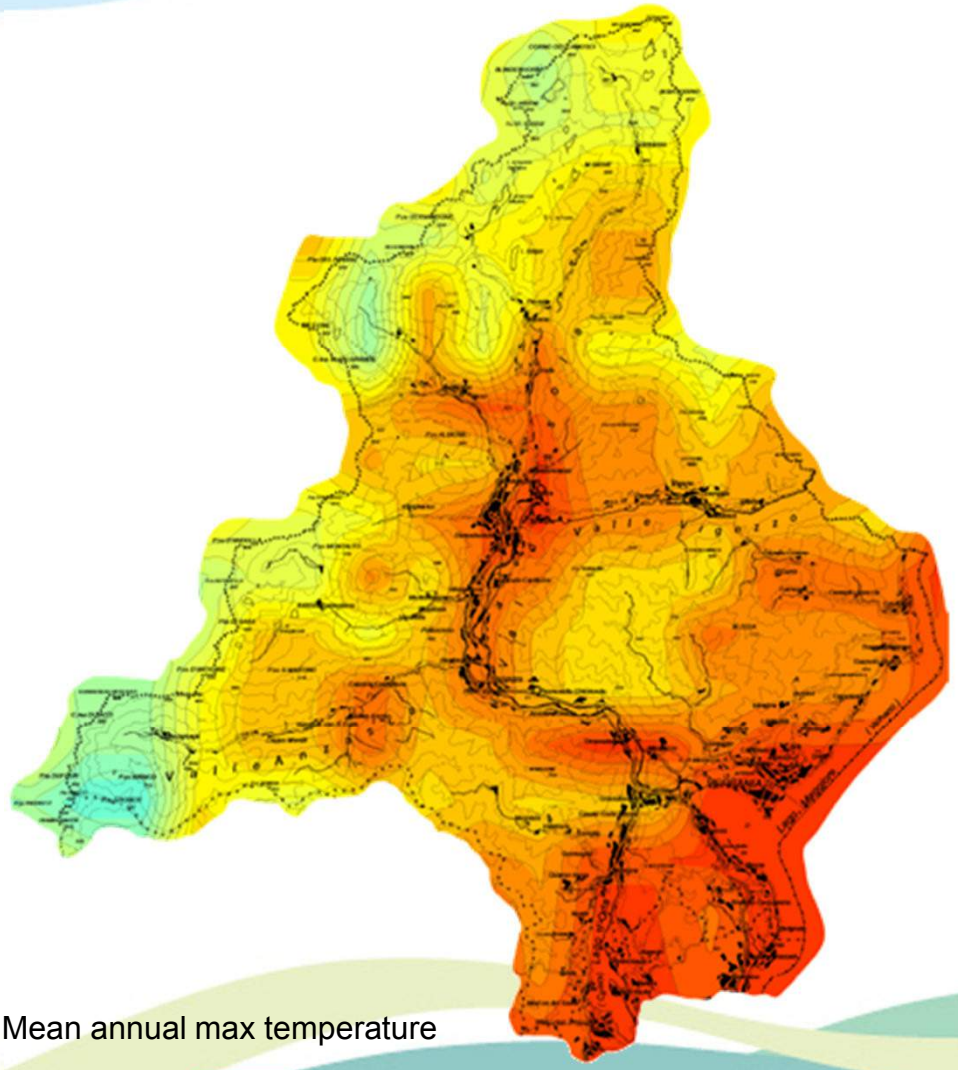
Old resolution 14 km



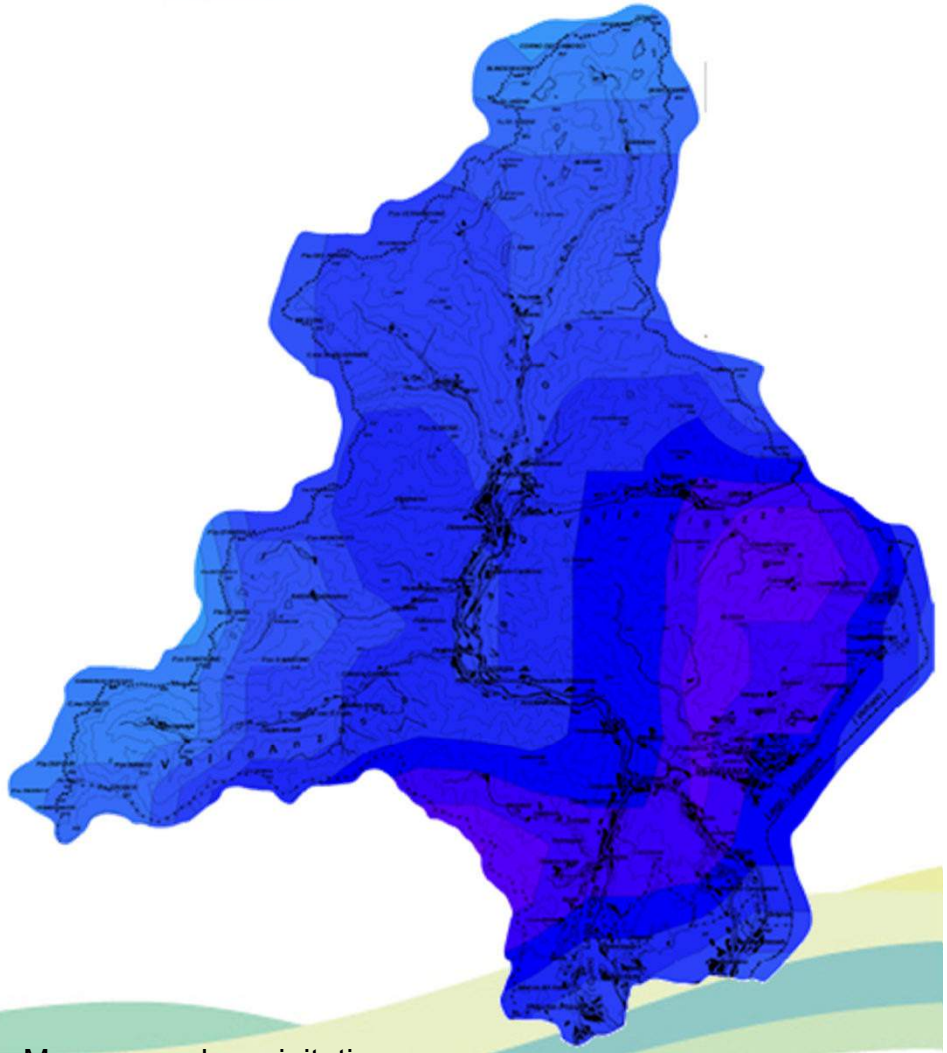
New resolution 7 km (1999 – 2009 y)



CLIMATE ATLAS



Mean annual max temperature



Mean annual precipitation

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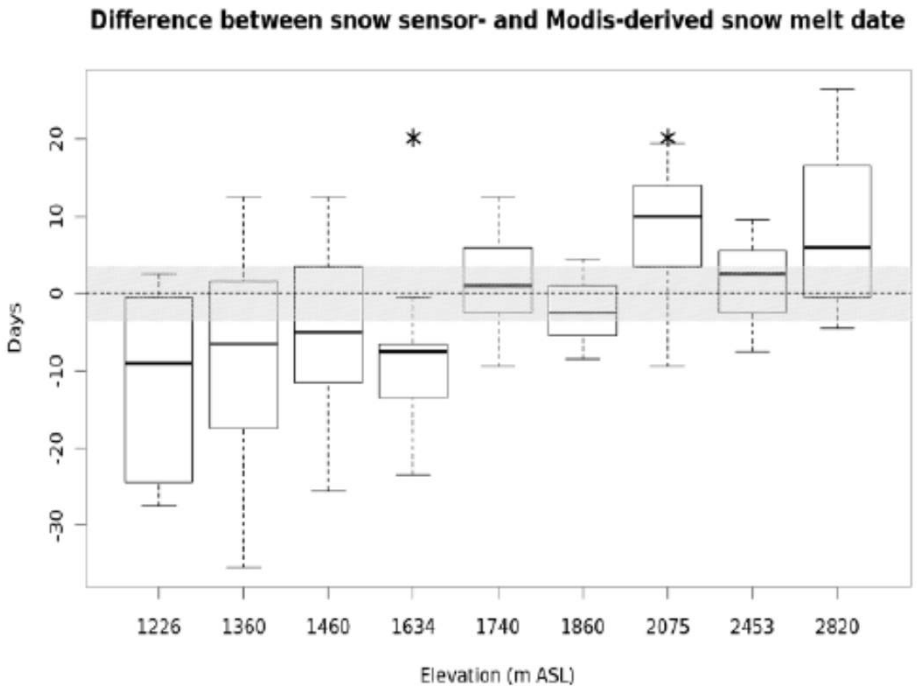
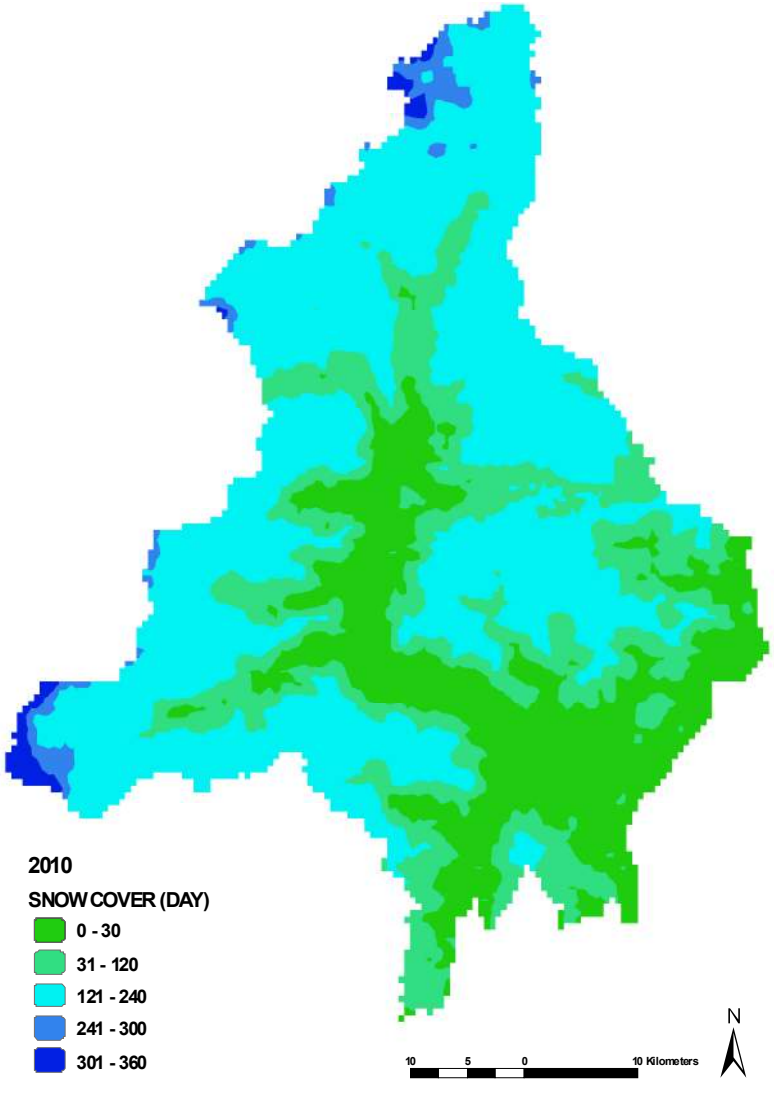
SNOW COVER EXTENT AND DURATION

using MODIS time series in comparison with in-situ measurements





International Journal of Environmental Protection IJEP

Snow Cover Extent and Duration in MODIS Time Series: a Comparison with In-Situ Measurements (Provincia Verbano Cusio Ossola, NW Italy)

Danilo Godone, Gianluca Filippa, Silvia Terzago, Enrico Rivella, Alessio Salandin, Secondo Barbero, Gabriele Gomero, Michele Freppaz

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Vannino Area

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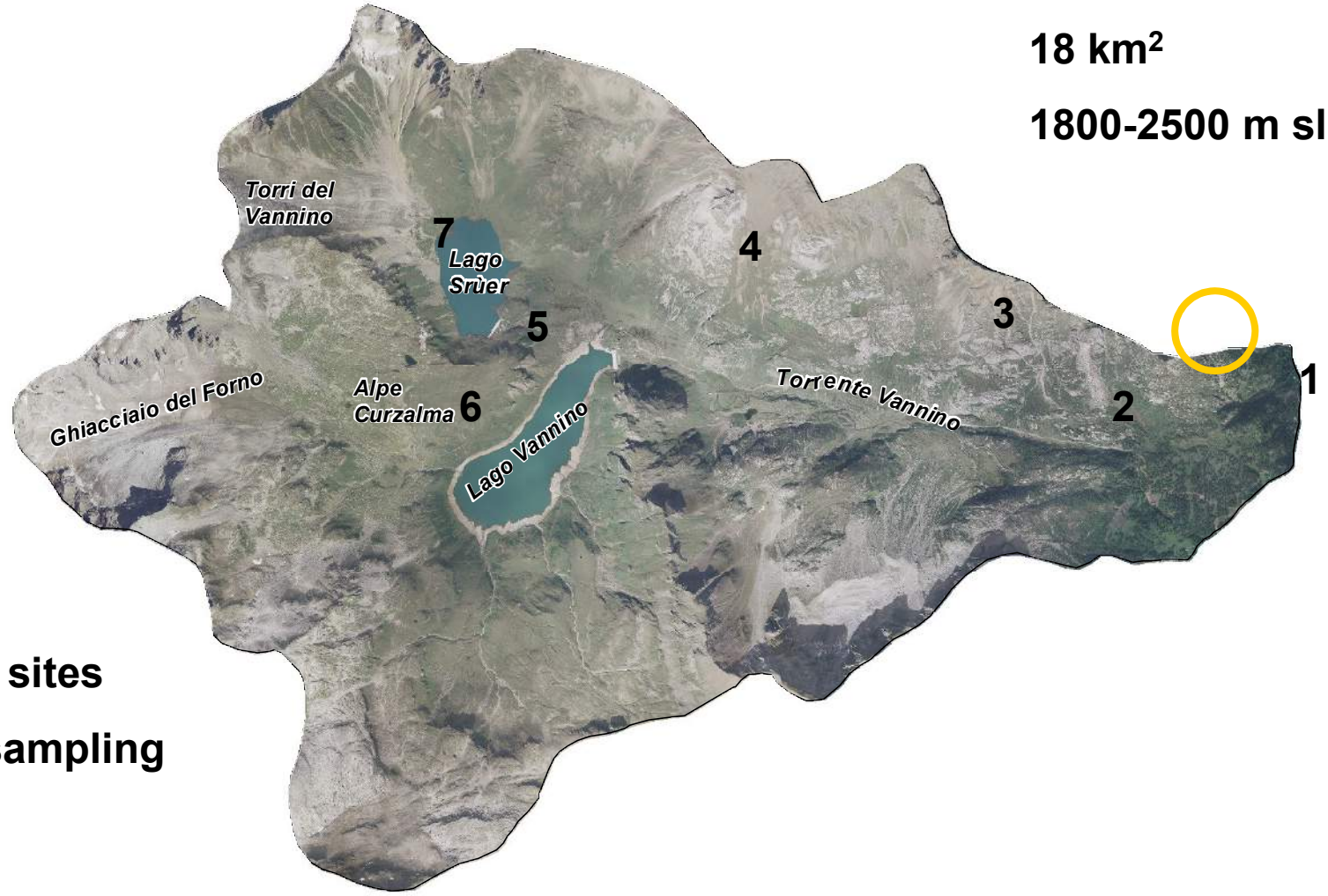
Vannino Area (Formazza)



