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Spatial patterns in alpine flora communities in response to variation in glacial melt-water flow

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BES 2009, Hertfordshire

Submitted abstract

Alpine glacial retreat alters melt-water flow and impacts streamside flora. We assess spatial patterns in plant communities' composition and diversity across a glacial braidplain subject to extremes of inundation, desiccation, and sediment deposition. Patterns are related to channel stability and plant community age. Implications for this fragile ecosystem are considered.

Outline

- Introduction, issues and current research
- Aims of this project
- The study area
- Method (chronosequence and braidplain)
- Results (flora community)
- Conclusions and future

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Introduction

Mountain flora are highly sensitive to climate change (Thuiller *et al*. 2005 *PNAS* **102** (23) 8245-8250)

Glacial retreat and snow pack melt will change regimes of melt water runoff (Barnett *et al*., 2005 *Nature* **438** 303–309)

Flora associated with melt water streams particularly vulnerable

- rapid changes in melt water flow (seasonal & diurnal)
- subject to extremes of inundation, sedimentation and desiccation

Vegetation may stabilise river channels with impacts on flow rate, sediment levels, chemistry and invertebrate populations

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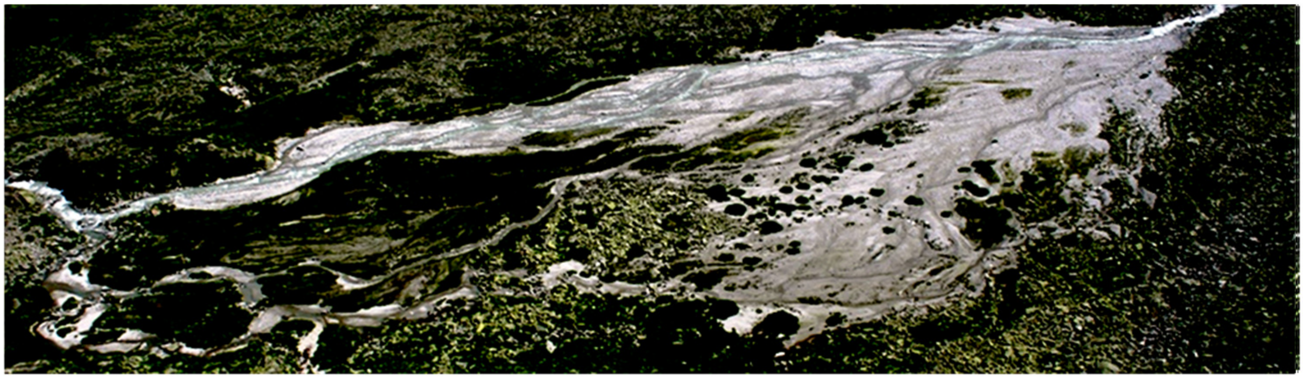
Issues and research



19 July 2008
Single channel
30 July 2008
Braided

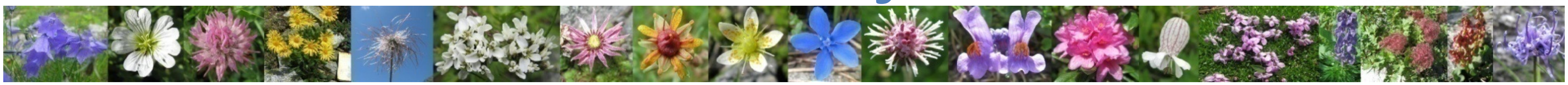
Impacts of melt-water flow on river system under investigation (Dickson, Brown, Carrivick)

- Water quality and flow
- Invertebrate communities

Relationship between river channel stability and vegetation may be important

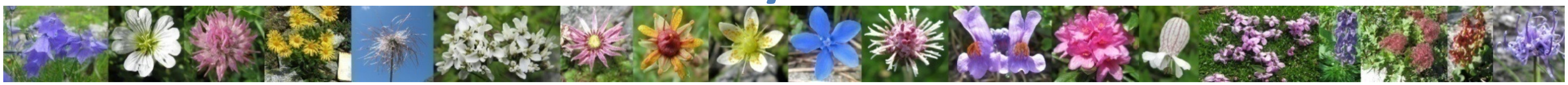
- River threatens plants
- Plants stabilize river

Aims and objectives



- We aim to investigate (inter)relationship between vegetation and river channel stability
- Use vegetation community composition to examine long-term glacial melt-water channel disturbance

Study area



Hohe Tauern National Park, Austria

Ödenwinkelkees glacial valley

2000-2400 metres elevation

Study area

Chronosequence

Glacial retreat documented in valley from 1850 to 1990

Opportunity to create chronosequence of vegetation succession and thus age vegetation communities

