Climate Change Impacts on Mediterranean Plant Diversity, Sept 25-28 2007

SEMCLIMED – M.A.I.CH.

Climate warming impacts on Europe's high mountain vegetation:

Evidences, modelling, and monitoring

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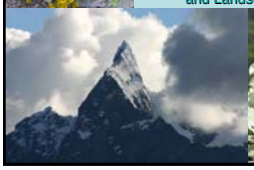
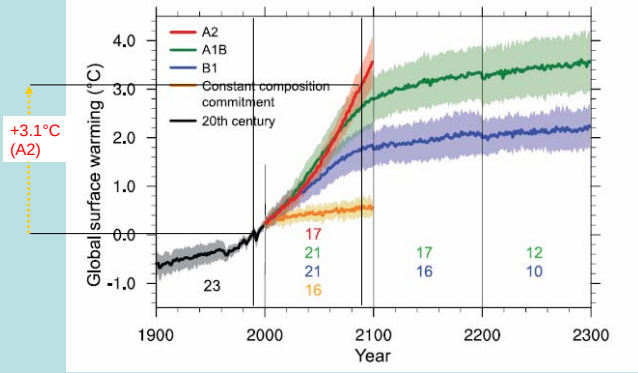
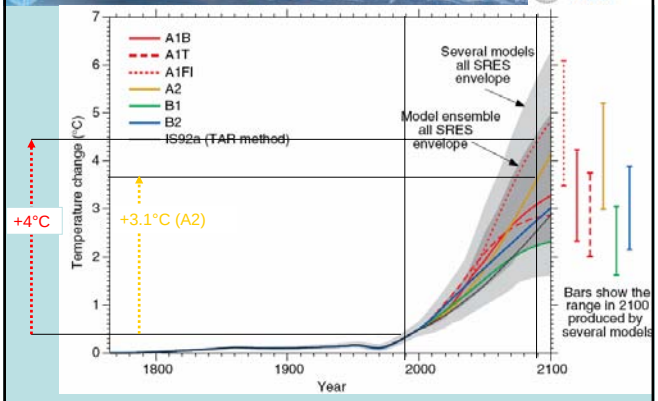


GLORIA-Europe: Some results

The rationale of plant upward moving



IPCC AR4



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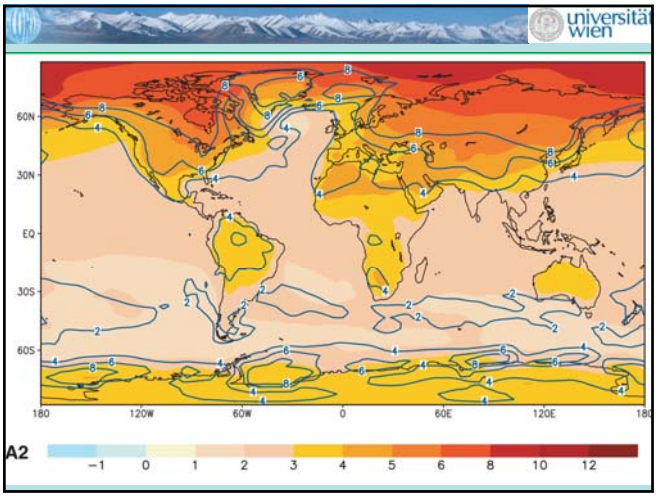
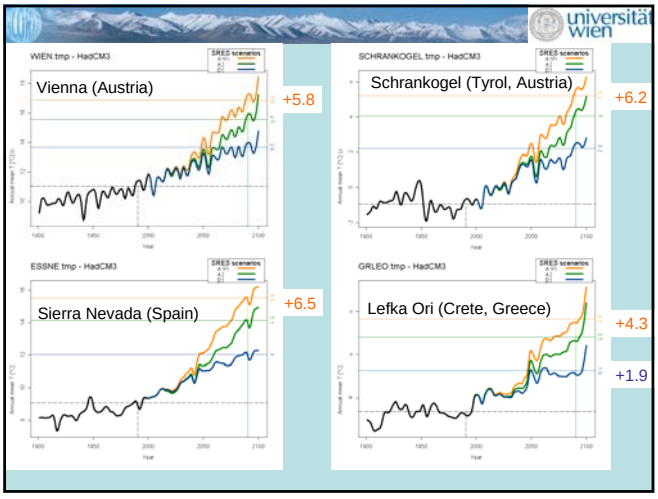
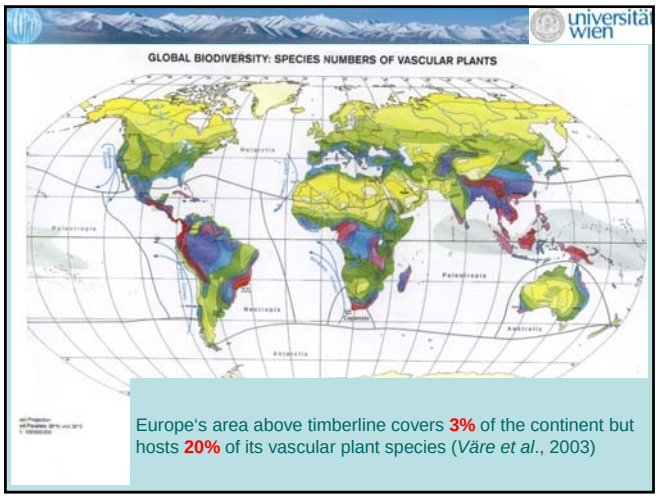
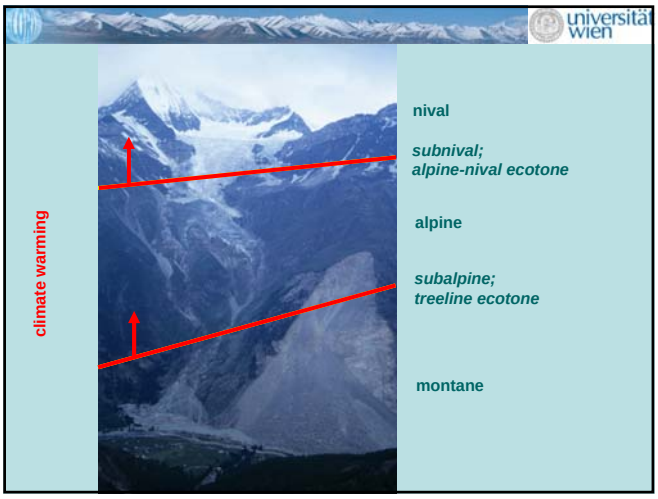