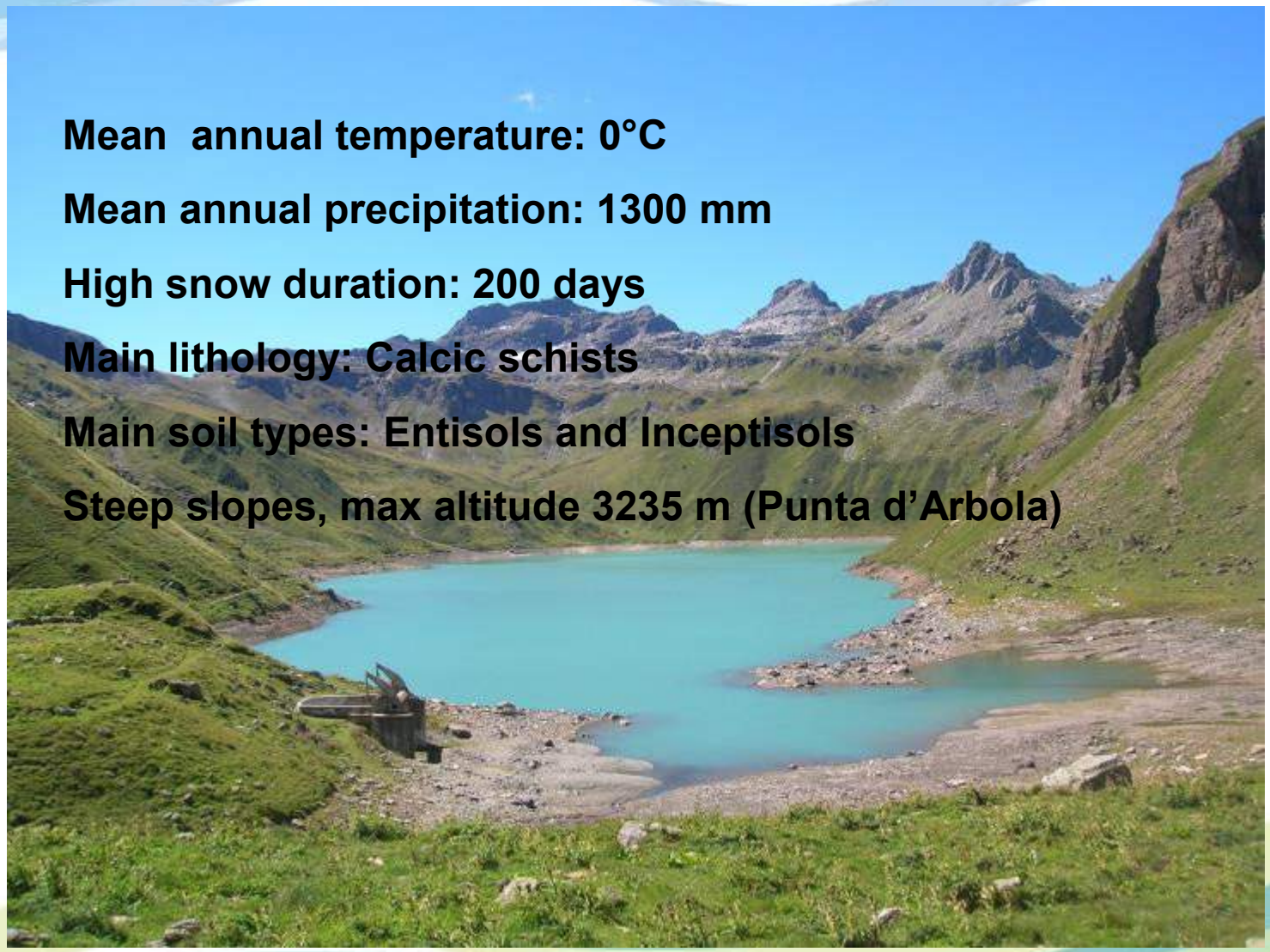
18 km²

1800-2500 m slm

Transect: 7 sites

Other 148 sampling points

Vannino area



Mean annual temperature: 0°C

Mean annual precipitation: 1300 mm

High snow duration: 200 days

Main lithology: Calcic schists

Main soil types: Entisols and Inceptisols

Steep slopes, max altitude 3235 m (Punta d'Arbola)

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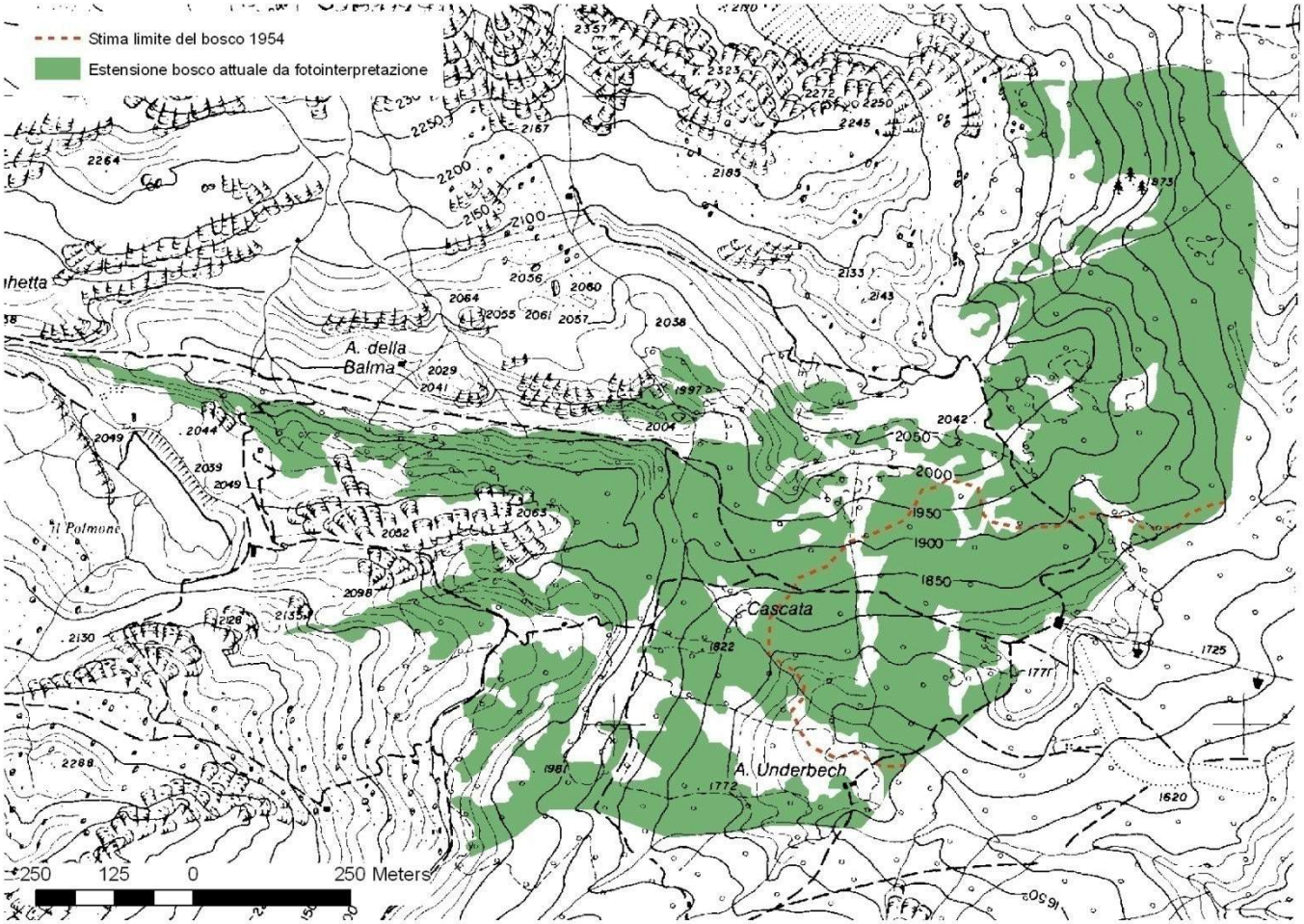
Diachronical *tree-line* analysis in Vannino



Last fifty years: more than 150 m

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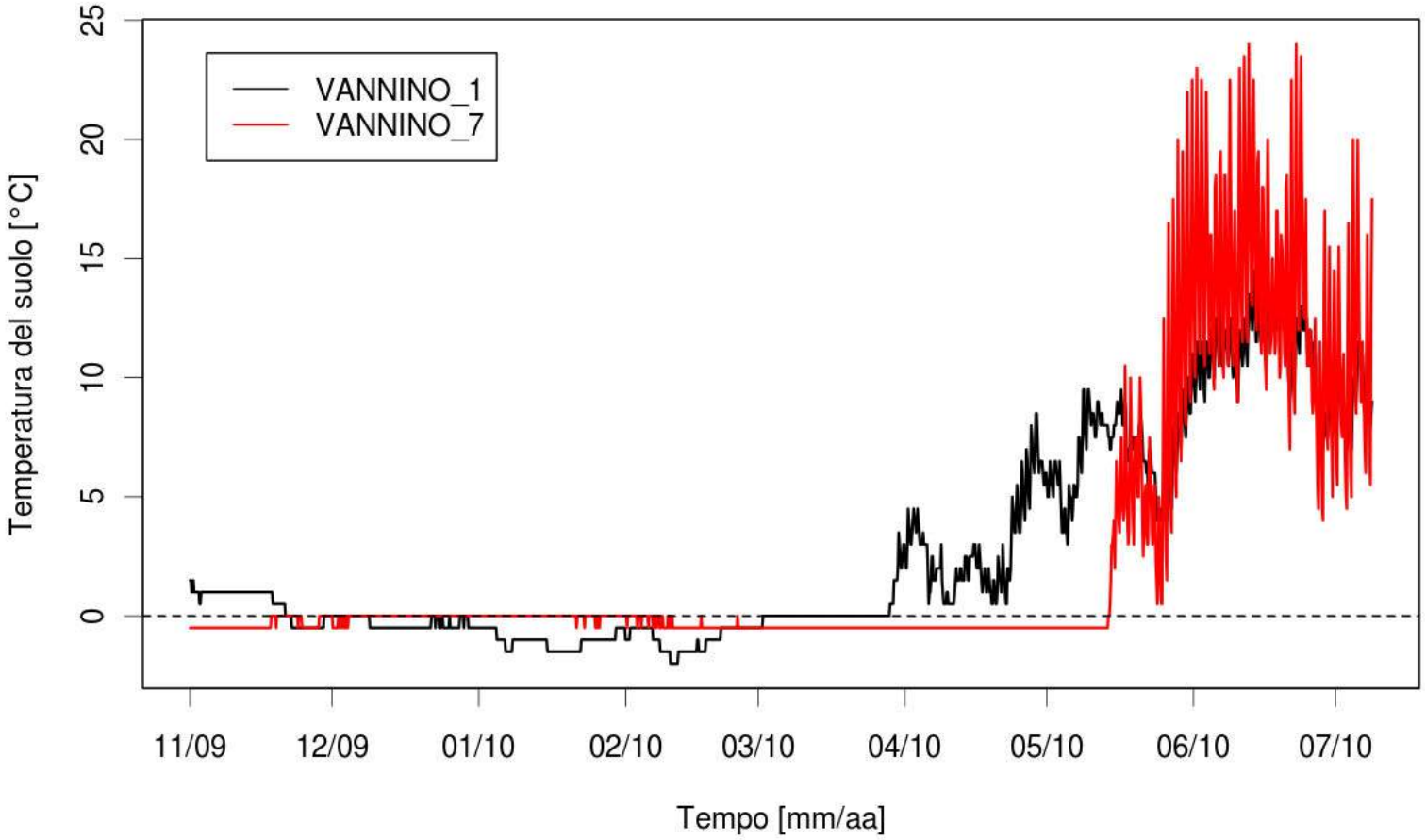
Soil temperature along the gradient (10 cm depth)



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A detailed vegetation survey was carried out in each sampling point. Data were referred to the main land covers:

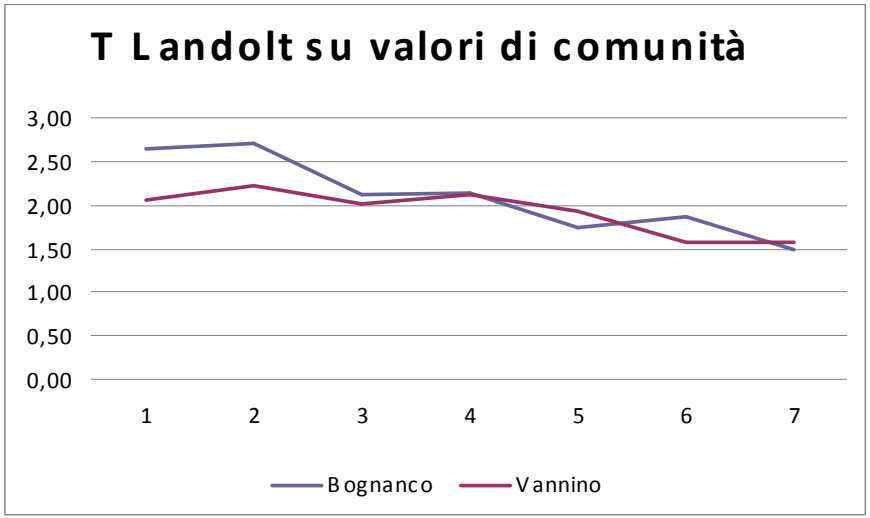
Forest (*Picea abies, Larix decidua*)

Grasslands (*Carex curvula, Agrostis sp., Nardus stricta…)*

Shrubs (*Juniperus communis, Rhododendron ferragineum, Vaccinium sp….*)

Scree plants (*Salix sp., Leucanthemopsis alpina, Luzula alpinopilosa, Silene acaulis…*

Vegetational Plot : 4 x 4 square meters



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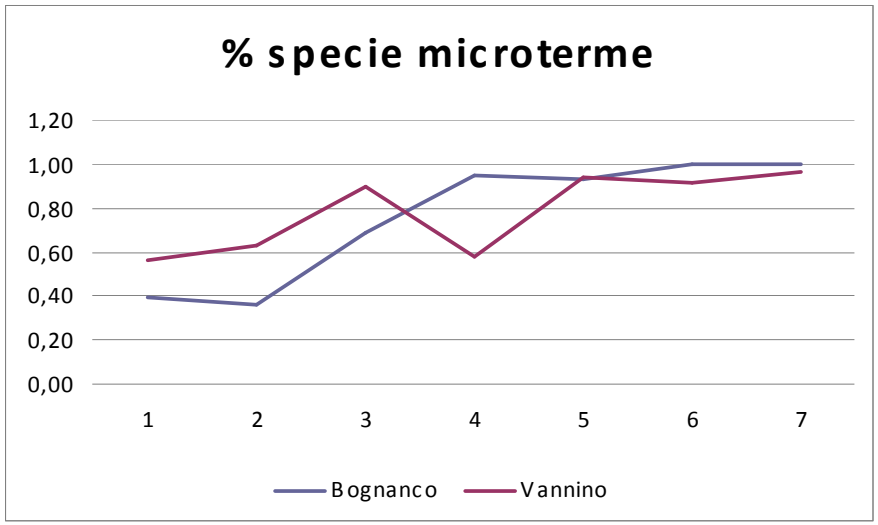

Cold-loving species cover

		Bognanco				Vannino			
		Micr. 1 %	Micr. 2 %	Altre			Micr. 1 %	Micr. 2 %	Altre
TR1	2009	0	16,73	83,27	TR1	2009	0	24,82	75,18
TR1	2010	0	18,52	81,48	TR1	2010	0	28,90	71,10
TR2	2009	0	4,74	95,26	TR2	2009	0,49	64,80	34,71
TR2	2010	0	5,26	94,74	TR2	2010	0,66	60,53	38,81
TR3	2009	0,17	22,98	76,85	TR3	2009	2,34	93,62	4,04
TR3	2010	0	27,99	72,01	TR3	2010	2,78	92,78	4,44
TR4	2009	1,72	81,50	16,78	TR4	2009	20,63	52,06	27,31
TR4	2010	1,90	83,06	15,04	TR4	2010	21,28	49,31	29,41
TR5	2009	29,97	68,86	1,17	TR5	2009	7,49	90,50	2,01
TR5	2010	21,42	77,82	0,76	TR5	2010	7,92	91,64	0,44
TR6	2009	29,66	68,47	1,87	TR6	2009	46,33	53,67	0
TR6	2010	33,99	64,05	1,96	TR6	2010	41,58	58,42	0
TR7	2009	48,84	51,16	0	TR7	2009	46,18	53,48	0,34
TR7	2010	48,49	51,51	0	TR7	2010	46,10	53,37	0,53

Figura 1 - Copertura media dell'indice di temperatura T di Landolt delle piante erbacee

Legenda: Micr.1) piante tipiche alpine e artiche; Micr.2) piante tipiche subalpine, presenti in zona alpina anche in esposizione Sud; TR1-TR7) codice dei plot dei due transetti dal più basso (TR1, 1600 m circa) al più alto (TR7, 2600 m circa).

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Soil samples were analyzed for the determination of texture (% sand, silt, clay), pH, electrical conductivity (EC). Soil organic carbon and total nitrogen stocks in the top 10 or 20 cm of mineral soil were determined sampling on a volume basis a number of points (n. = 75) and measuring the stoniness (rocks) and bulk density (BD) of samples.