Braidplain

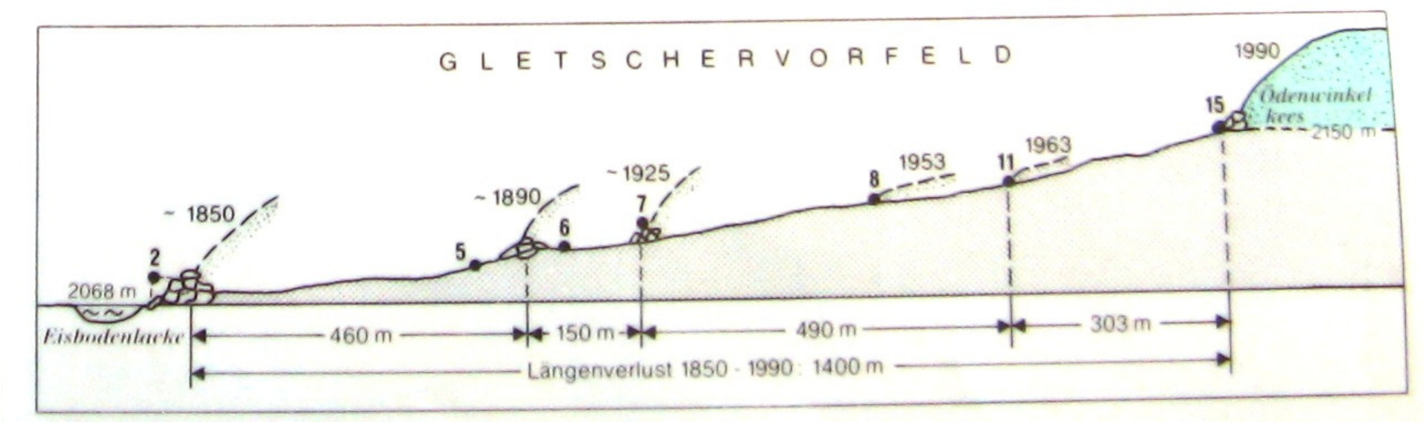
Braidplain located between 1850 and 1890 moraines

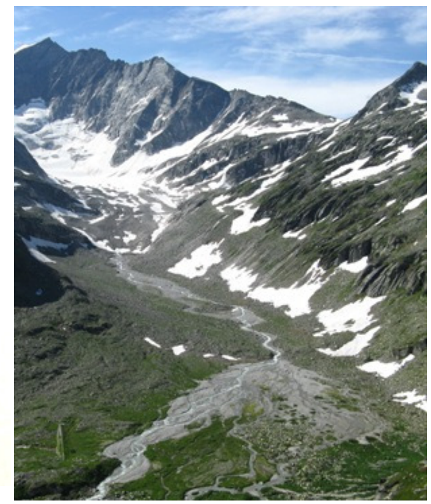
Examine vegetation communities in relation to age-known communities

Examine spatial patterns in communities with relation to dynamism of river channels

Methods - chronosequence

1 - Chronosequence of flora near and between dated moraines





Moraines deposited from glacier 18, 45, 55, 83, 118, and 158 years before this research

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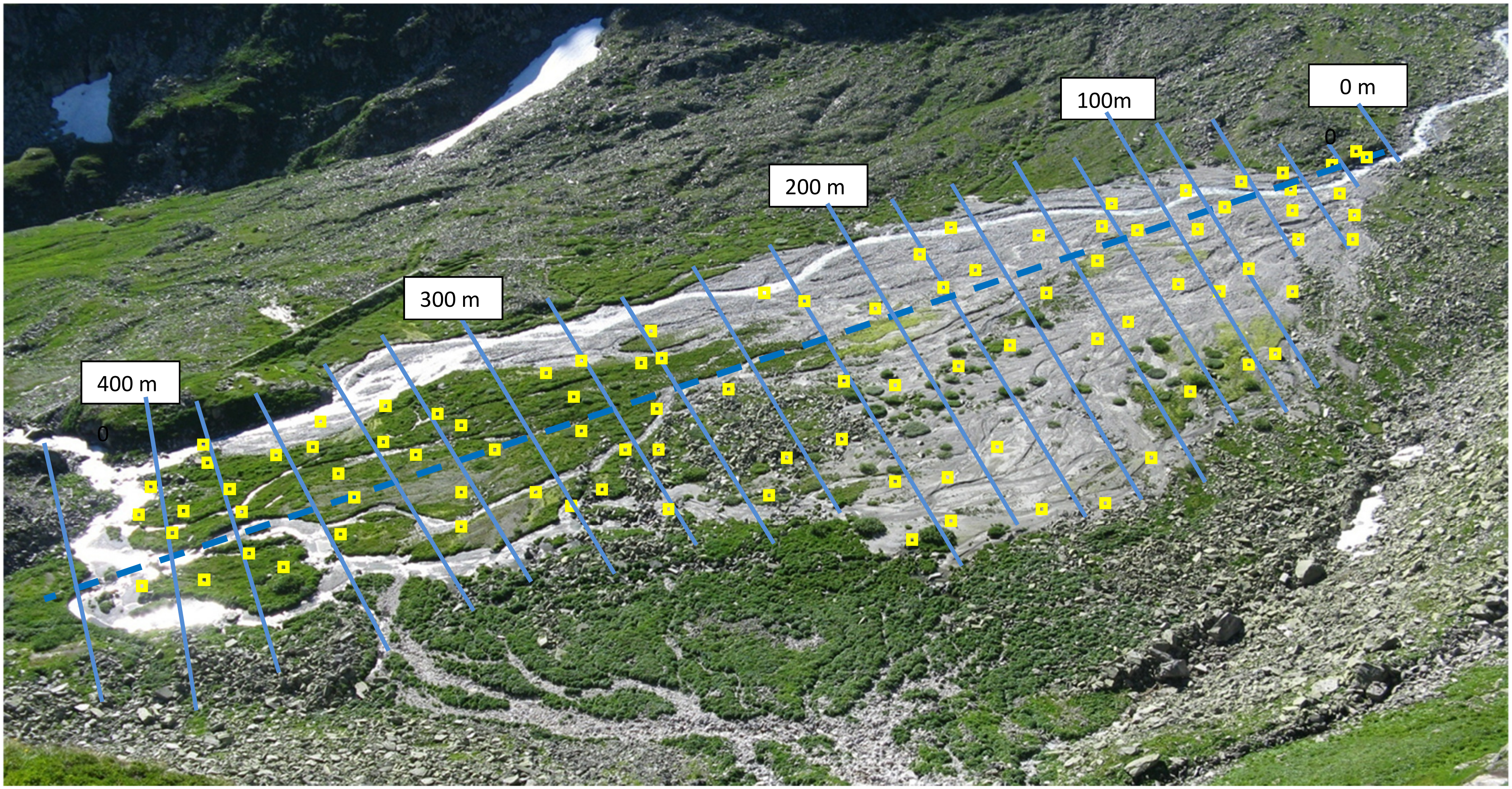
Methods - braidplain