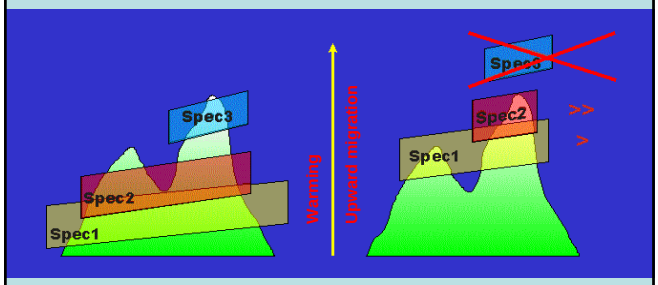




Europe's area above timberline covers **3%** of the continent but hosts **20%** of its vascular plant species (*Väre et al*., 2003)



Hypothesis



Current

Future

species distributions

GLORIA-Europe: Some results

The evidence

The Piz Linard (3411 m), the Grisons, Switzerland – Europe's Oldest Mountain Vegetation Study Site

Changes of species richness at Piz Linard, presence and abundance:
p present, c common, i intermediate abundance, r rare,
in increased abundance

species	1835	1864	1895	1911	1937	1947	1992
Androsace alpina	p	p	p	p	p	c	c, in
Ranunculus glacialis		p	p	p	p	c	c, in
Saxifraga bryoides			p	p	p	c	c, in
Saxifraga oppositifolia			p	p	p	c	c, in
Poa laxa				p	p	c	c, in
Draba fladnizensis				p	p	c	c
Gentiana bavarica				p	p	i	i
Cerastium uniflorum				p	p	i	r
Leucanthemopsis alpina		p			p	i	
Saxifraga exarata					p	r	
Cardamine resedifolia							r
Luzula spicata							r

Source:
Pauli, Gottfried & Grabherr, 200

Ecological Studies, Vol. 167
L. Nagy, G. Grabherr, Ch. Körner, D.B.A. Thompson (Eds.)
Alpine Biodiversity in Europe
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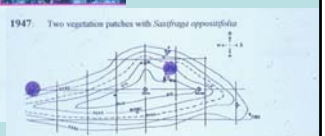

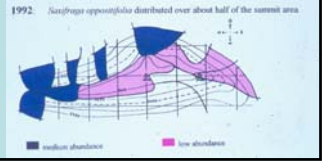

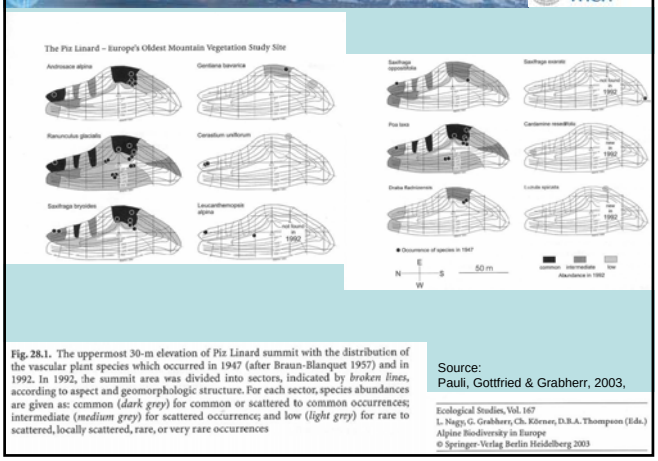

Fig. 28.1. The uppermost 30-m elevation of Piz Linard summit with the distribution of the vascular plant species which occurred in 1947 (after Braun-Blanquet 1957) and in 1992. In 1992, the summit area was divided into sectors, indicated by *broken lines*, according to aspect and geomorphologic structure. For each sector, species abundances are given as: common (*dark grey*) for common or scattered to common occurrences; intermediate (*medium grey*) for scattered occurrence; and low (*light grey*) for rare to scattered, locally scattered, rare, or very rare occurrences

Source:
Pauli, Gottfried & Grabherr, 2003,

Ecological Studies, Vol. 167
L. Nagy, G. Grabherr, Ch. Körner, D.B.A. Thompson (Eds.)
Alpine Biodiversity in Europe
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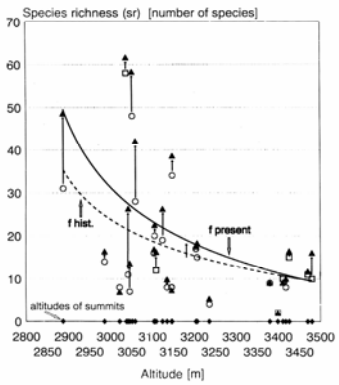
Climate effects on mountain plants