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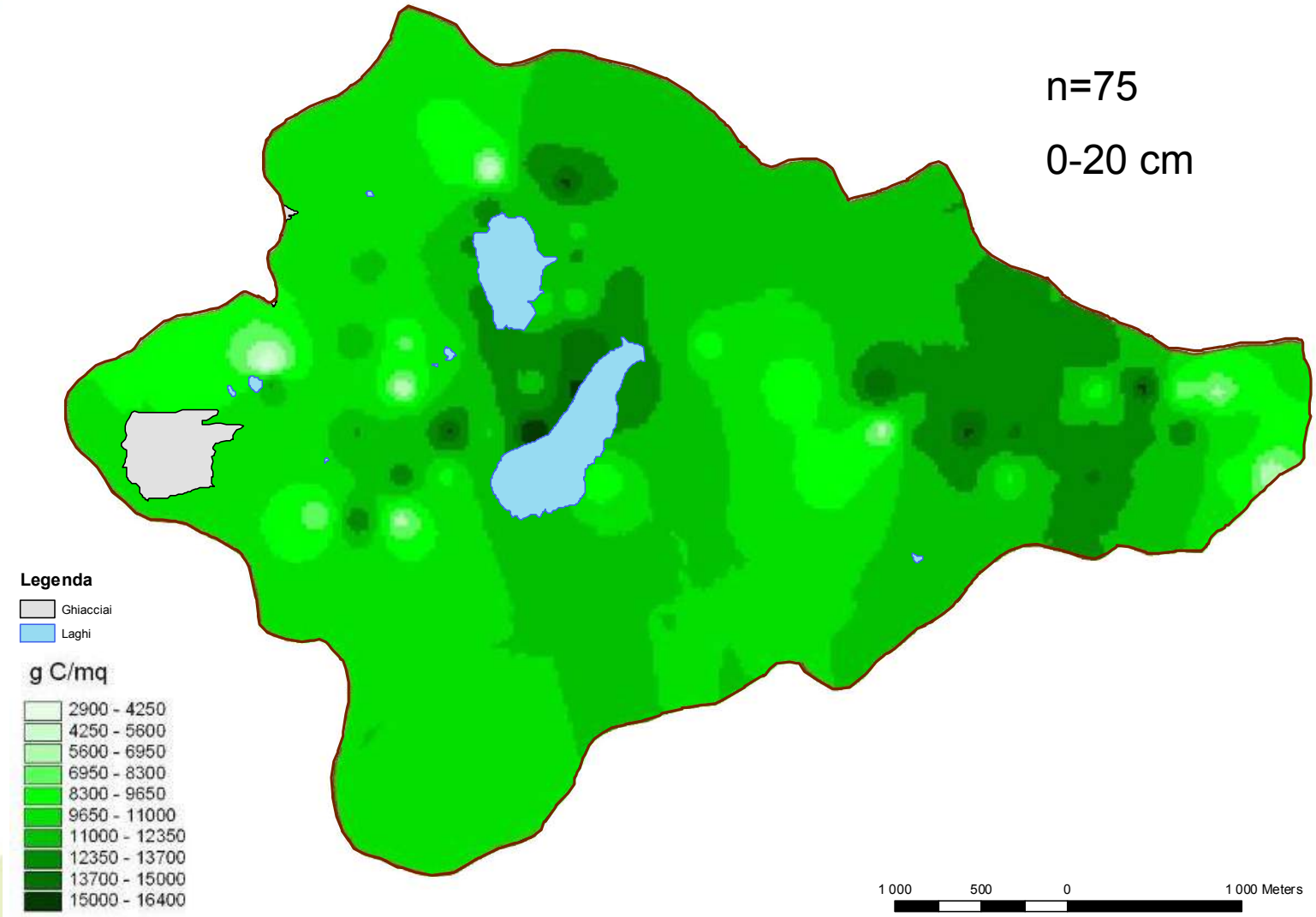
Soil organic carbon in the mineral soil



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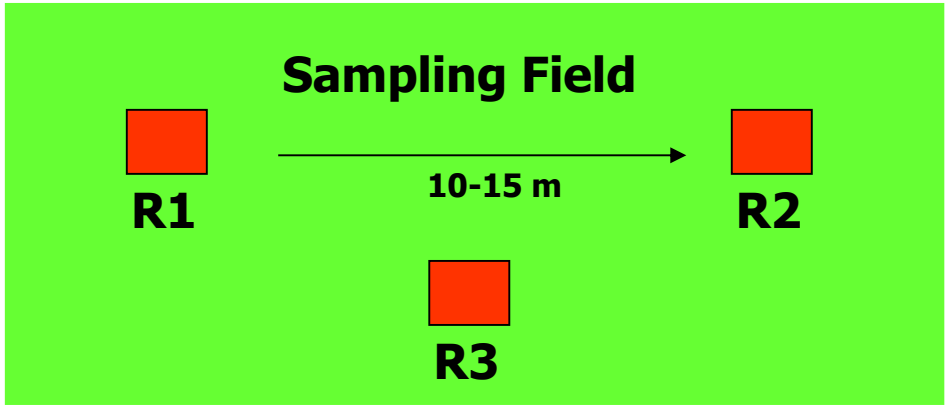
QBS (Biological quality of soil) – Sampling field

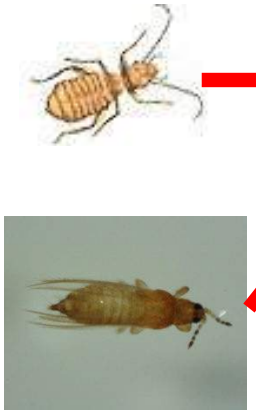
Each sample (R) consists in a 1 dm^3 of soil

The distance between samples is about 10-15 m



EMI values

F.B.	EMI
Pseudoscorpioni	20
Opilionidi	10
Araneidi	1-5
Acari	20
Isopodi	10
Diplopodi	10-20
Pauropodi	20
Sinfili	20
Chilopodi	10-20
Proturi	20
Dipluri	20
Collemboli	1-20
Ortotteri	1-20



F.B.	EMI
Embiotteri	10
Psocotteri	1
Emitteri	1-10
Tisanotteri	1
Coleotteri	1-20
Imenotteri	1-5
Ditteri	1
Mecotteri (larve)	10
Coleotteri (larve)	10
Ditteri (larve)	10
Imenotteri (larve)	10
Lepidotteri (larve)	10
Altri olometaboli	1

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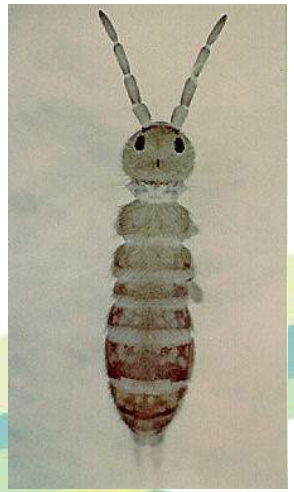
QBS-c (Quality of Soil- Collembola)

QBS-c is a method proposed recently by University of Parma, here applied to alpine soil.

Insect order Collembola: 6500 species known; 0,5-5 mm size.

They show a better sensibility than other pedofauna taxa to variation of organic matter soil content and changes in hydric regim of soil



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QBS-c – Method

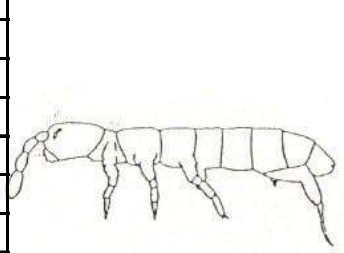
EMI Value assignment to better adaptation for each biological form

BIOLOGICAL FORM	16 main cases

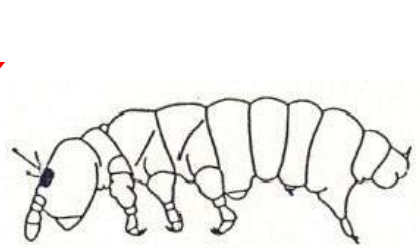
FEATURE	EMI VALUES
Sizes	0-2-4
Pigmentation	0-1-3-6
Fanera	0-1-3-6
Anophthalmia	0-2-3-6
Antennes	0-2-3-6
Legs	0-2-3-6
Furca	0-2-3-5-6

Ex. FORMULA: Isotomide 4-3-3-0-3-6-6 EMI=25

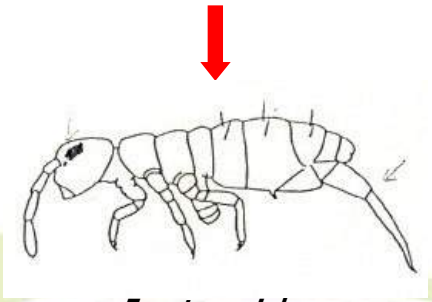
MAIN BIOLOGICAL FORMS FOUND IN ALTITUDE



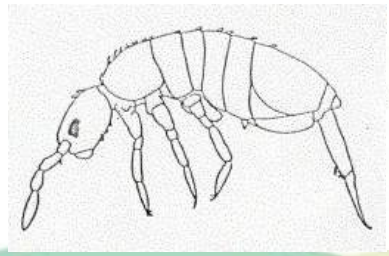
Criptopigide



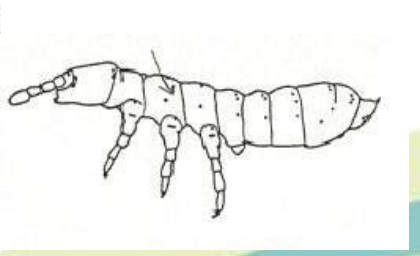
Ipogastruride



Isotomide



Lepidocirtoide



Onichiuride

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QBS results – Altitude gradient
Formazza (Vallone del Vannino)

							ARTHROPODA B.F. - N° SPECIMENS										COLLEMBOLA B.F. - N° SPECIMENS											
Site Code	Altitude (m)	Moisture (%)	QBS-ar	QBS-c	Total Biological Form-ar	Total Biological Form-c	Araneida	Acara	Protura	Collembola	Hemiptera	Thysanoptera	Coleoptera	Other Arthropoda	Totale Artropodi	acara/collembola	Anuroforide	Criptopigide	Dicirtomide	Folsomidea	Ipogastruride	Isotomide	Lepidocirtoide	Neauride	Onichiuride	Orchesellide	Sminturide	Sminturoide
FoTR1	1.795	30,0	149	565	13	8	4	903	294	391	188	0	4	65	1849	2,3	0	115	0	19	75	138	4	6	26	8	0	0
FoTR2	1.910	80,8	119	582	14	8	1	1316	8	350	27	2	1	27	1732	3,8	0	82	0	7	59	123	11	3	57	2	0	0
FoTR3	2.055	26,4	122	157	9	3	0	991	0	99	0	0	0	21	1111	10,0	0	0	0	0	43	6	0	0	137	0	0	0
FoTR4	2.165	24,3	59	83	9	4	0	63	0	21	3	7	1	17	112	3,0	0	0	0	0	1	9	0	0	0	3	0	1
FoTR5	2.268	50,0	106	77	13	4	6	205	1	28	16	5	10	19	290	7,3	0	0	0	0	1	14	0	0	0	11	0	1
FoTR6	2.394	27,9	58	48	12	3	5	42	0	25	1	6	4	11	94	1,7	0	0	0	0	1	20	0	0	0	0	0	3
FoTR7	2.546	62,3	80	37	11	1	8	30	0	11	1	5	3	20	78	2,7	0	0	0	0	0	0	0	0	2	0	0	0

Wood
Alpine prairie

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Ecological niche model BIOMOD (Guisan e Thuiller, 2000) + fate of soil C e stock assessment with model CENTURY, under the IPCC SRES climate scenarios A1B (+1.7 / +4.4 °C) and A1FI (+2.4 / +6.4 °C) in collaboration with Università della Sapienza (Roma) and Tuscia.

Analisys of 80 floristic relevees and 278 soil samples (TOC, TN, pH, Texture, bulk density)

Faunistical Suitability model for rock ptarmigan, *Lagopus mutus* (Arpa)

Rock Ptarmigan (Lagopus mutus)

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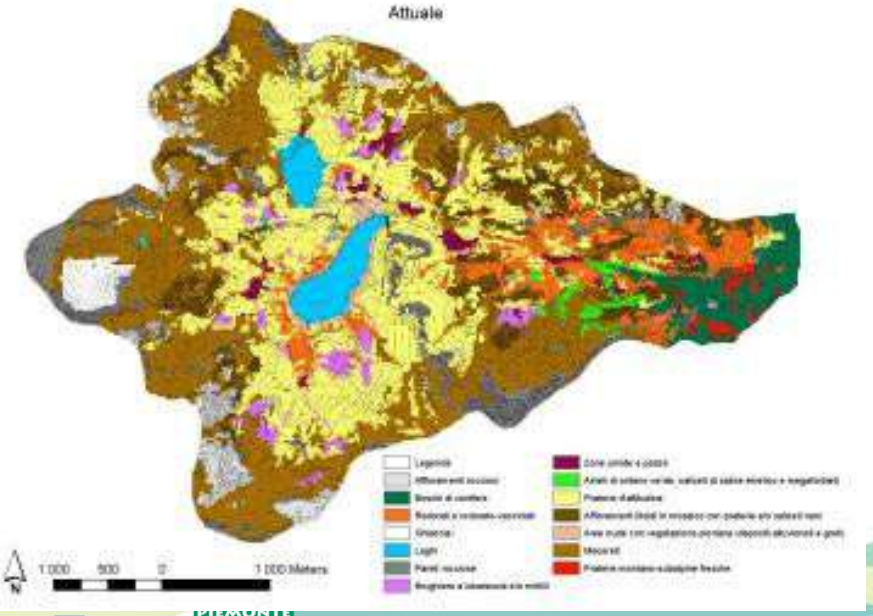
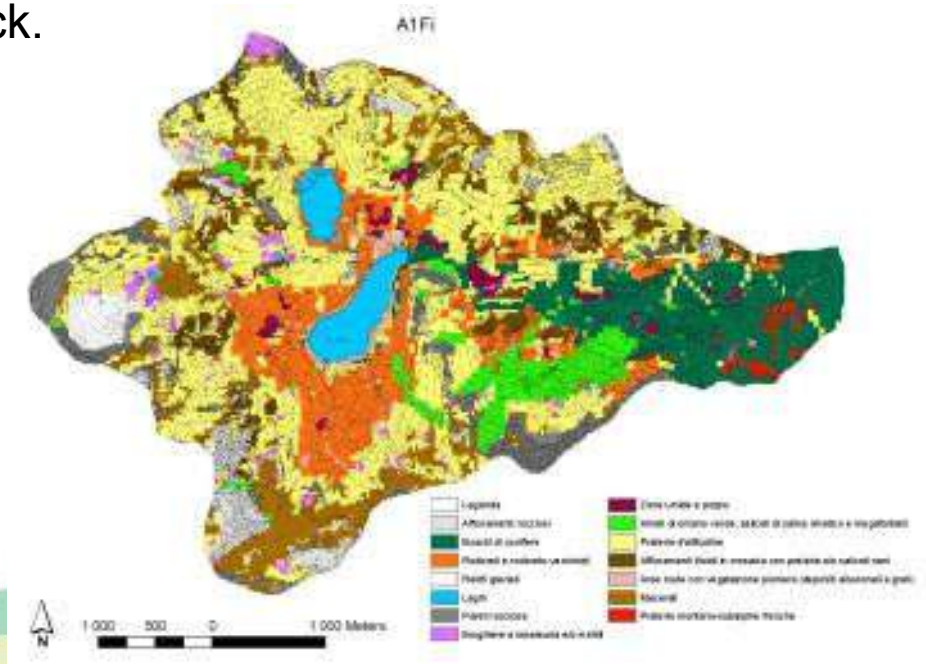
The BIOMOD model

By numerical and statistical downscaling methods, we analysed the possible fate of vegetation distribution in the study area under the IPCC SRES climate scenarios. The **BIOMOD** model was applied in order to estimate the current and future potential spatial distribution of the plant species in the study area. Among the environmental variables considered in the model it was included the soil C stock.





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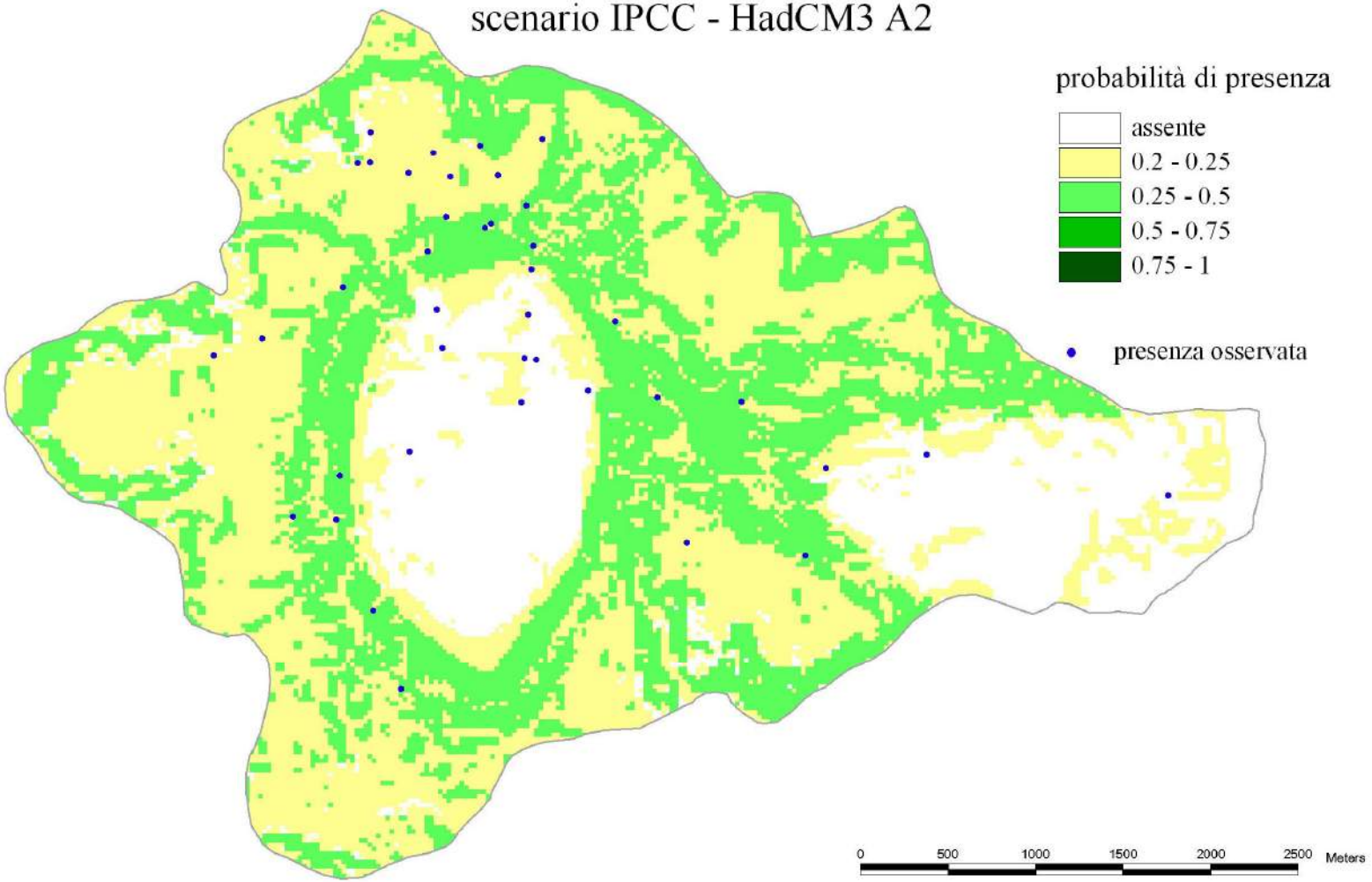
Festuca violacea