Methods




Sediment

- % cover by size class

Vegetation

- height (x 5)
- % cover by species

Analysis and Results

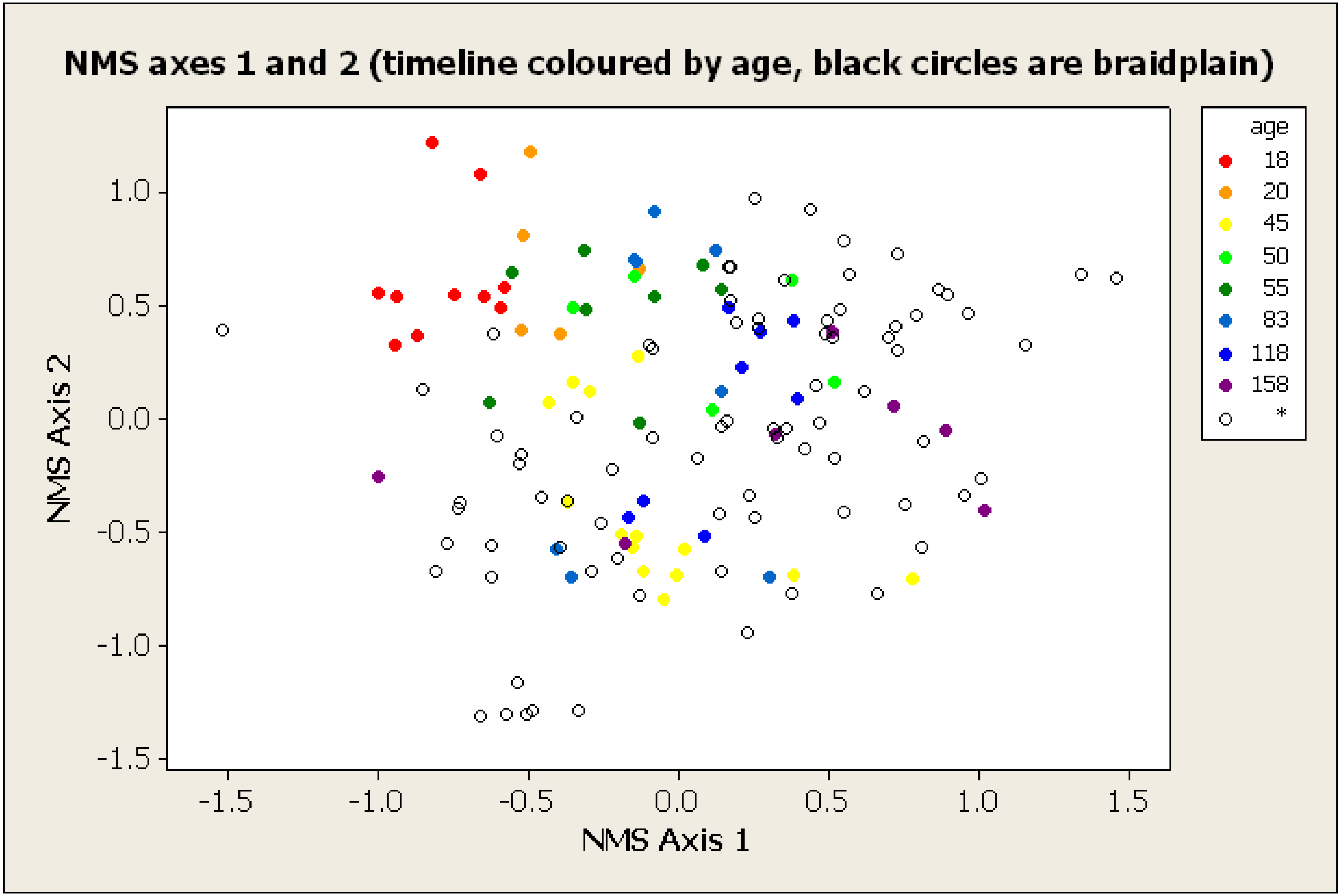
108 species (or groups)

65 quadrats in chronosequence (18 to 158 years)

92 quadrats across braidplain (83 vegetation)

Multivariate ordination (Non-metric multidimensional scaling, NMS) to show species data along axes of greatest change

