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

Naomi van der Velden, Lee Brown, Jonathan Carrivick, Neil Dickson

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

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



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

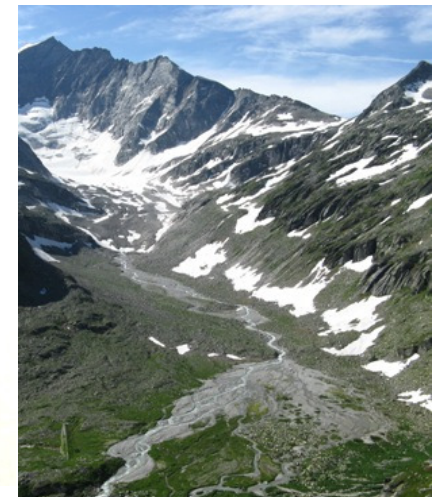
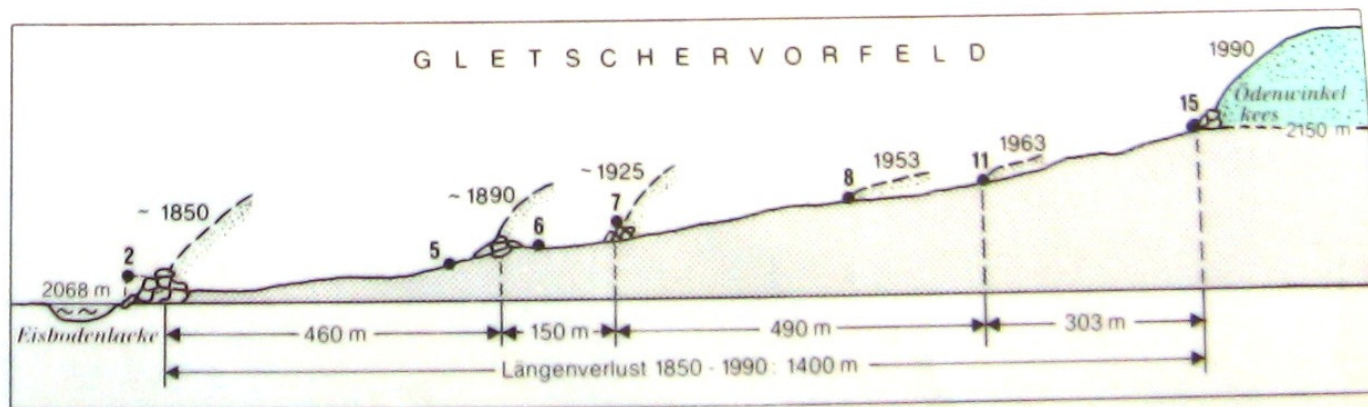
Examine vegetation communities in relation to age-known communities