Georg Grabherr, Michael Gottfried, Harald Pauli

NATURE · VOL 369 · 9 JUNE 1994



Gipfel	Höhe [m]	Jahr der historischen Aufnahme	Vergleichsbereich [m]	historische Artenzahl	aktuelle Artenzahl	gewichtete aktuelle Artenzahl	AI	gAI	gewichtete Artenzahlzunahme (Anstiegsindex) gAI [% pro 10 Jahre]
Piz dals Lejs	3042	1907	30	11	34	26,3	24,6	16,8	
Hohe Wilde-Süd	3480	1953	20	10	19	16,05	23,1	16	
Piz Laschadurella	3046	1919	30	7	17	13,55	19,6	13,4	
Stockkogel	3109	1953	9	12	19	16,25	15	9,1	
Napfspitze	2888	1912	3	31	53	48,6	8,9	7,2	
Monte Vago	3059	1905	30	28	51	42,05	9,4	5,8	
Piz Nuna	3124	1919	30	19	34	26,25	10,8	5,2	
Großer Lenkstein	3236	1912	2	4	6	5,3	6,3	4,4	
Wilde Kreuzspitze	3135	1907	3	8	10	9,85	2,9	2,9	
Piz Kesch	3418	1902	30	8	13	10	6,9	2,8	
Munt Pers	3207	1906	11	15	19	18,3	3,1	2,6	
Hint. Spiegelkogel	3426	1953	15	15	19	16,45	6,8	2,5	
Piz Forun	3052	1903	30	48	69	58,3	4,9	2,4	
Gorihorn	2986	1895	7	14	18	16,35	2,9	1,8	
Festkogel	3038	1953	35	58	63	61,7	2,2	1,7	
Hint. Seelenkogel	3470	1953	12	11	13	11,75	4,7	1,7	
Flüela Schwarzhorn	3146	1902	50	34	43	38,6	2,9	1,5	
Piz Stretta	3104	1903	30	20	28	22,5	4,5	1,4	
Liebenerspitze	3399	1953	20	2	3	2,05	12,6	0,6	
Piz Plazer	3104	1918	30	16	19	16,85	2,5	0,7	
Piz Sesvenna	3204	1918	30	17	19	17,5	1,6	0,4	
Piz Julier	3380	1900	30	9	10	9,05	1,2	0,1	
Piz Linard	3411	1947	30	10	10	9,1	0	-0,7	
Piz Trovat	3146	1907	24	8	7	7,3	-1,5	-1,1	
Radüner Rothorn	3022	1897	5	8	6	6,9	-2,6	-1,6	

Very stable slopes
(solid rock etc..)

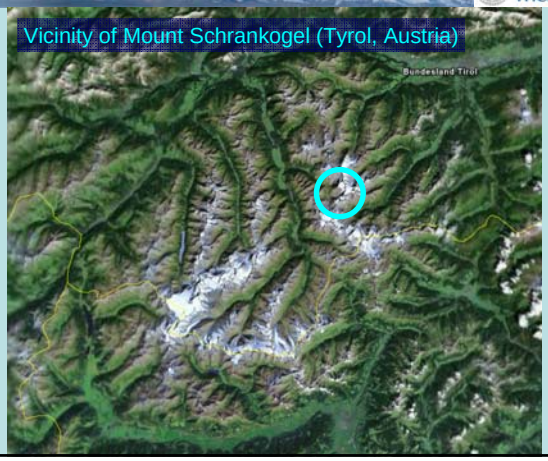
Moderately stable slopes

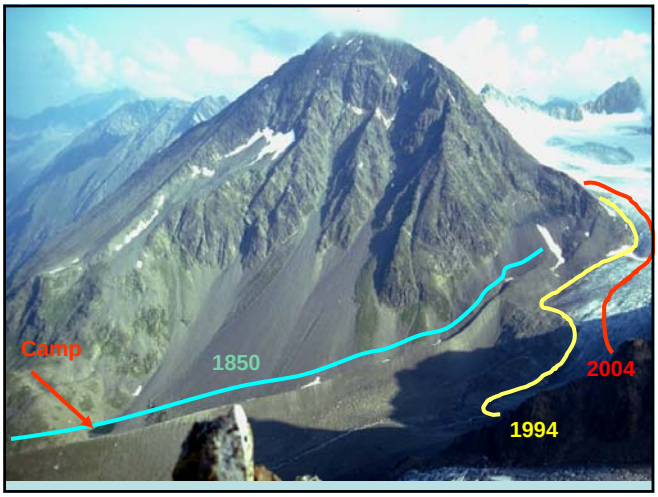
Very unstable slopes
(highly erosive screes etc..)