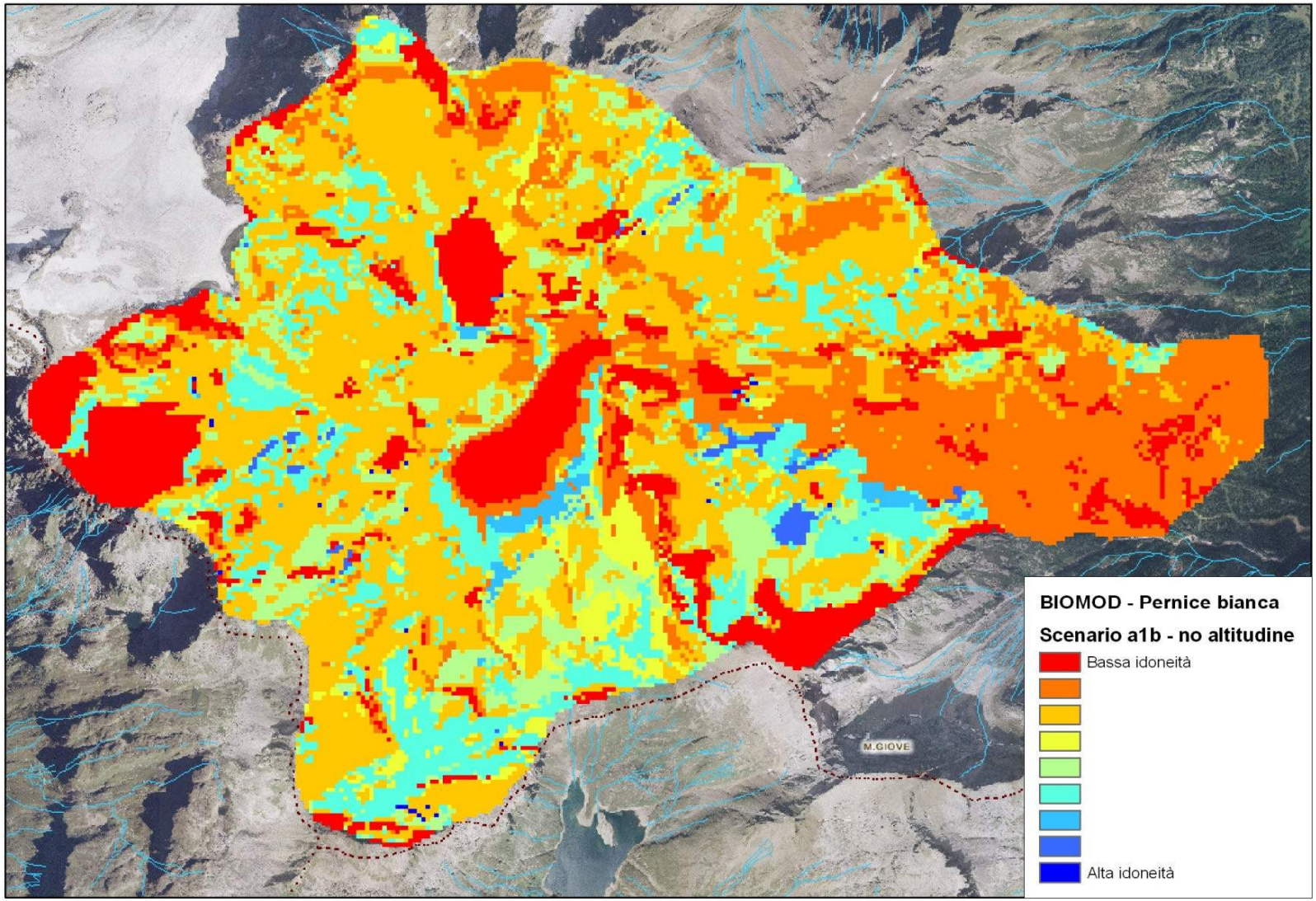
scenario IPCC - HadCM3 A2



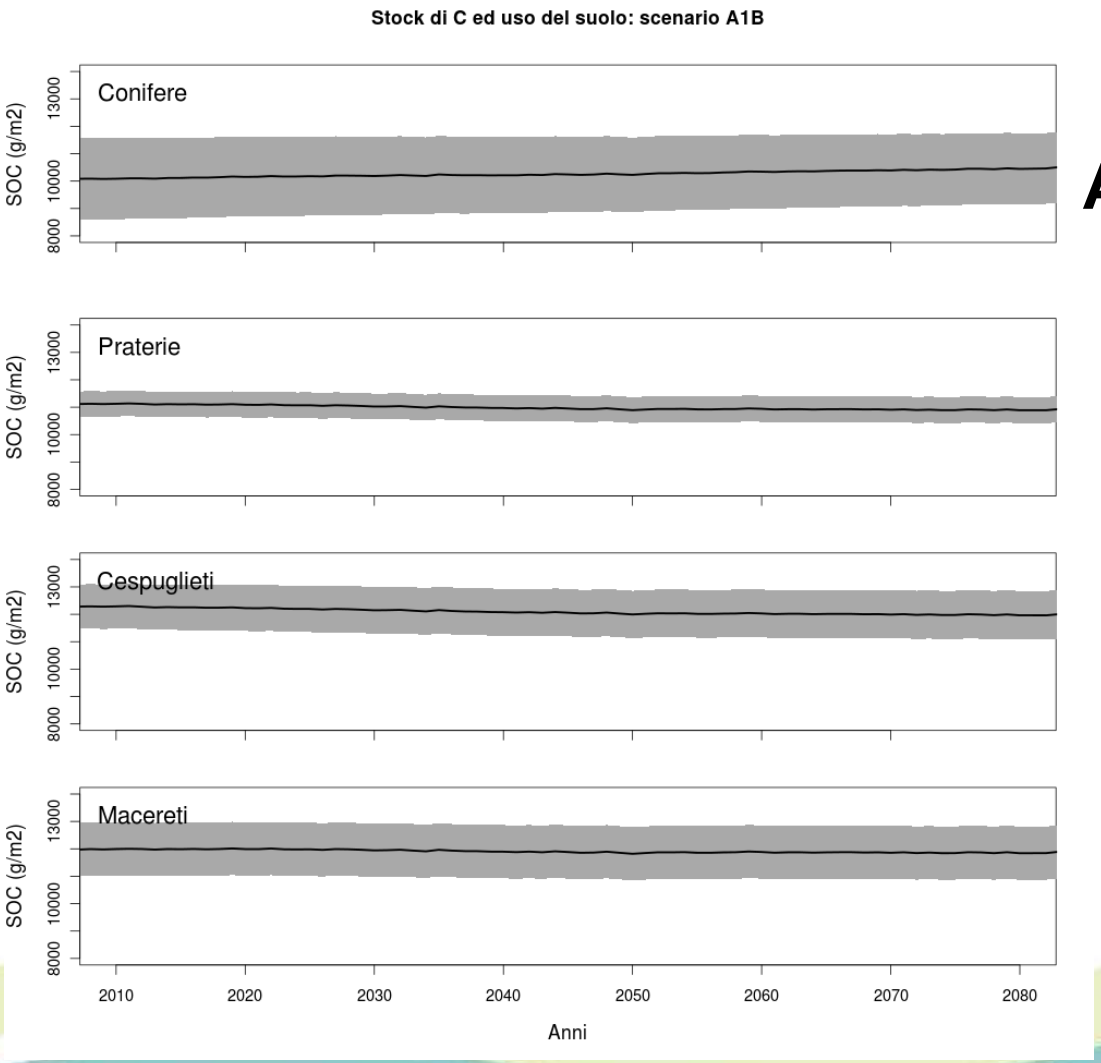
per la Protezione Ambientale

Suitability

Climate scenario A1b



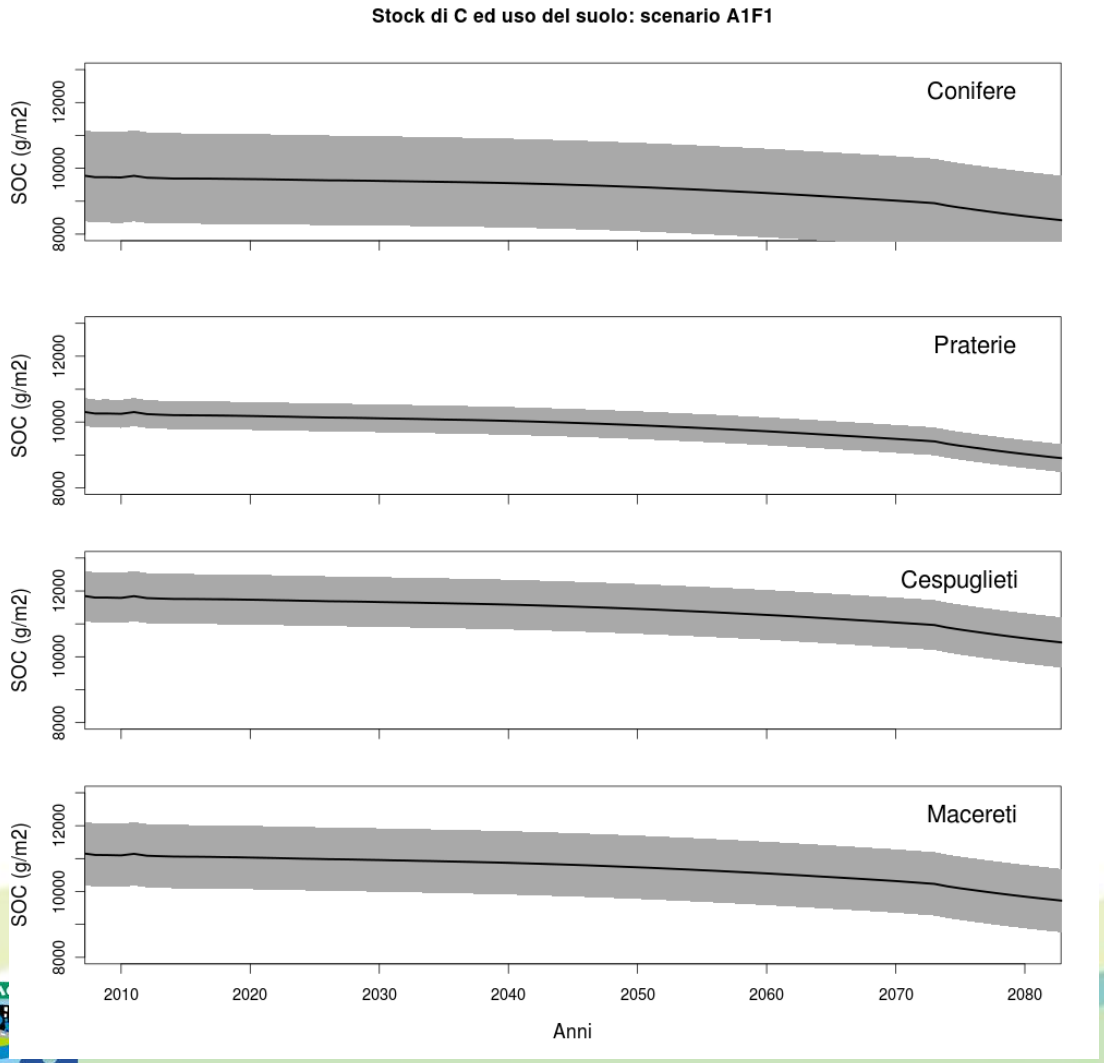
Soil C stock



A1B

Model Century

Soil C stock



A1FI

Model Century

ELEVATIONAL GRADIENT INDICATORS

- Cold-loving species cover
- Elevational migration ratio of botanical species
- Biodiversity indices of vegetation community
- Soil mesophauna (systematic groups of high altitude like Onichiuridae, Tisanoptera, Coleoptera EMI20, Araneidae)
- Soil Temperature
- Snow cover days

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La Balma peatland, located in a flat area at 2000 m a.s.l

With their small size and their relative simple community structure, ponds constitute ideal sentinel and early warning systems (De Meester et al. 2005). This is particularly true for alpine or subalpine ponds, characterised by species-poor communities. Such systems should therefore be used for monitoring the biotic impacts of climate changes.

Local extinctions of cold stenothermal species, or colonisation of lowland species, are early warning events for mountain waterbodies that should be monitored. (Oertli, 2010, BioRisk 5: 243–251).

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THE ROLE OF ODONATA AS INDICATORS OF CLIMATE CHANGE

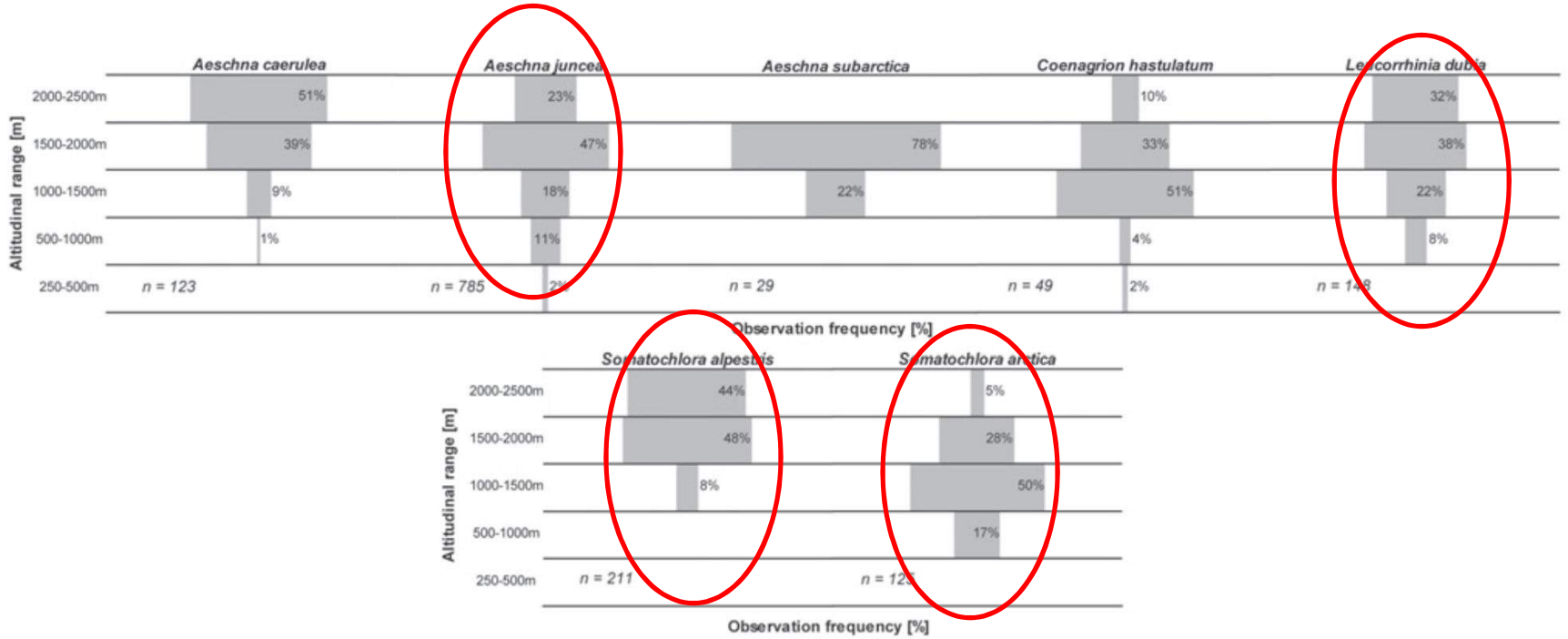

Figure 4. Altitudinal distribution in Switzerland of a set of 16 species frequently observed at high altitude (above 1500 m). **4a** The seven cold stenothermal species, expected to exhibit a decrease in their geographical area (at risk of extinction on the long range). (Oertli, 2010, Biorisk 5, 243-251)

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Results: recorded species and preliminary abundance estimates

Family	Genus	San Bernardo	Maximum number	Flight period	La Balma	Maximum number	Flight period
Coenagrionidae	*Ischnura pumilio*				X	2 m, 1 f	26/8
Coenagrionidae	*Coenagrion puella*	X	2 m	15/7			
Aeshnidae	*Aeshna cyanea*	X	1 m, 1 f	22/7 – 3/9			
Aeshnidae	*Aeshna juncea*	X	11-30 m, 4-10 f	15/7 – 15/9	X	4-10 m, 2 f	22/7 – 10/9
Corduliidae	*Somatochlora arctica*	X	4-10 m	15/7 – 15/9			
Corduliidae	*Somatochlora alpestris*	X	4-10 ads	15/7 – 22/8	X	4-10 m, 2 f	29/7 – 26/8
Libellulidae	*Libellula quadrimaculata*	X	1 m	15/7 – 22/7	X	1 m	11/8
Libellulidae	*Sympetrum sanguineum*	X	1 m	19/8 – 15/9			
Libellulidae	*Leucorrhinia dubia*	X	31-100 ads	15/7 – 22/7			