Results - community



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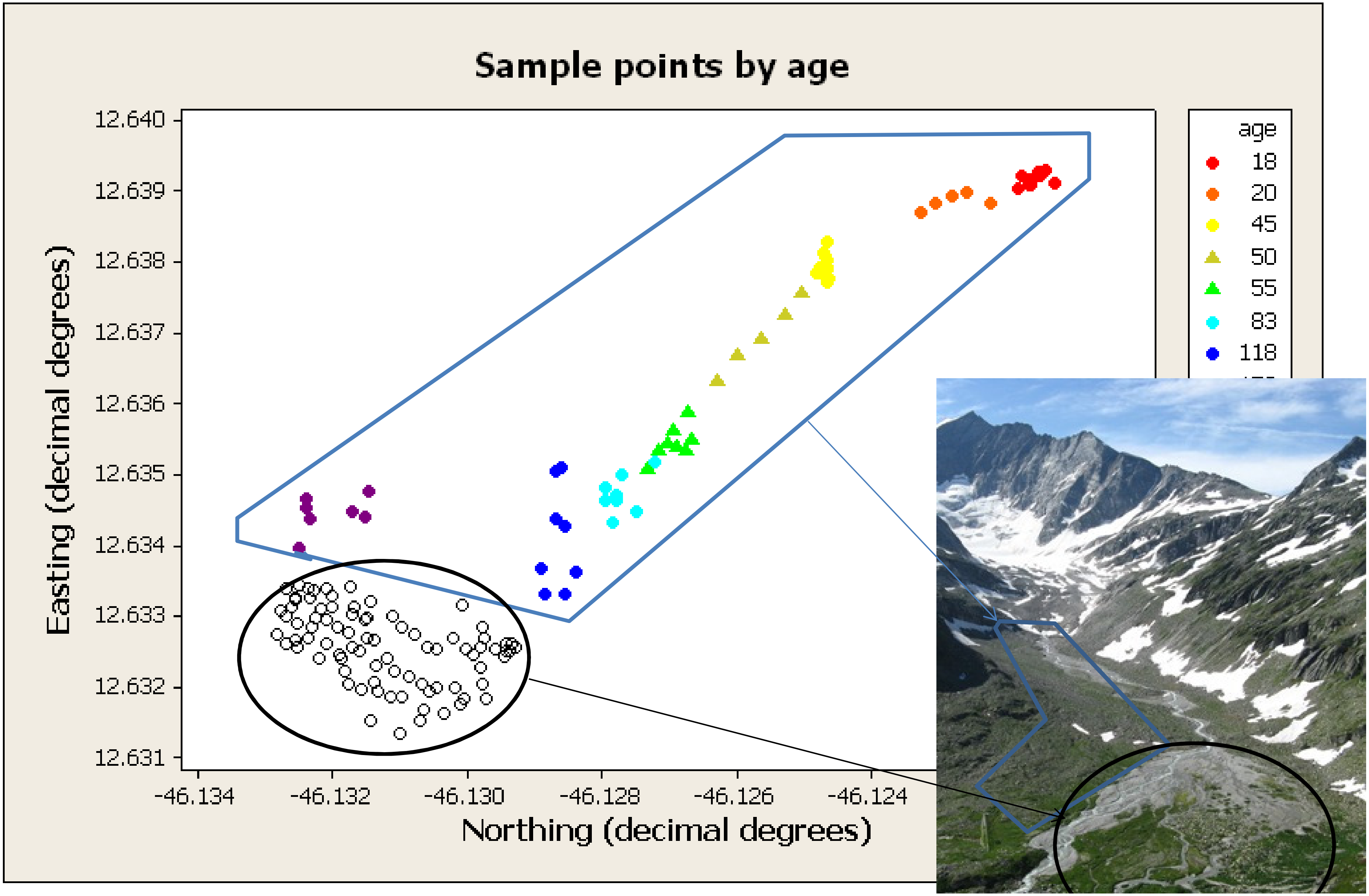
Results - community