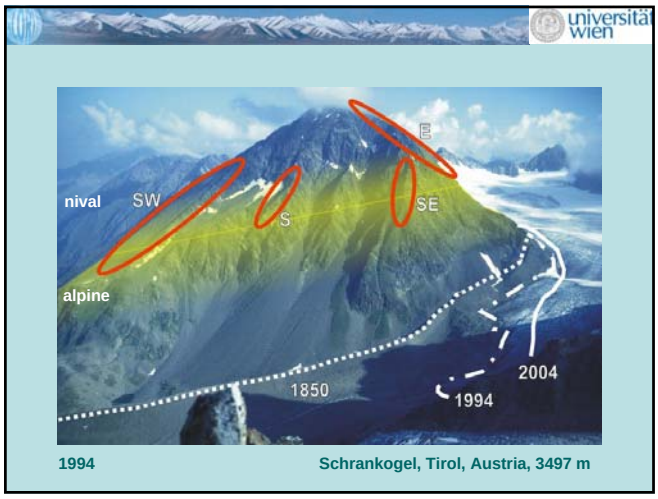
GLORIA-Europe: Some results

The regional monitoring

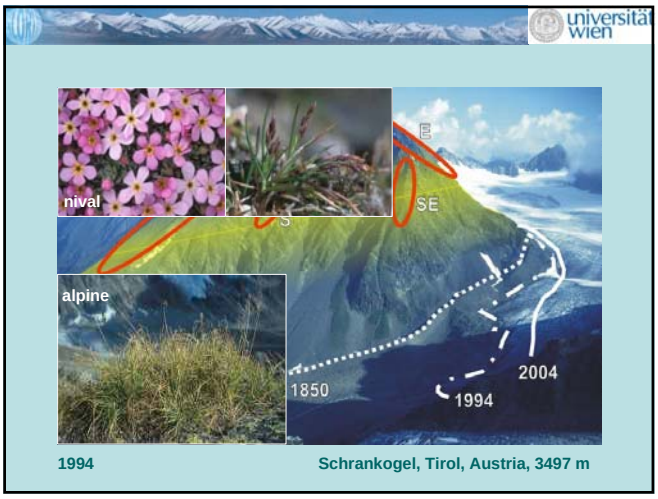
Vicinity of Mount Schrankogel (Tyrol, Austria)



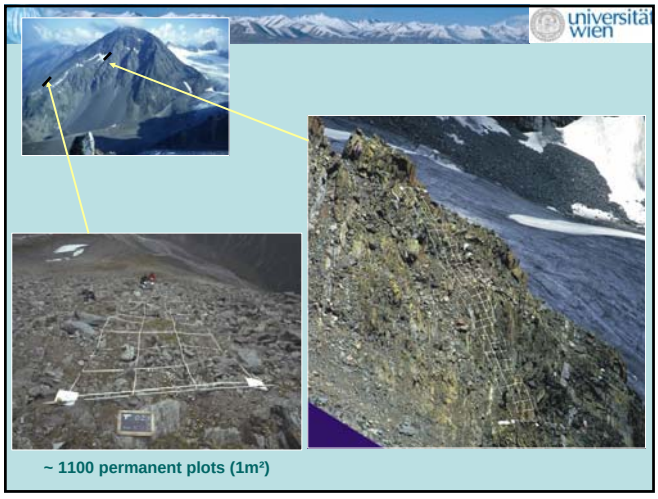




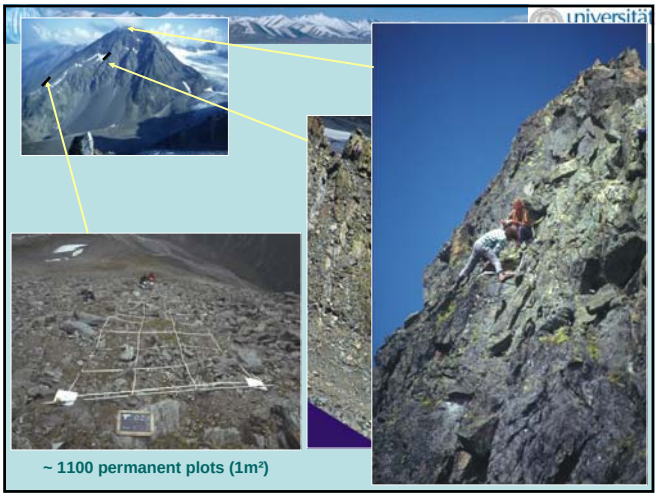
1994 Schrankogel, Tirol, Austria, 3497 m



1994 Schrankogel, Tirol, Austria, 3497 m



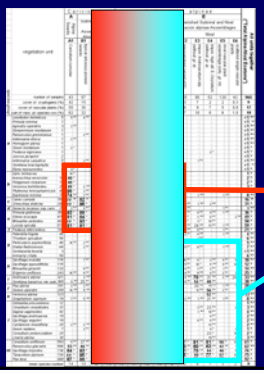
~ 1100 permanent plots (1m²)



~ 1100 permanent plots (1m²)

Alpine and nival plant assemblages

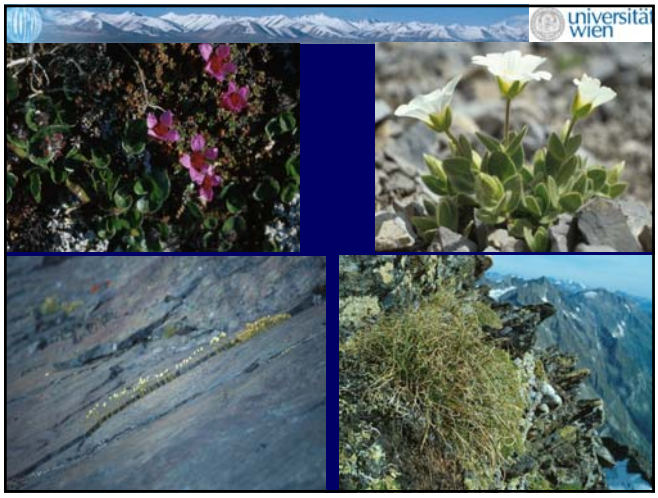
69 species found at the ecotone in 1994 (24 species in more than 10% of the plots)