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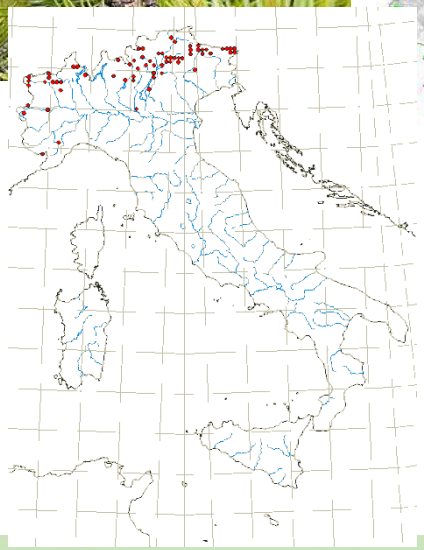
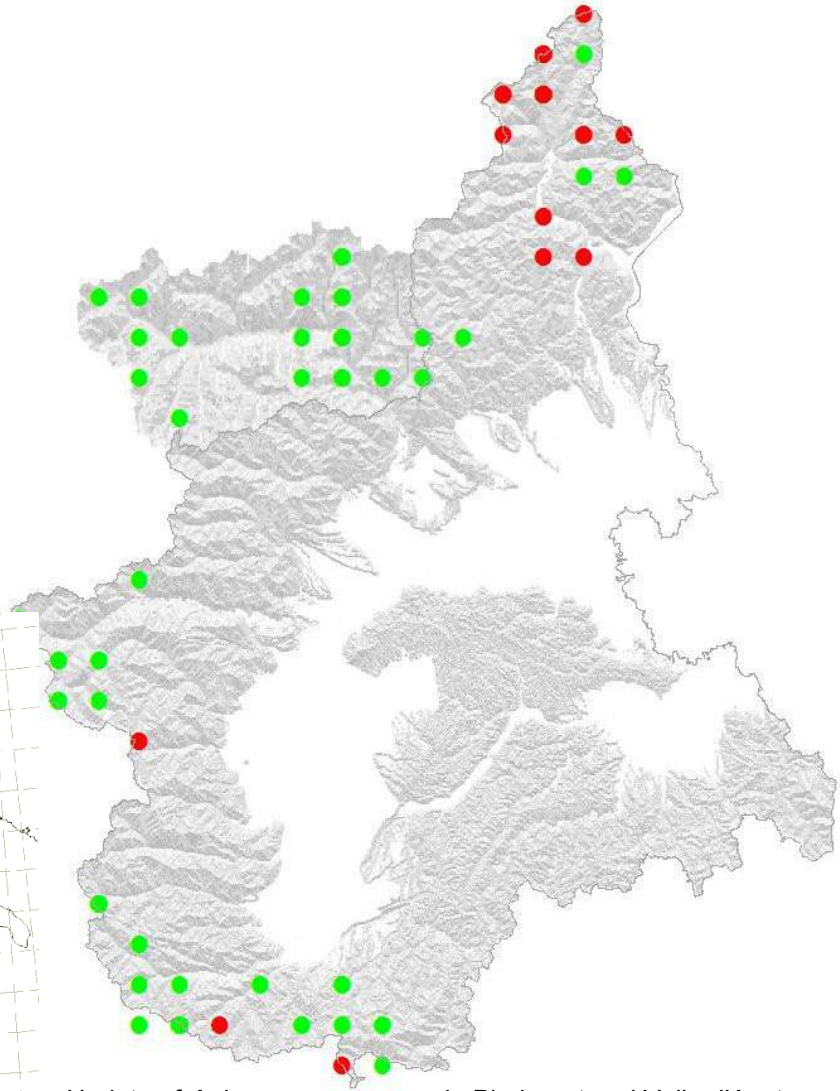
Results: *Aeshna juncea*





Update of *A. juncea* occurrence in Piedmont and Valle d'Aosta. Green dots are records until 2007 (Boano *et al*., 2007), red dots are records after 2007 (R. Sindaco, *comm. pers.*)

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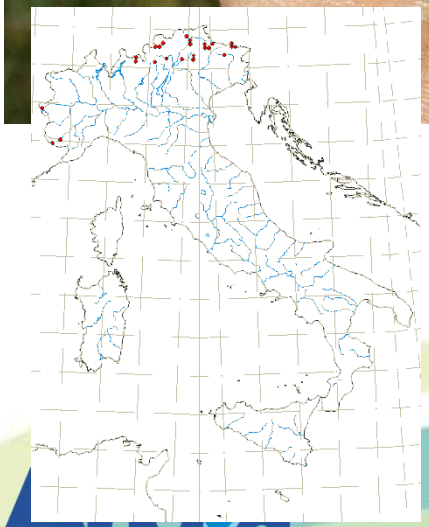
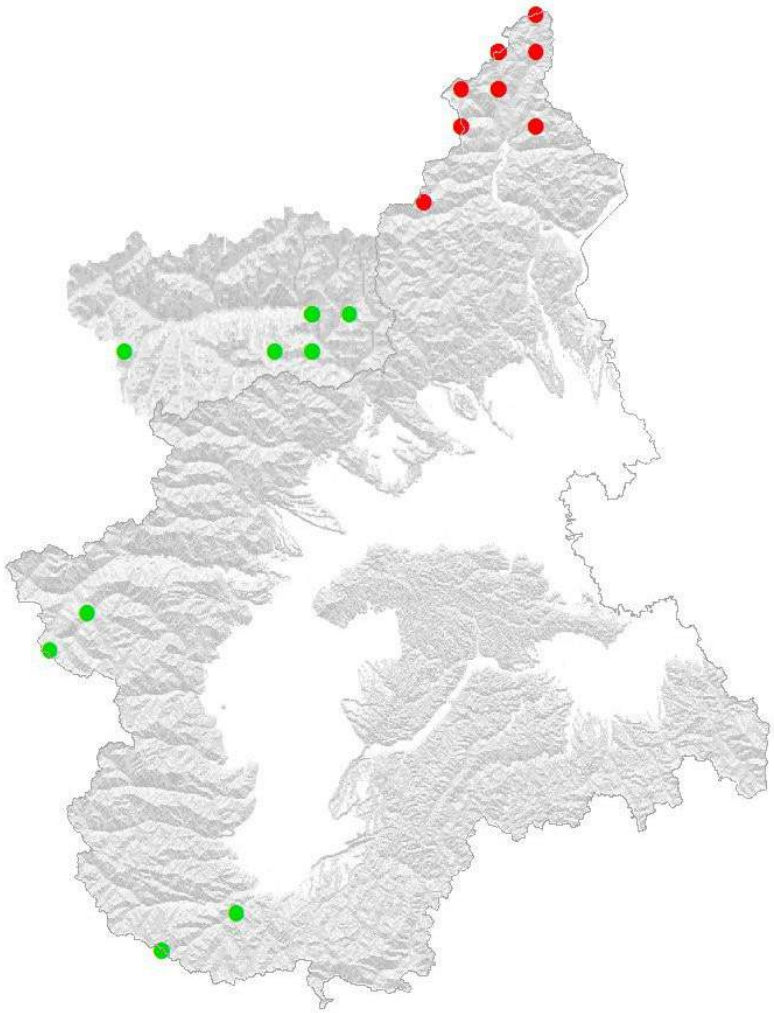
Results: *Somatochlora alpestris*





Update of *S. alpestris* occurrence in Piedmont and Valle d'Aosta. Green dots are records until 2007 (Boano *et al*., 2007), red dots are records after 2007 (R. Sindaco, *comm. pers*.)

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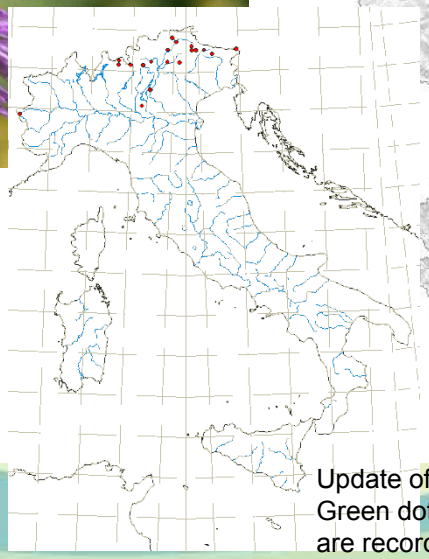
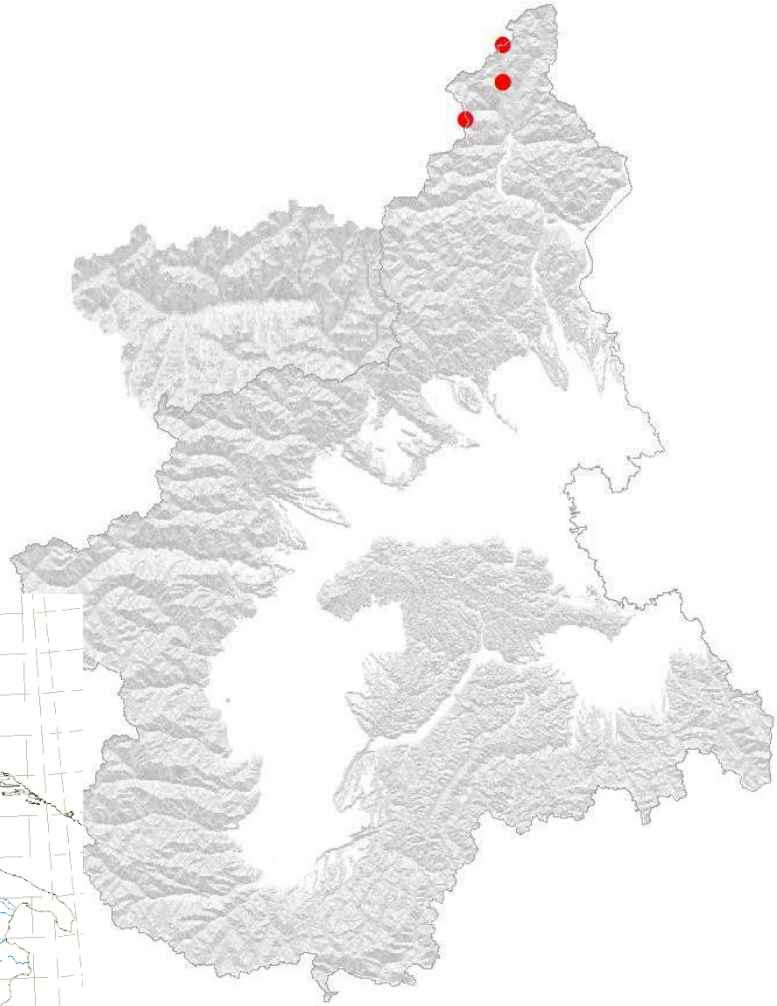
Results: *Somatochlora arctica*

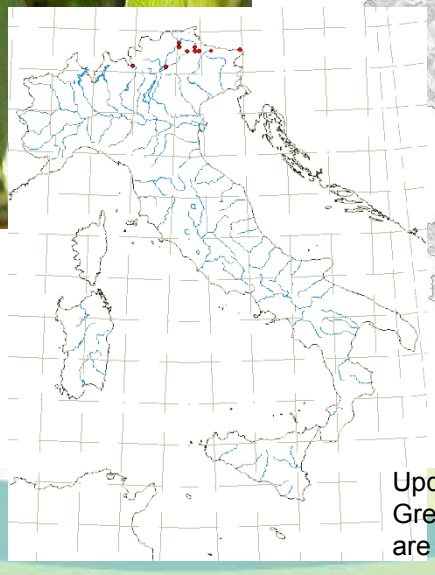
Photo: Lucia Pompilio

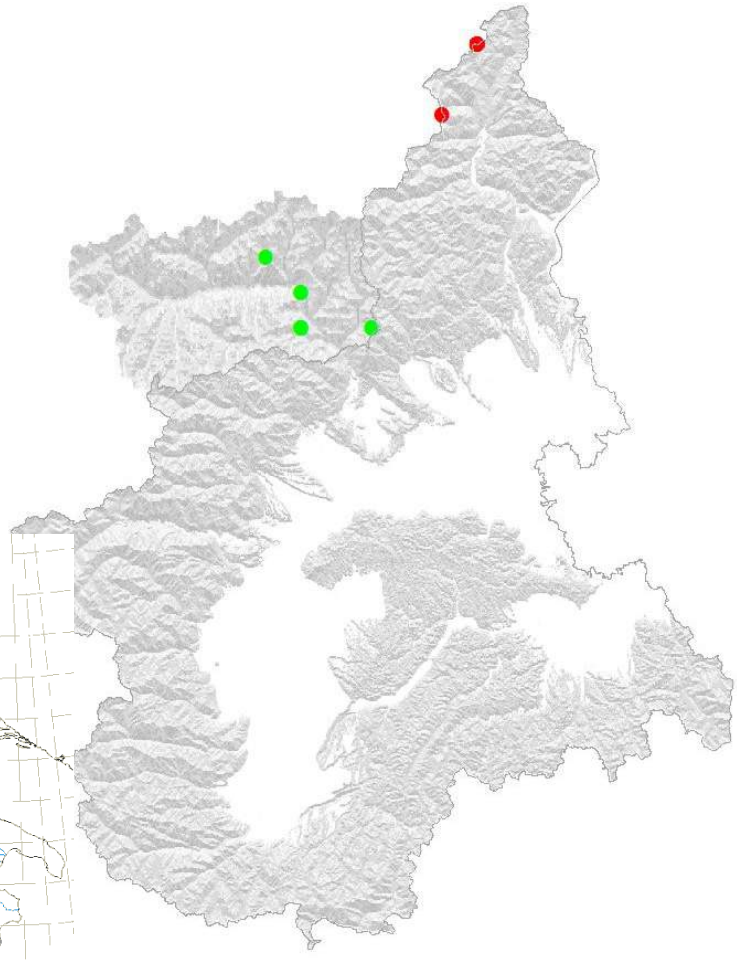




Update of *S. arctica* occurrence in Piedmont and Valle d'Aosta. Green dots are records until 2007 (Boano *et al*., 2007), red dots are records after 2007 (R. Sindaco, *comm. pers*.)

Results: *Leucorrhinia dubia*





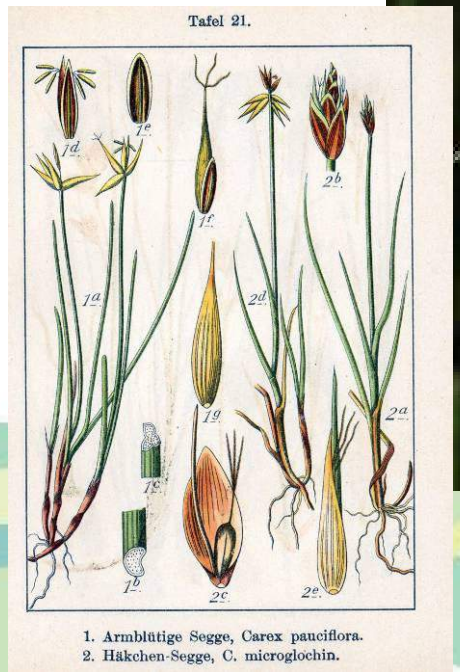
Update of *L. dubia* occurrence in Piedmont and Valle d'Aosta. Green dots are records until 2007 (Boano *et al*., 2007), red dots are records after 2007 (R. Sindaco, *comm. pers*.)