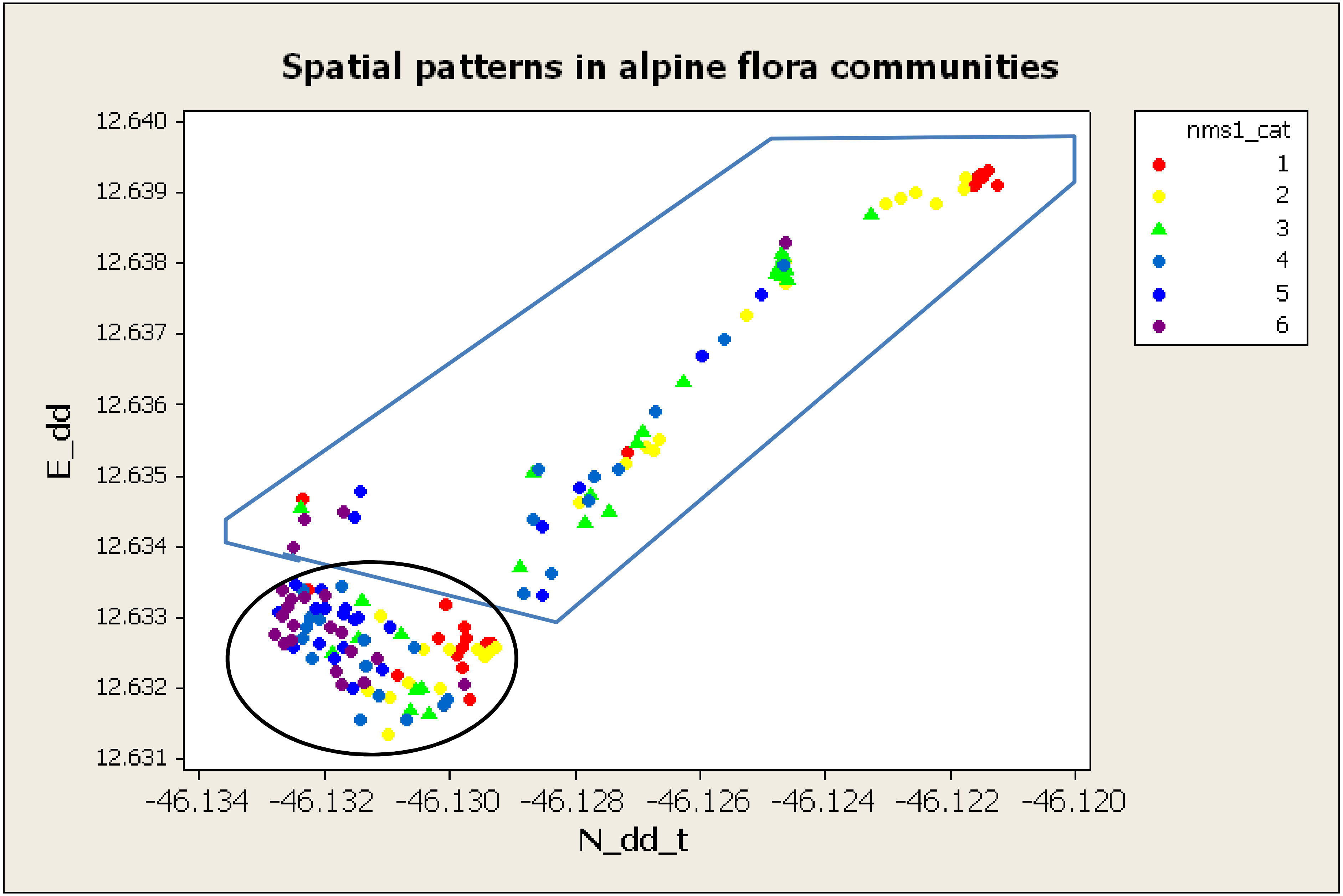
	nms1	nms2	nms3
vegetation height	0.727***	0.240***	0.132
age	0.591***	-0.303*	0.551***
elevation	-0.468***	0.222***	0.230***
slope	-0.071	0.071	0.006
aspect	-0.008	-0.123	0.040
% fine sediment	-0.005	-0.148	-0.360***
% sediment <1cm	-0.205*	-0.239***	-0.404***
% sediment 1-5cm	-0.429***	-0.164*	-0.371***
% sed 5-10cm	-0.386***	-0.305***	-0.272***
% sed 50-150cm	0.181*	-0.005	0.056
% sed >150cm	0.111	-0.065	-0.021