Source: *Pauli et al. 1999, Phytocoenolgia*

nival species pool

alpine species pool



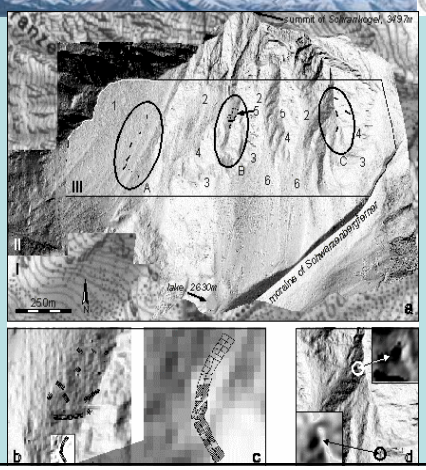
Oreochloa disticha ***alpine***

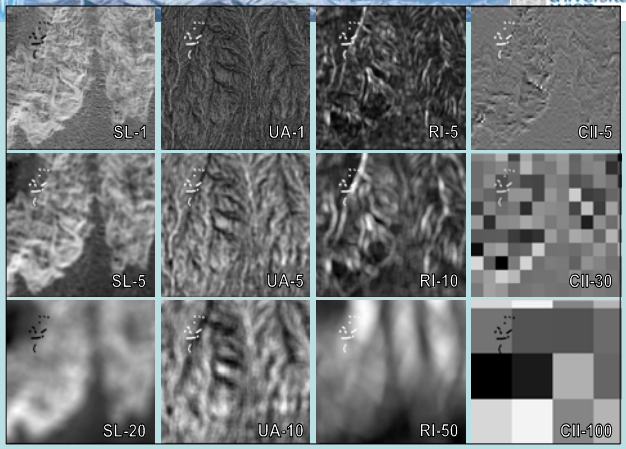
Minuartia sedoides ***alpine***

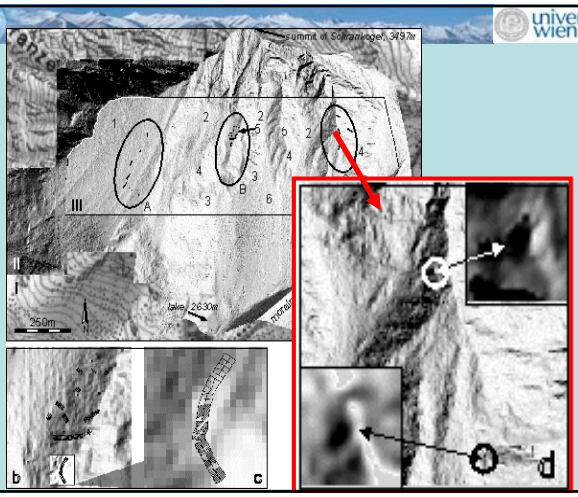
Ranunculus glacialis ***nival***

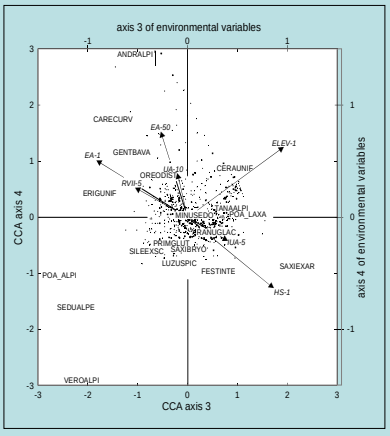
Poa laxa *nival*

Androsace alpina *nival*





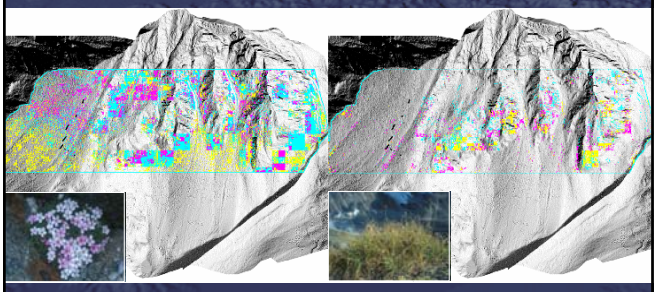




CCA

Canonical Correspondence Analysis

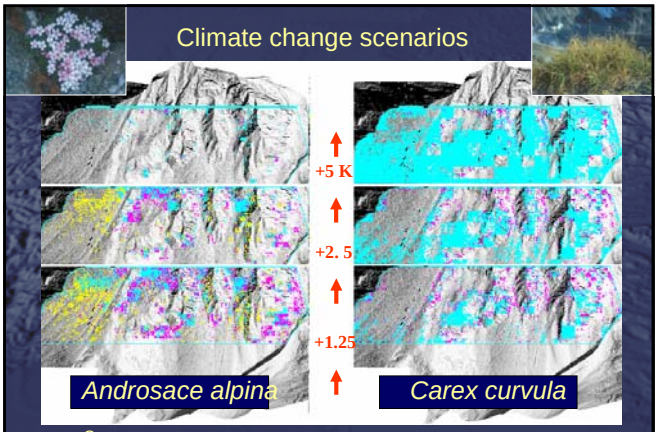
Modelling of current distribution patterns