Action Plan on Climate Change of the Convention of Alps: *Preserve peatlands as pool of CO_2 and biodiversity*

- **Distribution of raised bog community and target species (*C. pauciflora*, *Eriophorum vaginatum*)**
- **Analysis of Odonata community**
- **Dynamic of C and N in the soil**
- **Asssessment of CO_2 fluxes**
- **Analysis of nutritional content of *Vaccinium uliginosum* leaves for mismatch assessment of *Colias palaeno* (Lepidoptera)**

Bryophites

Carex pauciflora



Colias palaeno eggs on Vaccinium uliginosum leaves

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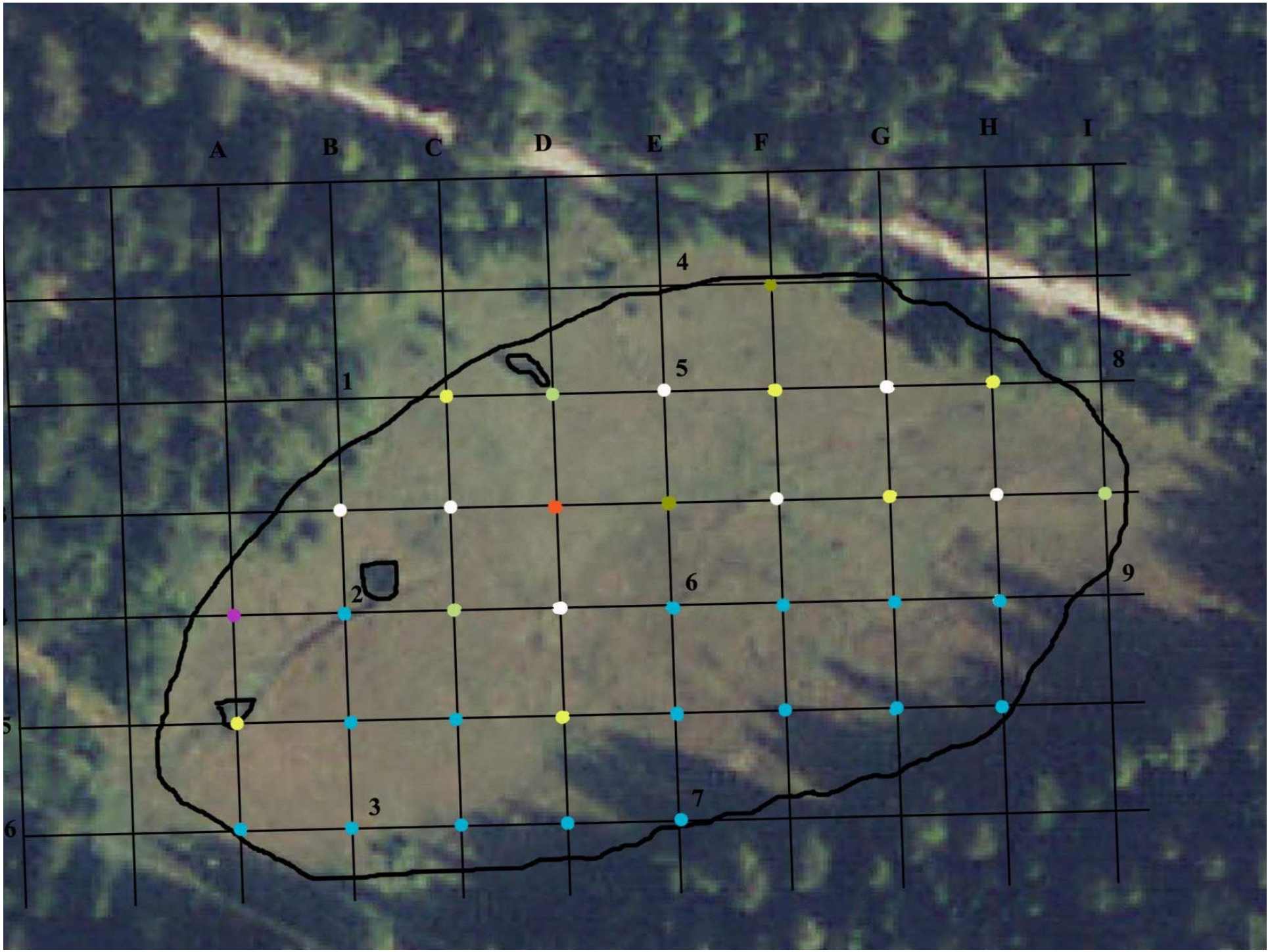
A
B
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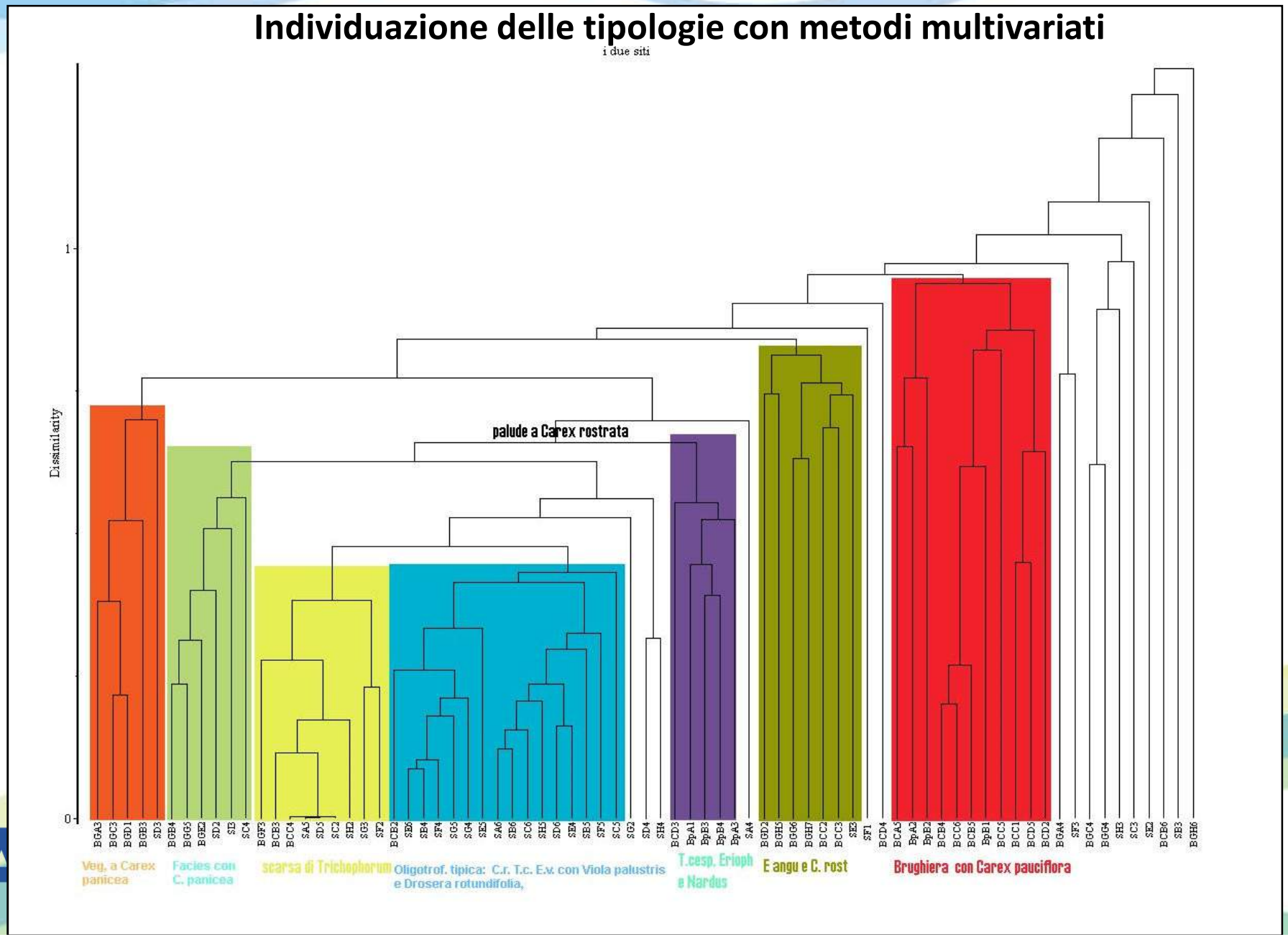
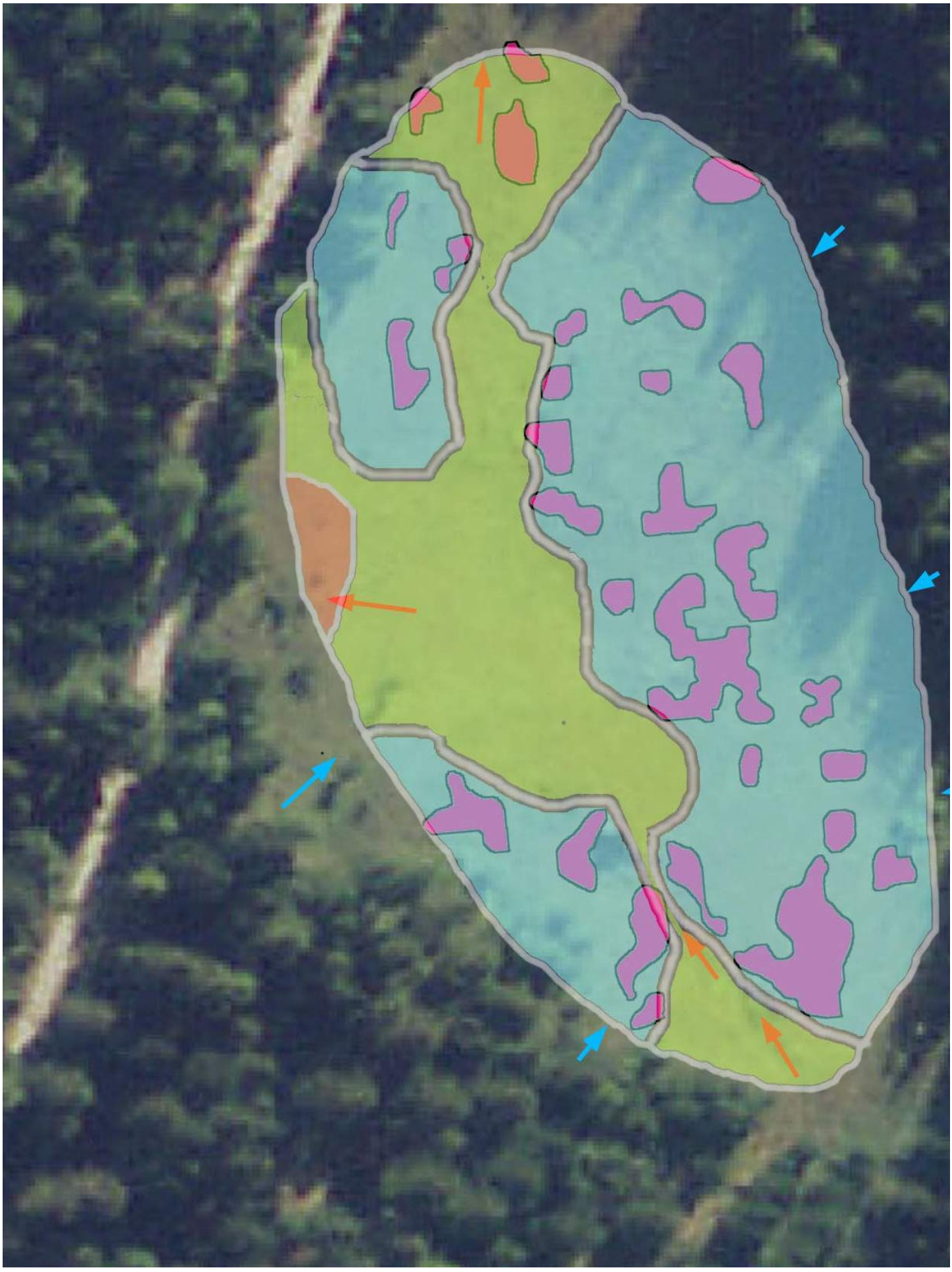
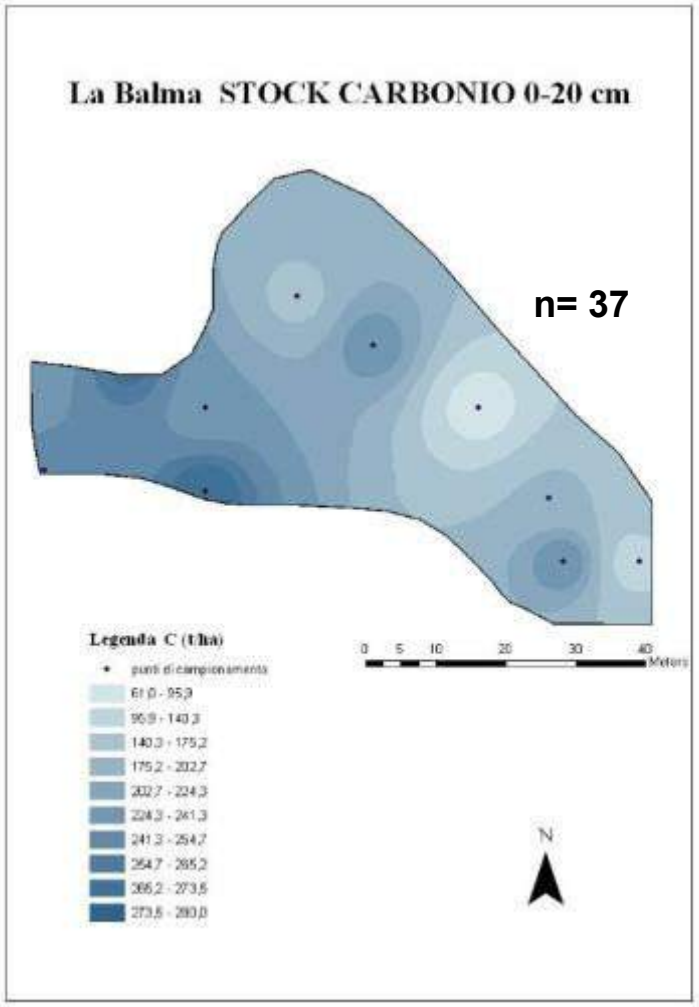
9

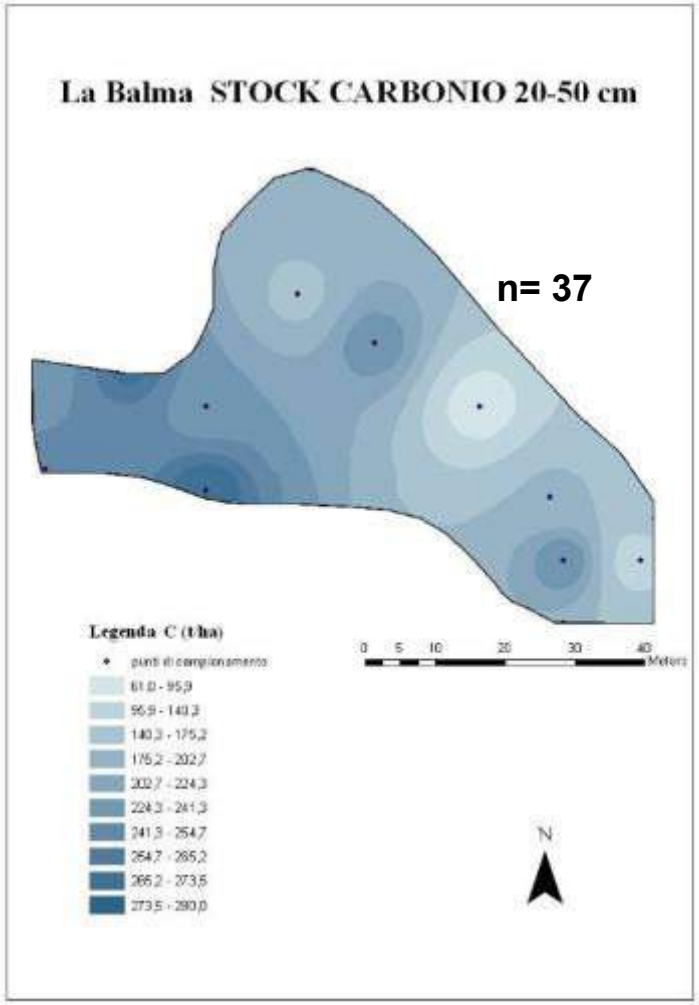
Classification of the plant communities in the two studied bogs with multivariate analysis





Carbon stock in peatland





Stock 0-50 cm: 339 t/ha = 33900 g/m^2

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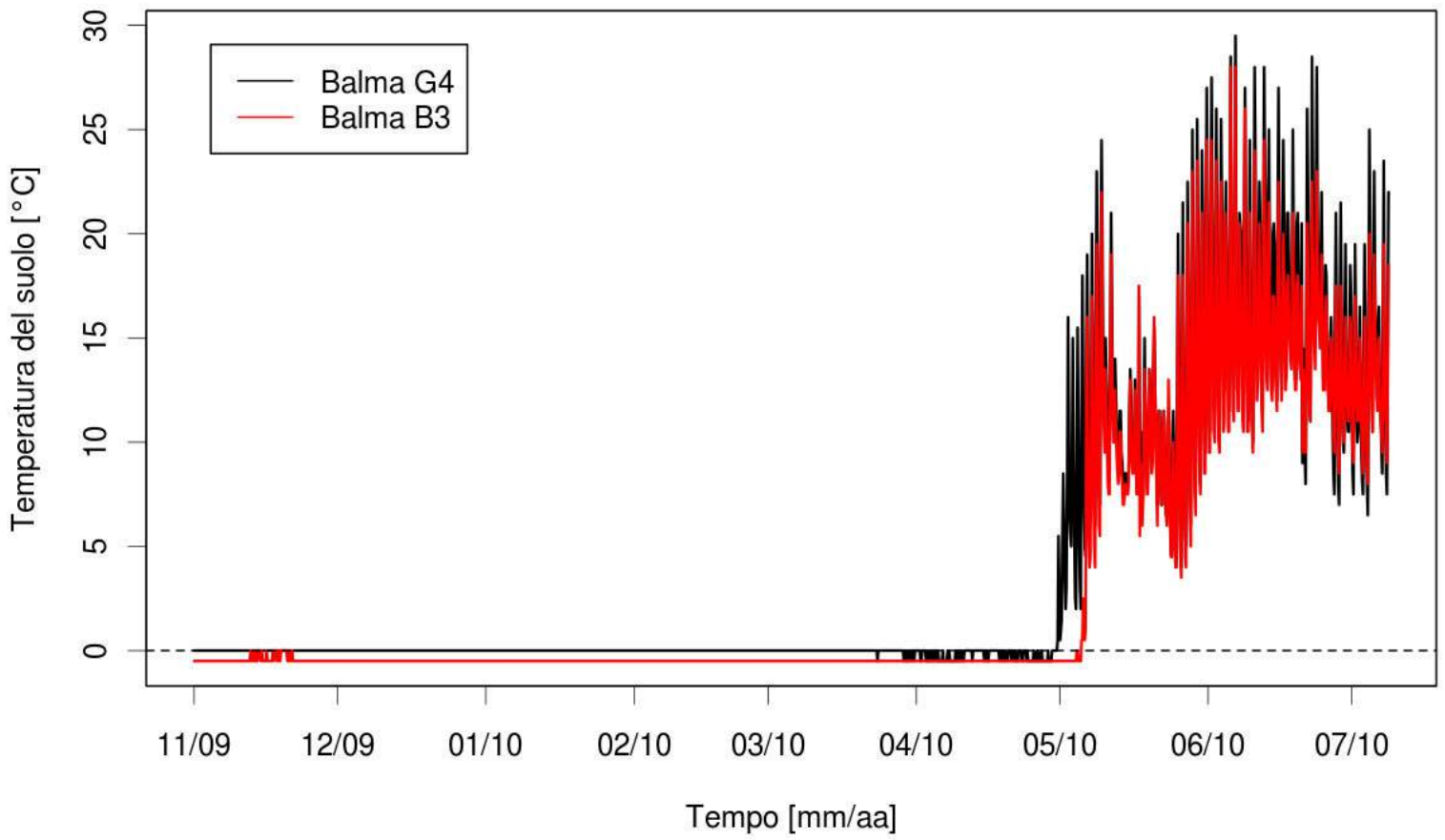
LNSA