Pearson correlation * p 0.05 ** p 0.01 *** p 0.005

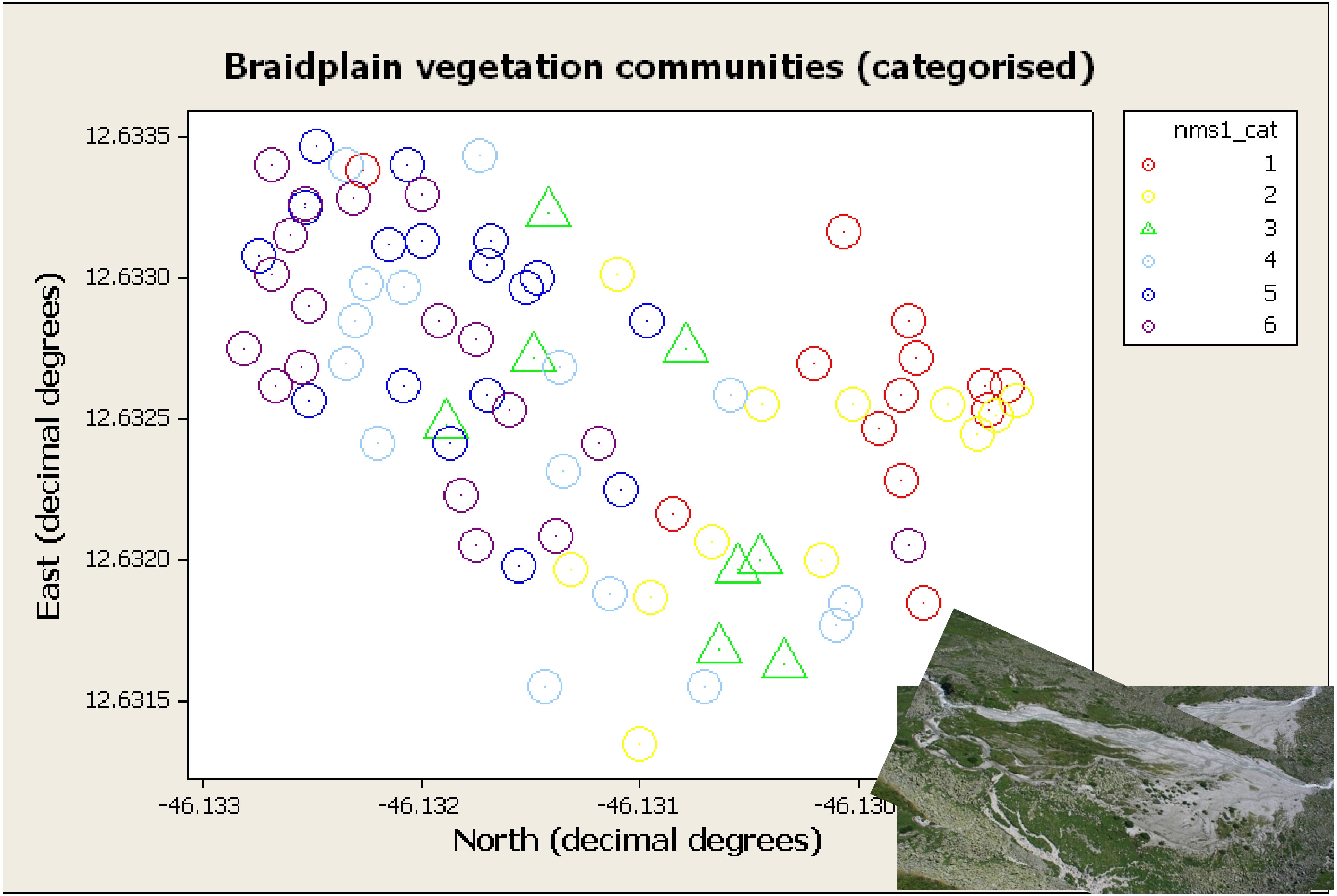
Results – age of morraine

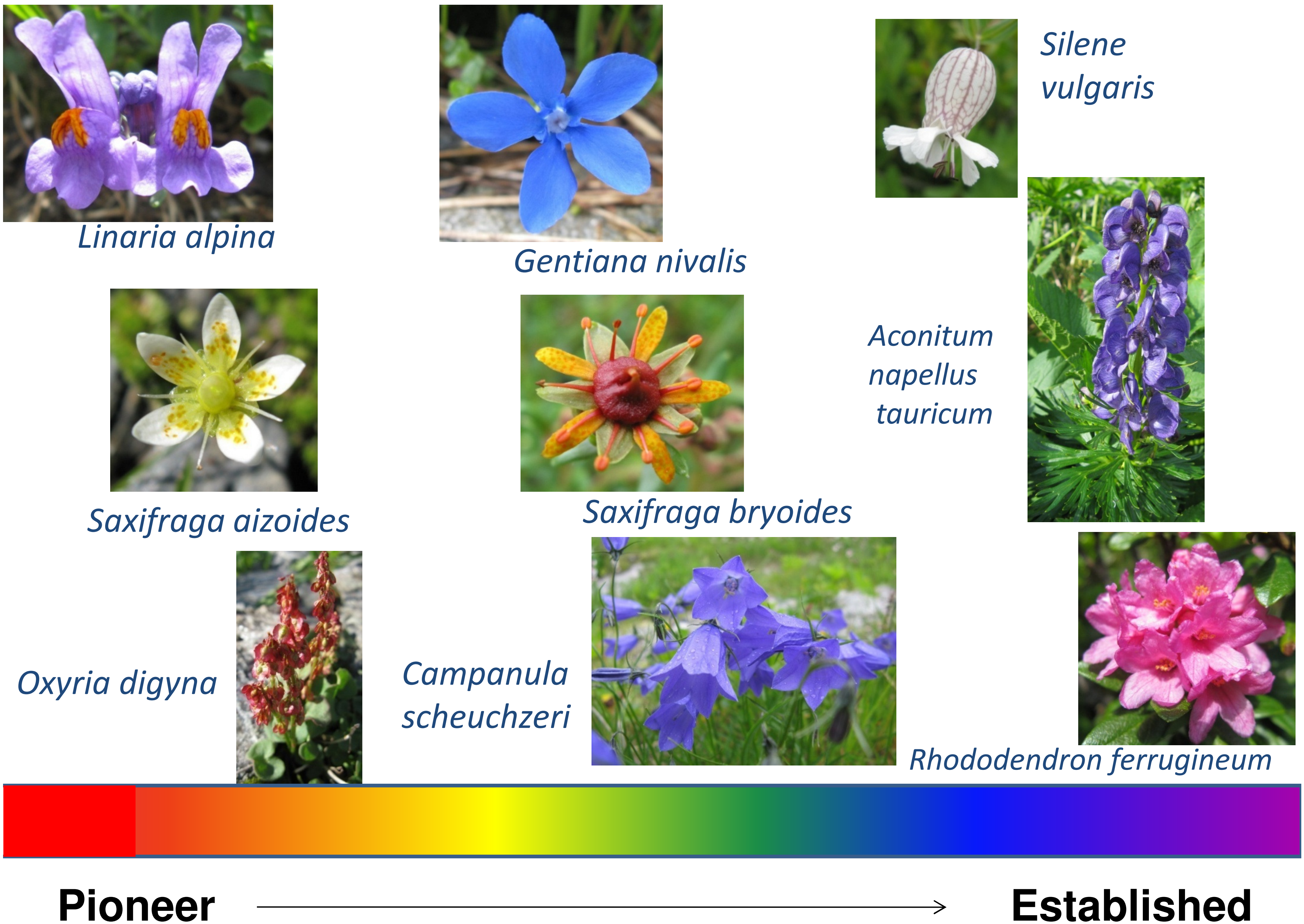


Results - community



Categorised NMS score (-1.5 to 1.5)