Androsace alpina *Carex curvula*

Sources:
Gottfried et al. 1998 Antarctic, Arctic and Alpine Research
Gottfried et al., 1999 Diversity and Distributions

Climate change scenarios



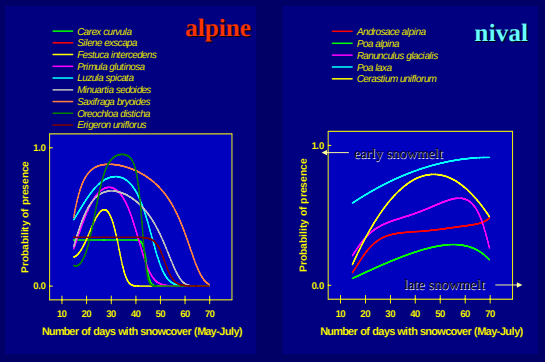
Sources:
Gottfried et al. 1998, Antarctic, Arctic and Alpine Research
Gottfried et al. 1999, Diversity and Distributions

Measuring Climatic Gradients

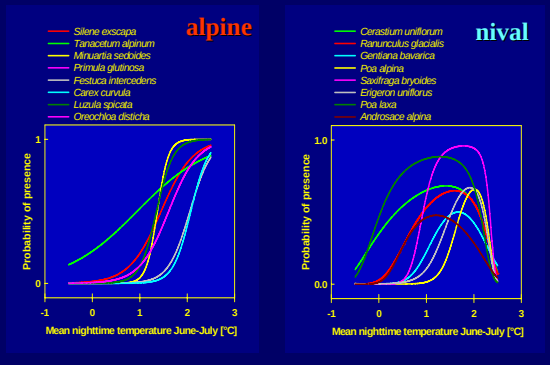
- Snow:
  Number of days with snowcover May-July
- T:
  Nighttime temperature June-July

How do these climatic elements separate the alpine from the nival species pool?

Measuring Climatic Gradients / Snow

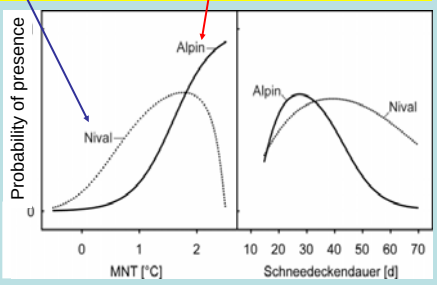


Measuring Climatic Gradients / Nighttime T



Average response of nival ("high altitude") and alpine ("low altitude") species to climate (T and snowcover duration):

Temperatur time-series from 32 measurement points within the alpine-nival ecotone



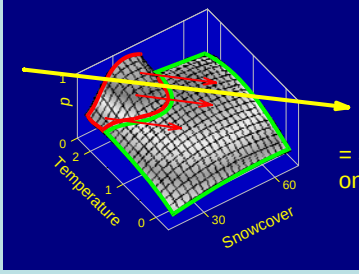
Source:
Gottfried et al. 2002, Mountain Biodiversity - A Global Assessment (ed. Körner)

Mean night-time temperature (June-July)

Days with snow cover (May-June)

Measuring Climatic Gradients / Scenarios

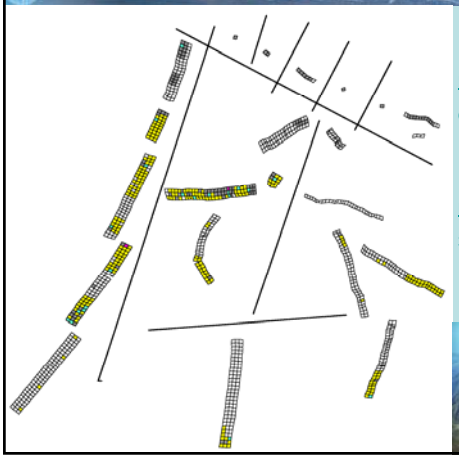
Scenario 2: Temperature +, Snow -



= Strong pressure on nival species

GLORIA-Europe: Some results

The regional re-investigation

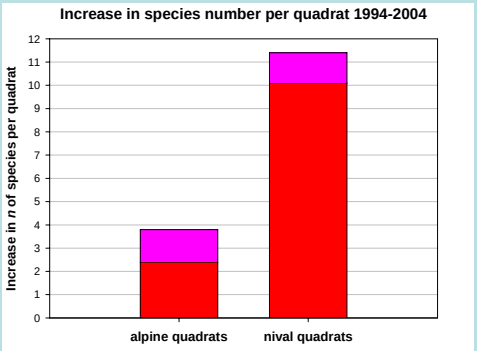


First investigation 1994:

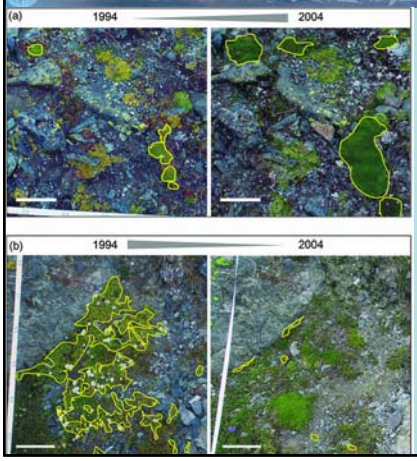
c. 1000 quadrats

Re-investigation 2004:

374 quadrats, c. 40%



species richness increase is BY FAR higher in NIVAL than in ALPINE habitats



Alpine species pool:
cover increase;
e.g., Silene exscapa

Nival species pool:
cover decrease;
e.g., Cerastium uniflorum

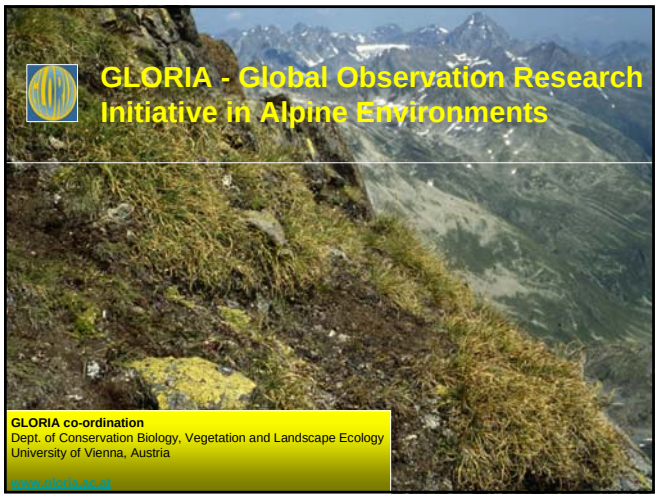
All nival species decrease, almost all alpine species increase in cover !

Alpine, alpine to nival, nival species

COVER ↑ INCREASED	COVER ↓ DECREASED
Cerastium cerastoides	*Androsace alpina*
Erigeron uniflorus	*Carex curvula*
Festuca intercedens	*Cerastium uniflorum*
Oreochloa disticha	*Luzula spicata*
Pedicularis asplenifolia	*Phyteuma hemisphaeric.*
Saxifraga seguieri	*Poa laxa*
Sibbaldia procumbens	*Potentilla frigida*
Silene exscapa	*Ranunculus glacialis*
Leucanthemopsis alpina	*Saxifraga bryoides*
Veronica alpina	*Saxifraga oppositifolia*

p=0.02

Source: *Pauli, Gottfried, Grabherr et al.* 2007, Global Change Biology



GLORIA - Global Observation Research Initiative in Alpine Environments

GLORIA co-ordination
Dept. of Conservation Biology, Vegetation and Landscape Ecology
University of Vienna, Austria
www.gloria.ac.at

Contents

The purpose of GLORIA

is to establish and maintain a long-term observation network for the comparative study of the effects of climate change on mountain biota

High mountains, being controlled by low temperatures, are globally distributed from the tropics to the polar regions.

Comparatively low impacts from human land use.

Mountain environments host an outstandingly diverse and highly specialised flora.

The roots of GLORIA — observed changes

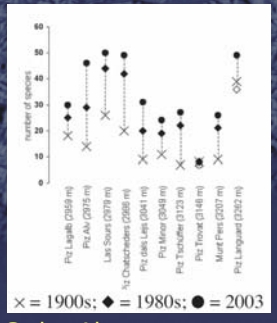
Treeline advances observed, e.g., in the Scandes, Bulgaria, Urals, New Zealand, Alaska

Southern Ural

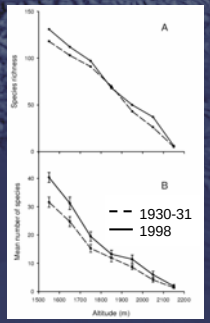
Source: *Moiseev & Shiyatov* 2003, Ecological Studies, Springer

The roots of GLORIA — observed changes

Upward shifts of alpine plant species



Swiss Alps
Walther et al. 2005, Journal of Vegetation Science



S-Scandes, Norway
Klanderud & Birks 2003. The Holocene

The roots of GLORIA — brief history

1994: Schrankogel – permanent plot study at the alpine-nival ecotone

1996: IGBP-meeting – Kathmandu – recognising the demand for long-term monitoring sites in mountain regions

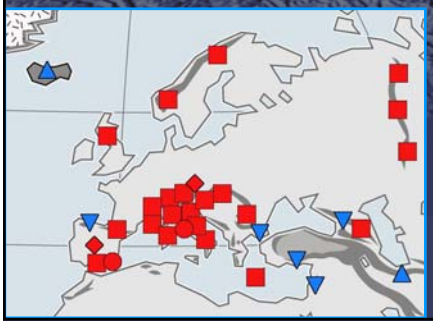
1997-2000: ALPNET – ESF-project on European mountain biodiversity - permanent plots largely lacking

1998-1999: first GLORIA test summit (NE-Alps/Sierra Nevada)

2001-2003: GLORIA-Europe (FP-5), continent-wide setup

GLORIA: Global Observation Research Initiative in Alpine Environments

Start 2001 with GLORIA-Europe:



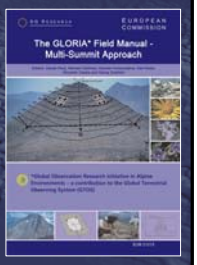
•EU FP5
•24 partners
•18 target regions

•Co-ordination:
Grabherr et al., Vienna

The Multi-Summit Approach

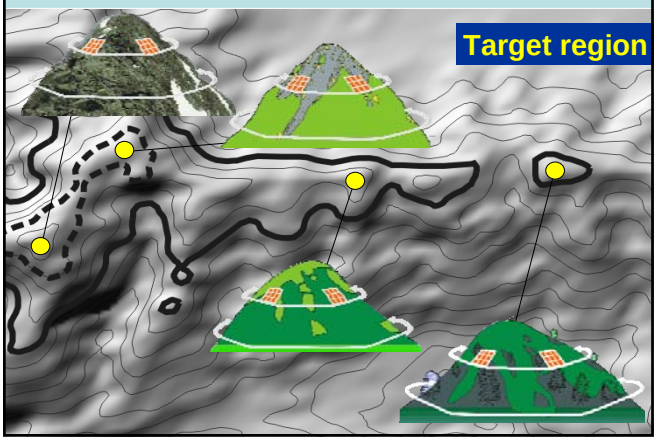
GLORIA's basic sampling design

- focus on summit sites
- vascular plants; *cryptogams optional*
- a fairly inexpensive standardised method for long-term monitoring above the treeline
- should be applicable on a global level



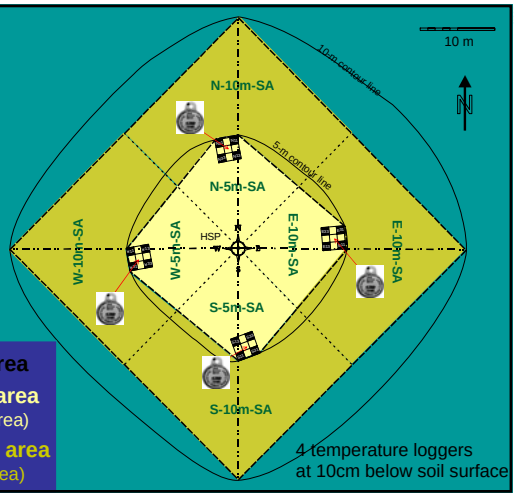
available at
www.gloria.ac.at
in English, Spanish, and Chinese

The Multi-Summit Approach



The Multi-Summit Approach

Plot types

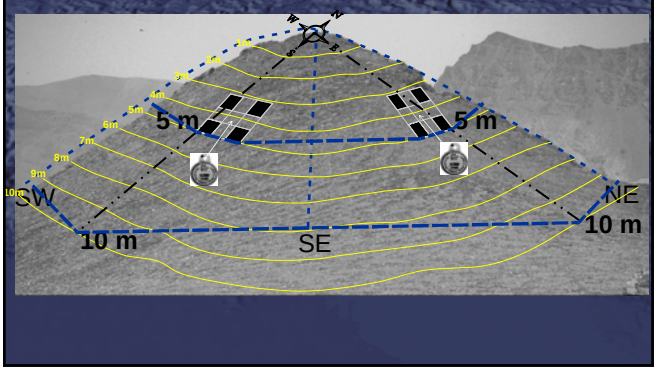


16-quadrat area
5-m summit area
(upper summit area)
10-m summit area
(lower summit area)

4 temperature loggers at 10cm below soil surface

The Multi-Summit Approach

Plot types



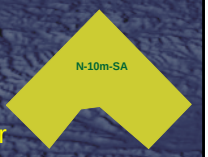
Species recording

- Vegetation sampling in the 1 x 1 m quadrats by visual %-cover estimation of species (changes in species composition and cover)

- Frequency counts of species in 100 cells per 1m² (changes in spatial species patterns)

Species recording

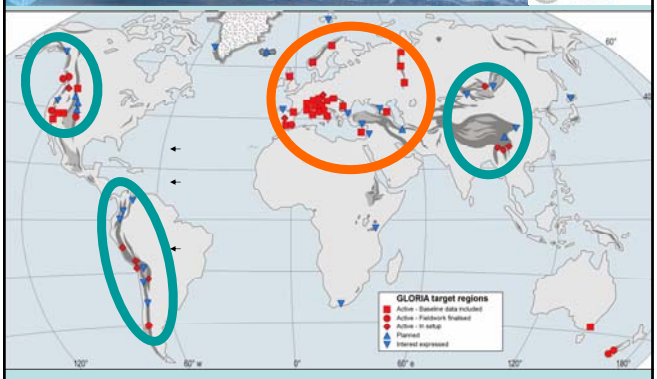
- Species sampling in the summit area: complete species list plus species abundance / cover (species invasions, comparison of species richness)



- Photo documentation

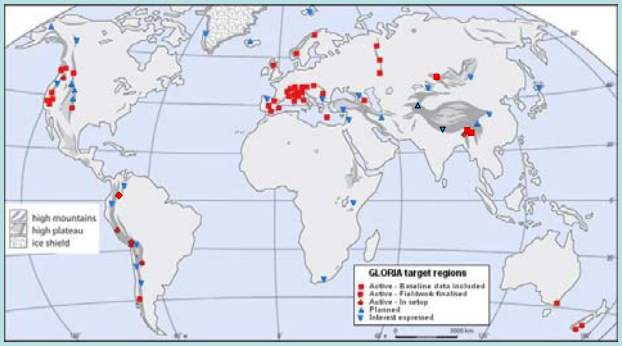
The GLORIA target regions (March 2007)

Target region	Europe	Asia	Austral-asia	North America	South America	Africa
Active	27	3	3	8	5	0
Planned or in setup 2006/2007	2	4	0	4	2	0
Interest expressed	5	8	0	4	4	2



- Implementation of new target regions
- Planning of the European monitoring campaign 2008: model prove

The GLORIA target regions (March 2007)



More information on GLORIA at: www.gloria.ac.at