Soil temperature peatland Balma



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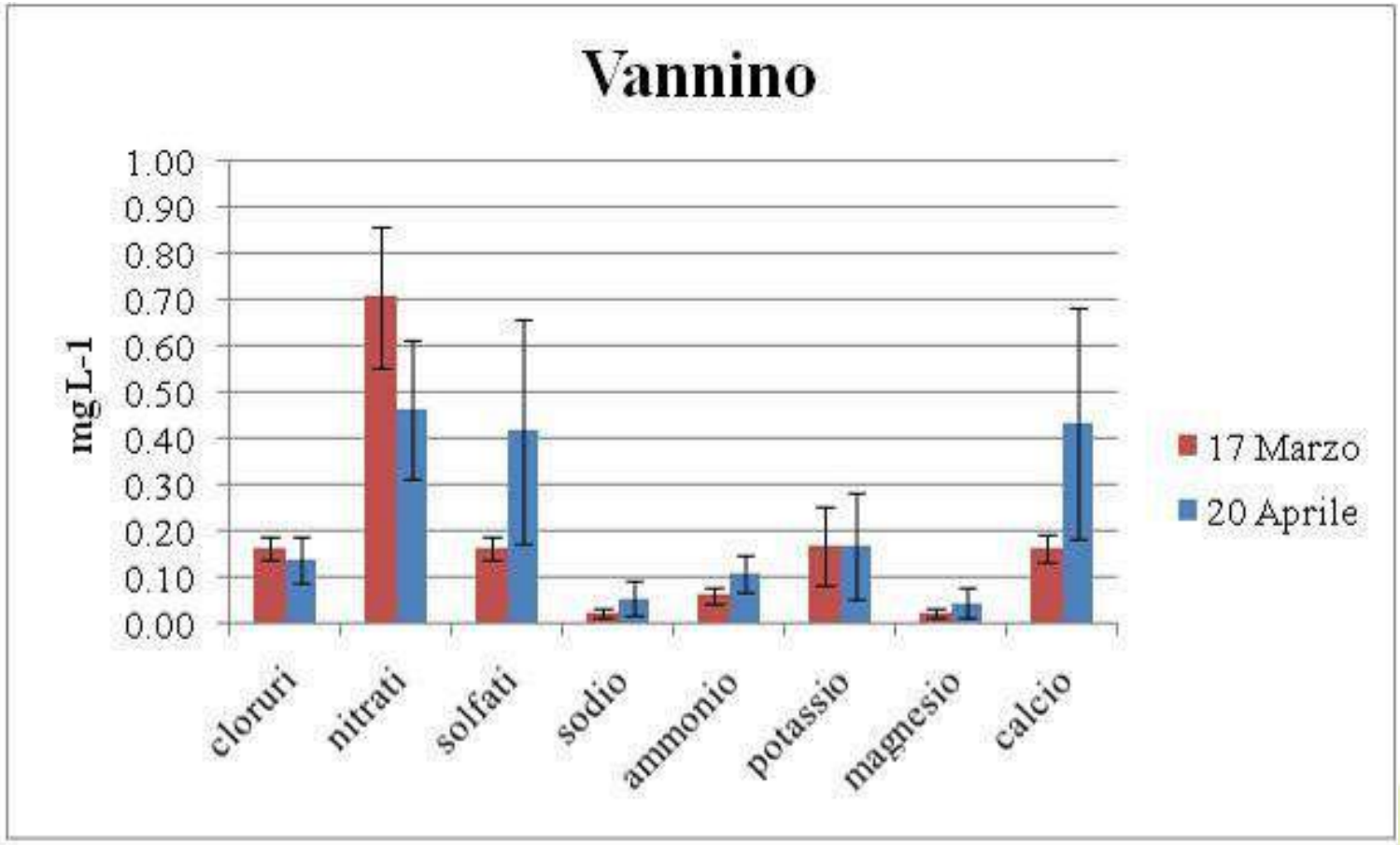
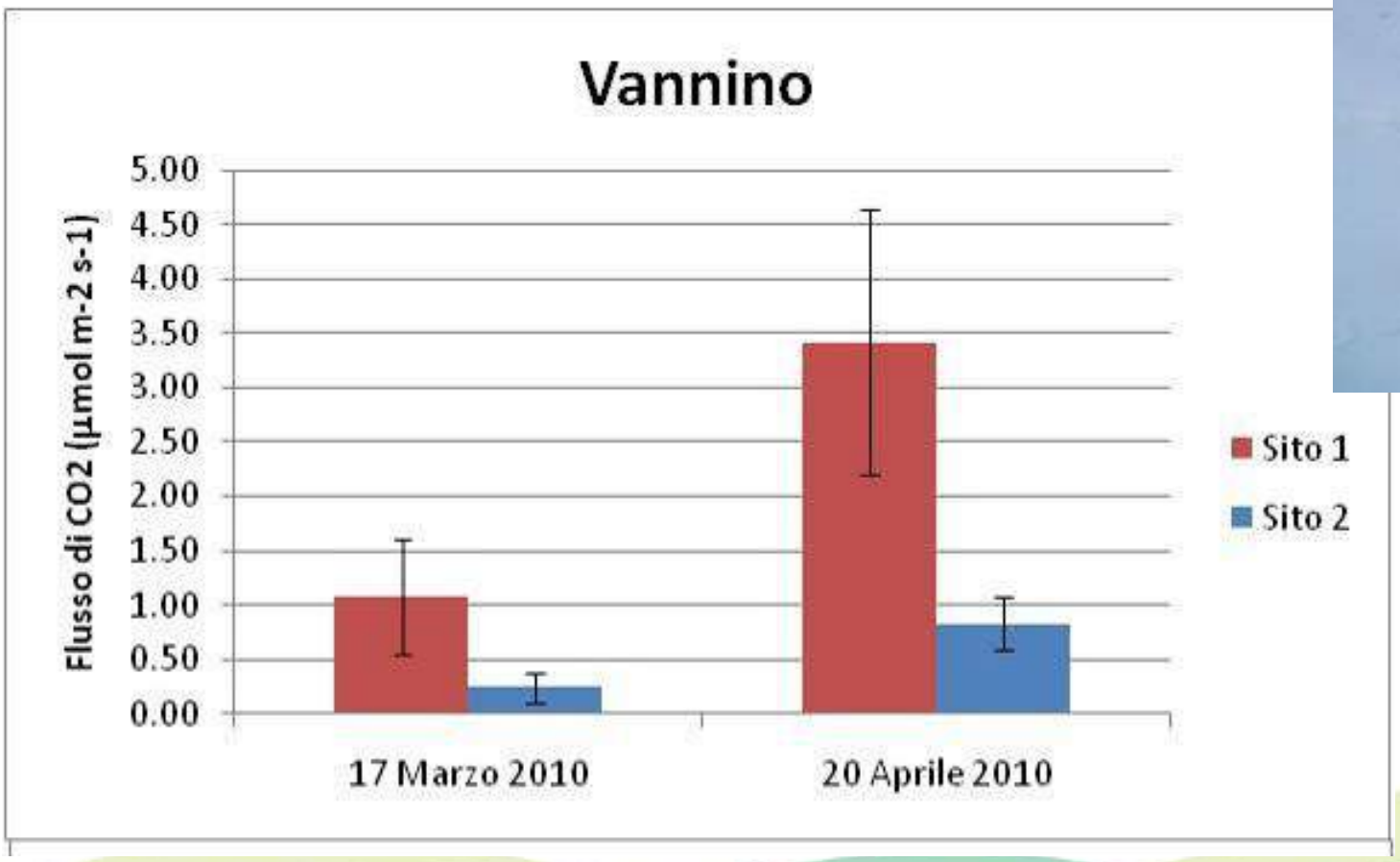
Chemical characteristics of snowpack

Winter 2010, 2150 m slm



Gianluca Filippa, Michele Freppaz, Mark W. Williams, Ermanno Zanini (2010) Major element chemistry in inner alpine snowpacks (Aosta Valley Region, NW Italy) COLD REGIONS SCIENCE AND TECHNOLOGY 64: 158- 166

CO_2 winter emissions



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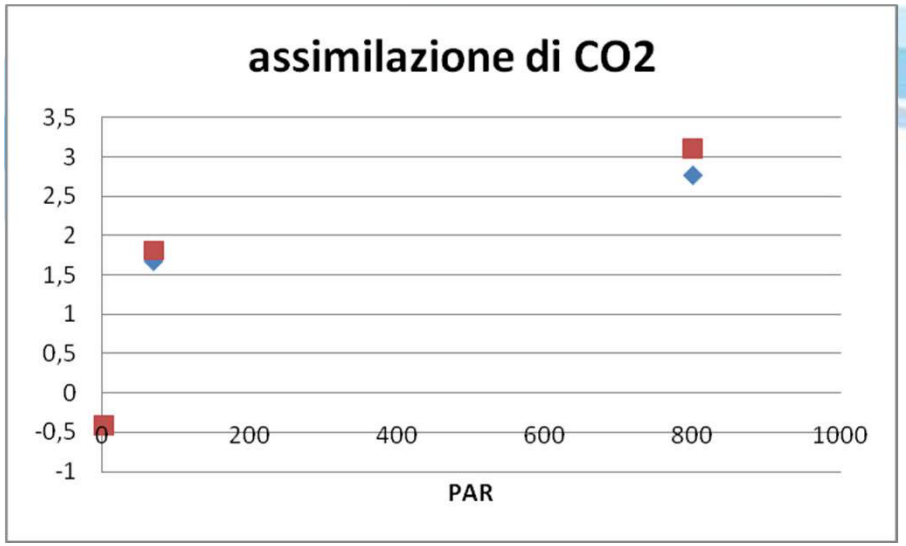
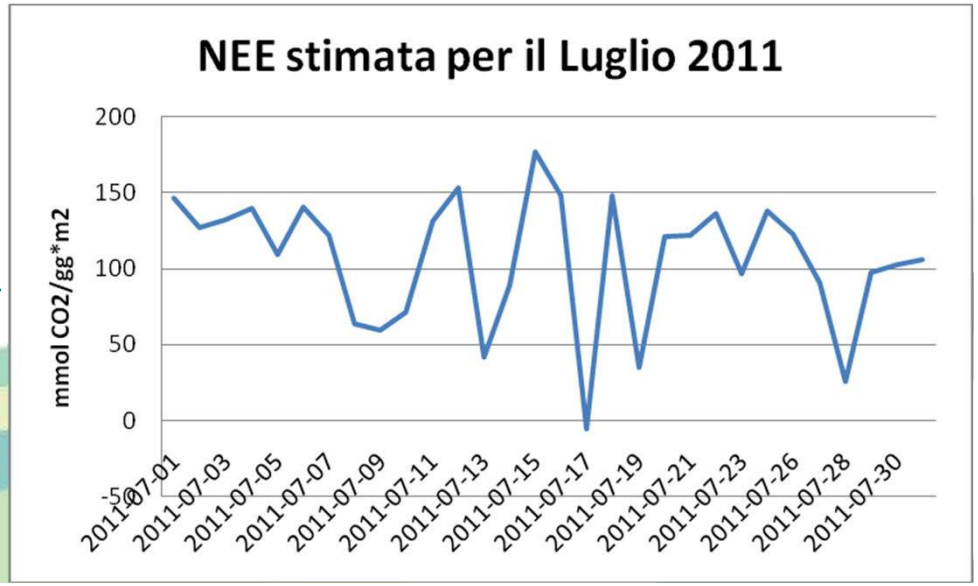


A/q, data obtained with IRGA & canopy chambers at Balma and San Bernardo bogs

CO_2 NEE valuation starting from solar radiation ad Vannino lake



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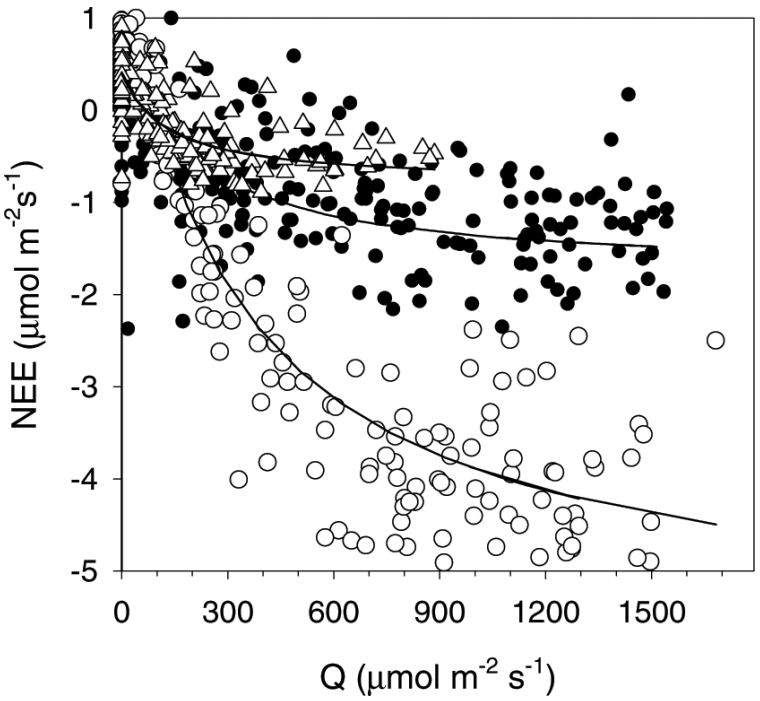
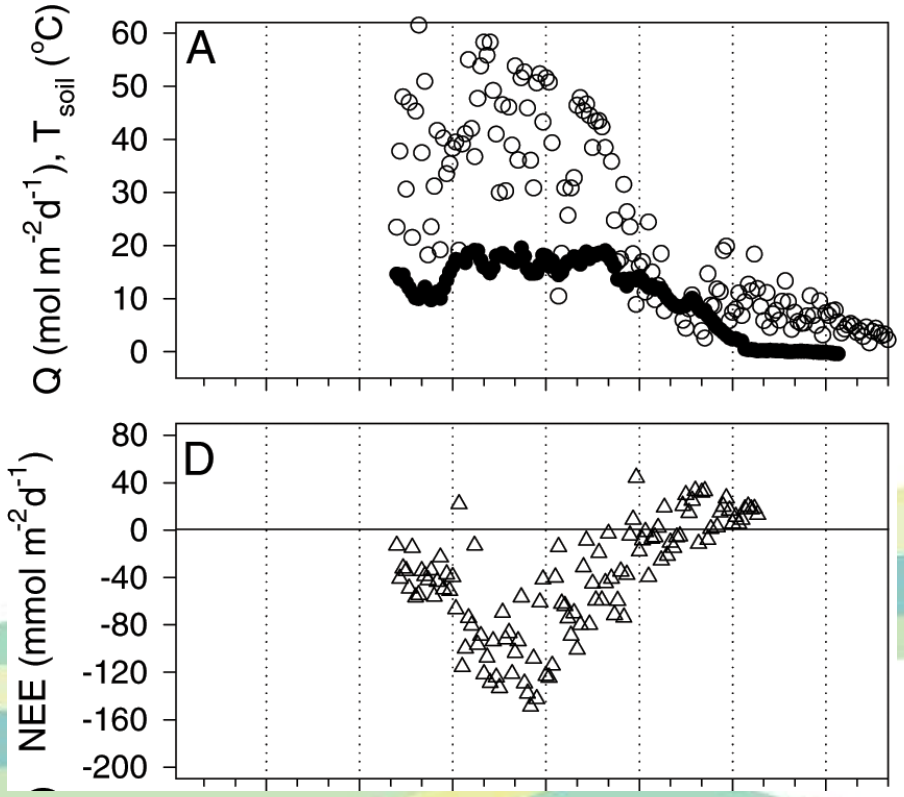
Data on C exchange of the N-emisphere bogs