Linaria alpina
Gentiana nivalis
Silene vulgaris
Saxifraga aizoides
Saxifraga bryoides
Aconitum napellus tauricum
Oxyria digyna
Campanula scheuchzeri
Rhododendron ferrugineum
Pioneer
Established

Results

Effective use of temporal data to explain spatial patterns

Suggests similar change in community composition on the braidplain as along the chronosequence

Surprisingly, the full range of communities found:

Ages “18” to “158”

The 158-year pattern of succession is represented in a much smaller space on the braidplain

Works well in categories, looking at statistical models to explain data predicatively

Results - biodiversity

NMS axis 1 less closely correlated with biodiversity that NMS axis 2 and NMS axis 3

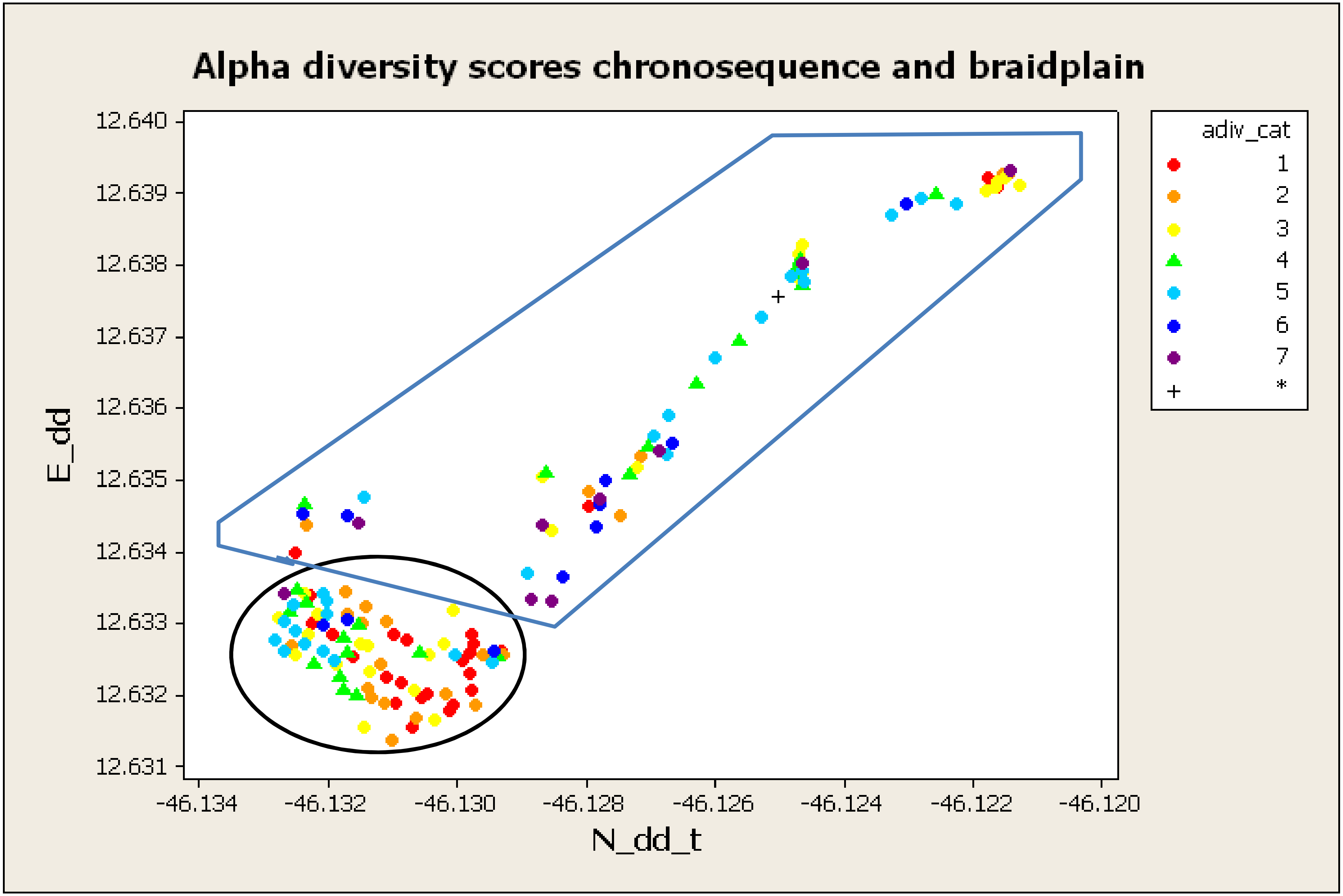
	NMS1	NMS2	NMS3
alpha diversity	0.181*	0.351***	0.473***
Berger-Parker 1-d	-0.173*	-0.275***	-0.322***
Shannon-Weiner H'	0.203*	0.317***	0.440***
Simpson's 1-D	0.197*	0.284***	0.381***