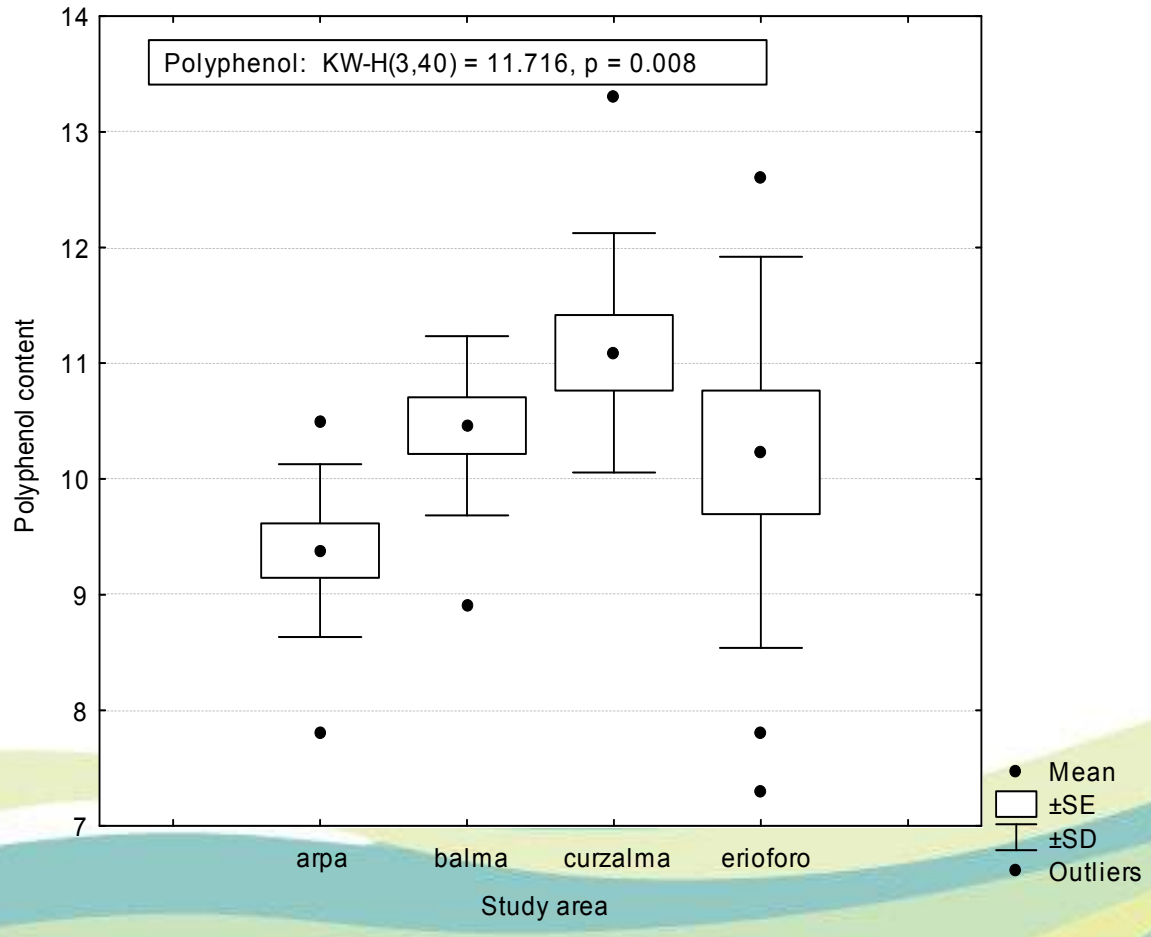




Colias palaeno

High levels of athmospheric CO_2 can increase photosynthetic activity causing a dilution of N in the leaves, a higher ratio C:N reducing the nutritional power of the leaves and increasing the production of secondary metabolites.

Knepp et al. 2005



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The future; a new elevational gradient between the Hohsand glacier and Blinnenhorn summit

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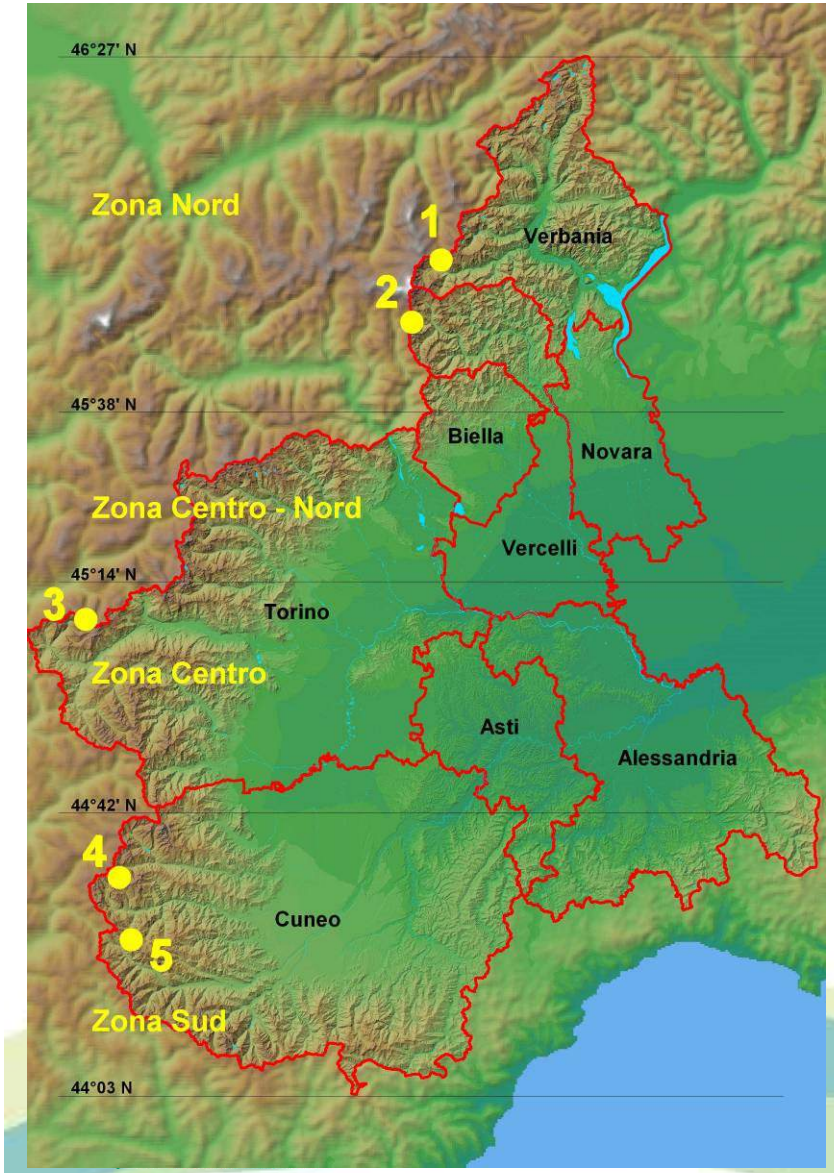
Thanks to the contribution of Alpine Space European Project "Permanet", in 2009 a first permafrost monitoring network has been established in Piedmont Alps.



The permafrost stations consist in the monitoring temperatures at different dephts (10 to 100 m) in vertical borehole drilled in the bedrock

5 sites have been selected:

1 – Monte Moro Pass (Macugnaga, VB), 2,870 m asl

2 – Corno del Camoscio – Salati Pass (Alagna Valsesia, VC), 3,020 m asl

3 – Sommeiller Pass (Bardonecchia, TO), 3,000 m asl

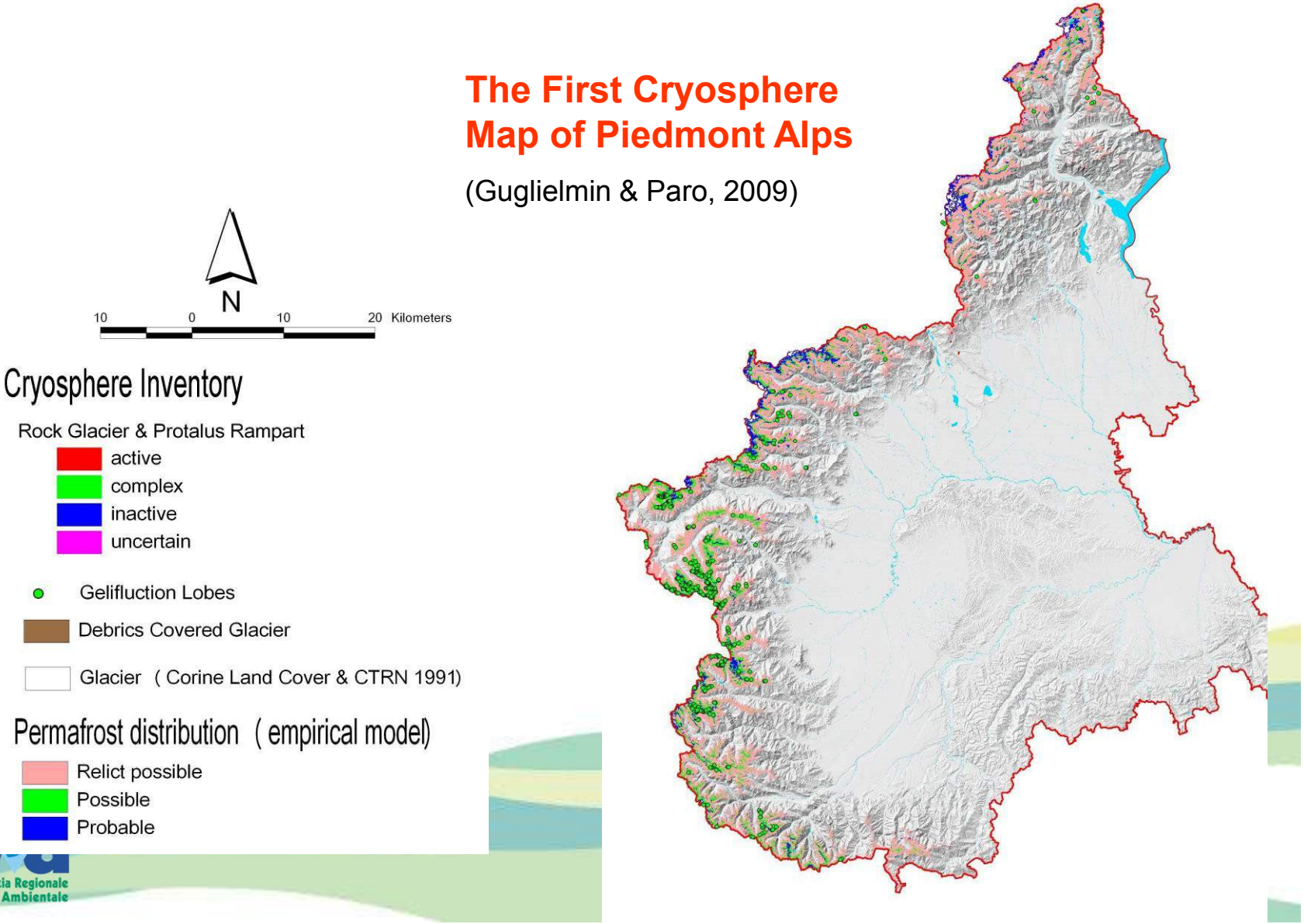
4 – La Colletta Pass (Bellino, CN), 2,840 m asl

5 – Gardetta Pass (Canosio, CN), 2,500 m asl

Starting from all periglacial and glacial data available for the Piemonte region, a First Cryosphere Map of Piedmont Alps has been carried out in 2009.

The First Cryosphere Map of Piedmont Alps

(Guglielmin & Paro, 2009)



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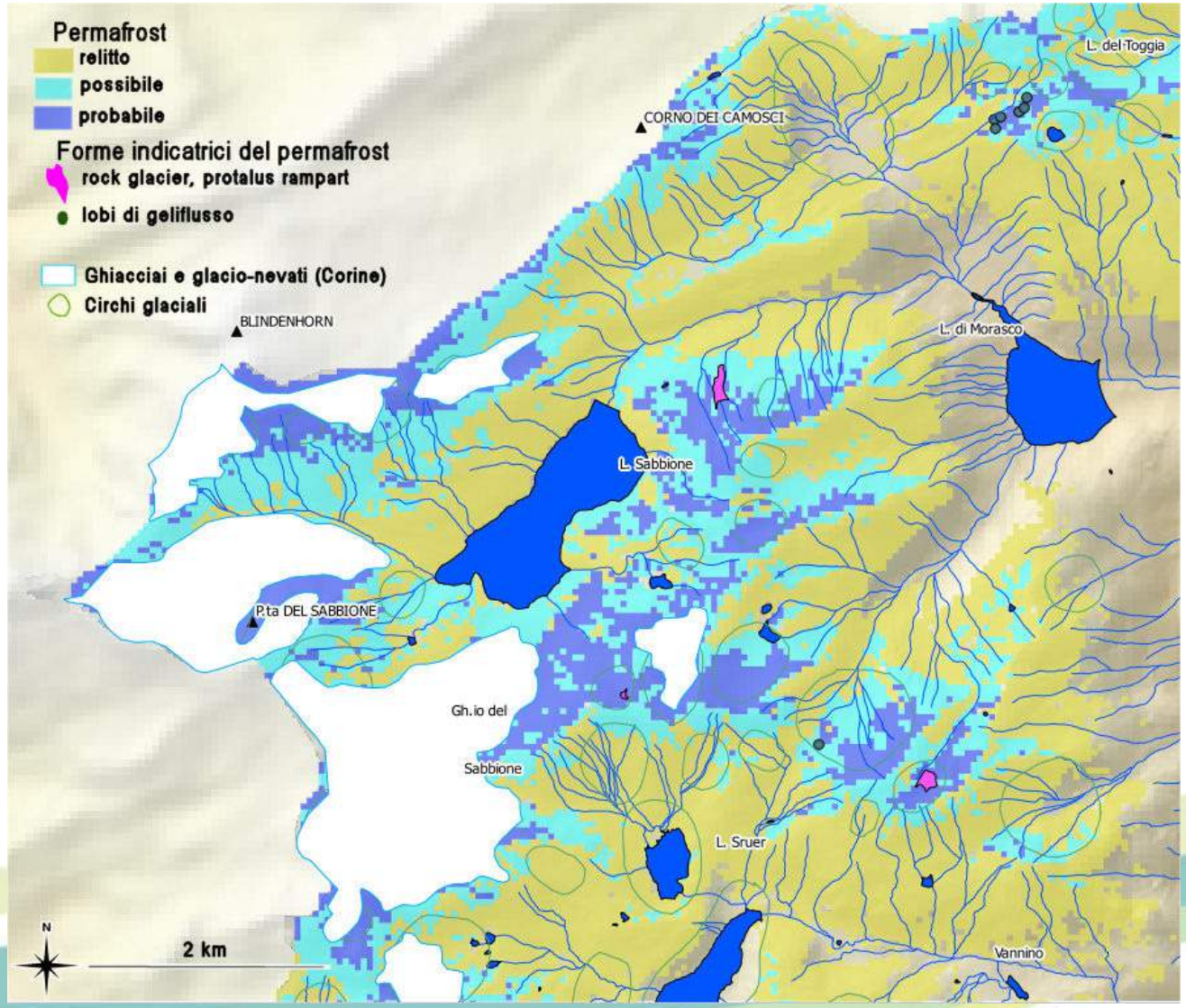
Glacial and periglacial studies in the Sabbioni area



Primary grassland on the Blinnenhorn (3000 m)

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Carex bicolor

Weather station in Pian dei Camosci (2450 mt)

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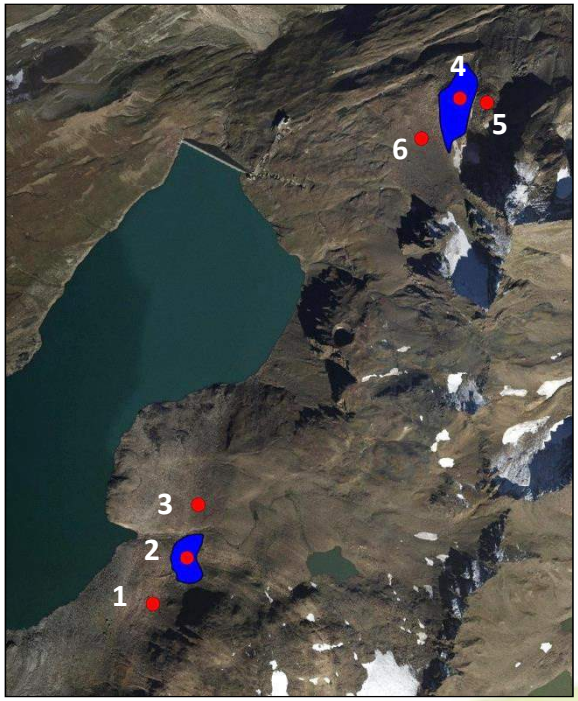
Phenological studies on *Artemisia genipi*

6 study sites in and outside active rock-glaciers: 120 individual sampling for each site (40 in depression sites, 40 in edge and 40 in neutral areas)

Phenological phases of *Artemisia genipi*



Red spots: collecting area of *Artemisia genipi*; blue polygons: rock-glaciers

CONCLUSIONS AND PERSPECTIVES

- CREATE A MONITORING NETWORK ON THE REGIONAL SCALE, PREFERABLY IN COLLABORATION WITH PROTECTED AREAS

- MONITORING PROTOCOLS INTEGREATED WITH DIFFERENT DISCIPLINES

- ASSURE A LONG-TERM CONTINUITY OF MONITORING

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