Pearson correlation   * P <0.05   ** p< 0.001   *** p<0.0005

NMS axis 3 used for following visualisation

Species richness categories

1 = 1 to 4	2 = 5 to 8	3 = 9 to 12	4 = 13 to 16
5 = 17 to 20	6 = 21 to 24	7 = 25 to 30	



Species richness categories

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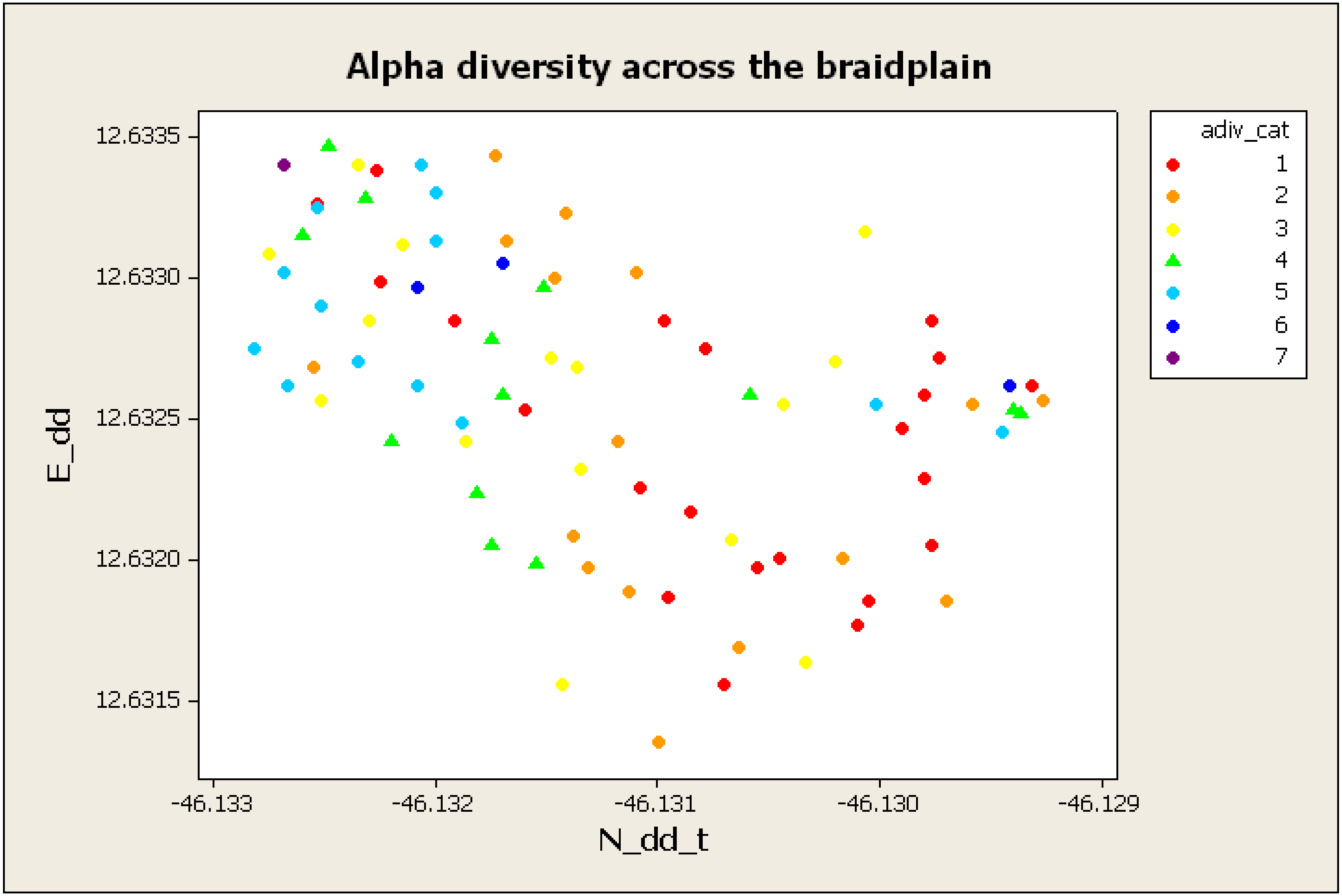

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Conclusions and future

Disturbance at a small scale can mimic patterns of a longer temporal scale and may be important in maintaining populations of early successional species

As the glacier is exhausted, glacial melt-water flow will decrease:

- Less disturbance to vegetation on the braidplain
- Community successional development unrestricted
- Likely to see larger, late-successional species develop across the whole area
- Changes to river channel stability, water flow and chemistry
- Consequences for in-stream invertebrates, algaes, and other species


Thanks to:
Dr Andy Evans &
River Basins Research Cluster
School of Geography, University of Leeds
Alpine Rudolfshütte, Zell am See, Austria


Achillea moschata
Adenostyles alliariae
Campanula scheuchzeri
Cerastium uniflorun
Aconitum napellus tauricum
Gentiana
Doronicum poss clusii
Rhododendron ferrugineum
Oxyria digyna
Trifolium pratense
Saxifraga aizoides
Saxifraga bryoides
Phyteuma hemisphaericum
Silene vulgaris
Linaria alpina
Homogyne alpina
Silene acaulis
Geum reptans