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

Methods - chronosequence

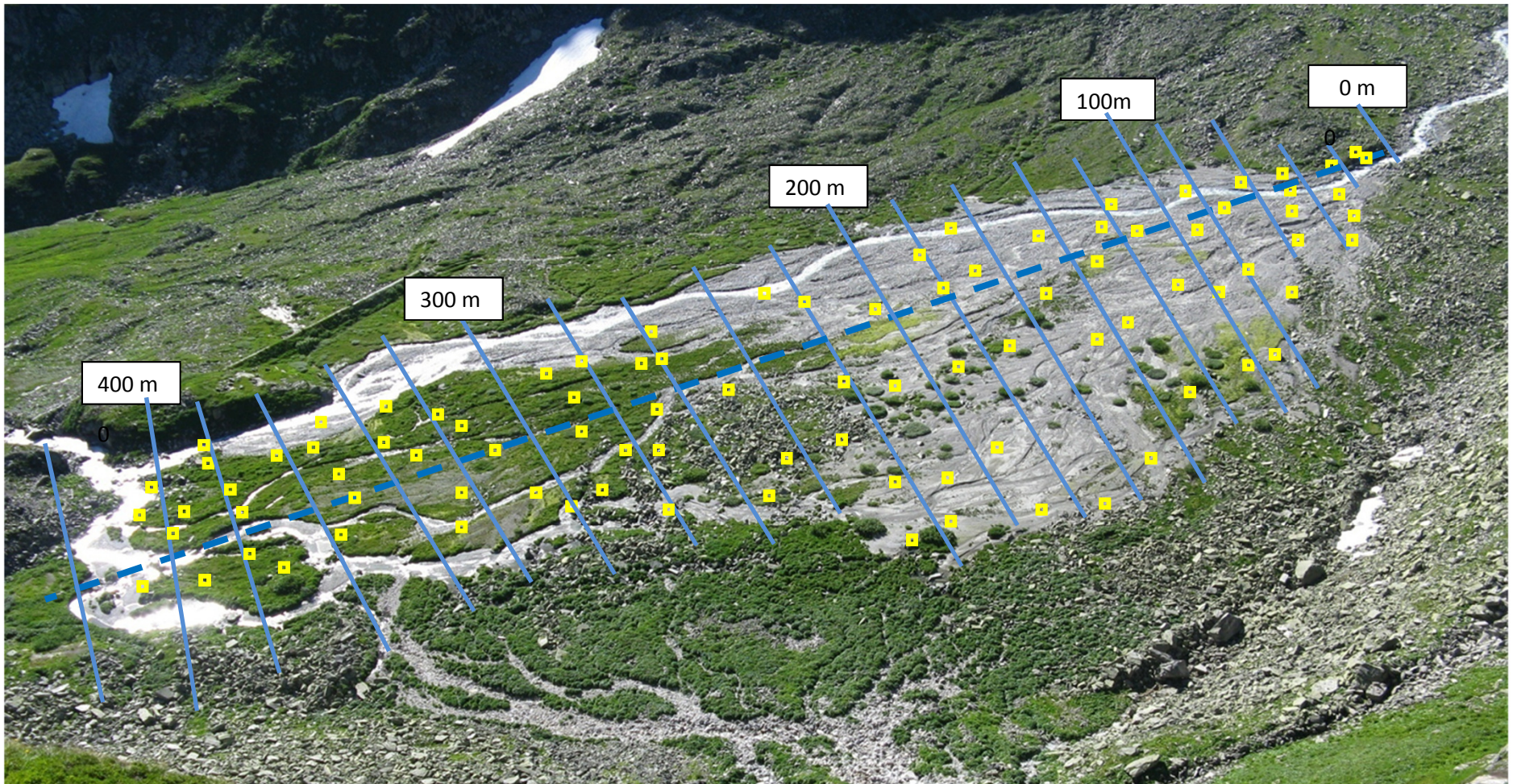


1 - Chronosequence of flora near and between dated moraines



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

Methods - braidplain



Methods



Sediment

- % cover by size class

Vegetation

- height (x 5)
- % cover by species

Analysis and Results



108 species (or groups)

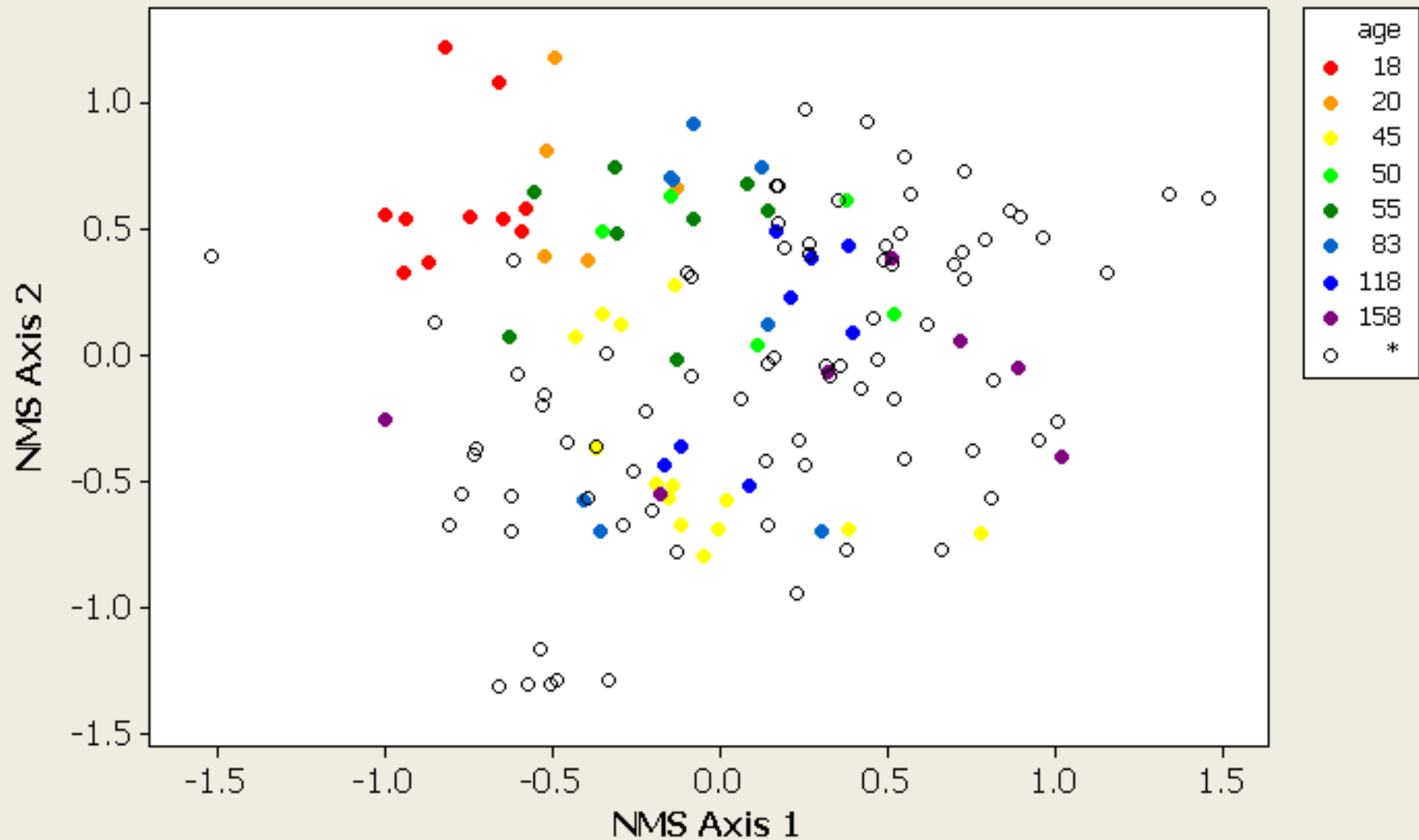
65 quadrats in chronosequence (18 to 158 years)

92 quadrats across braidplain (83 vegetation)

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

Results - community

NMS axes 1 and 2 (timeline coloured by age, black circles are braidplain)



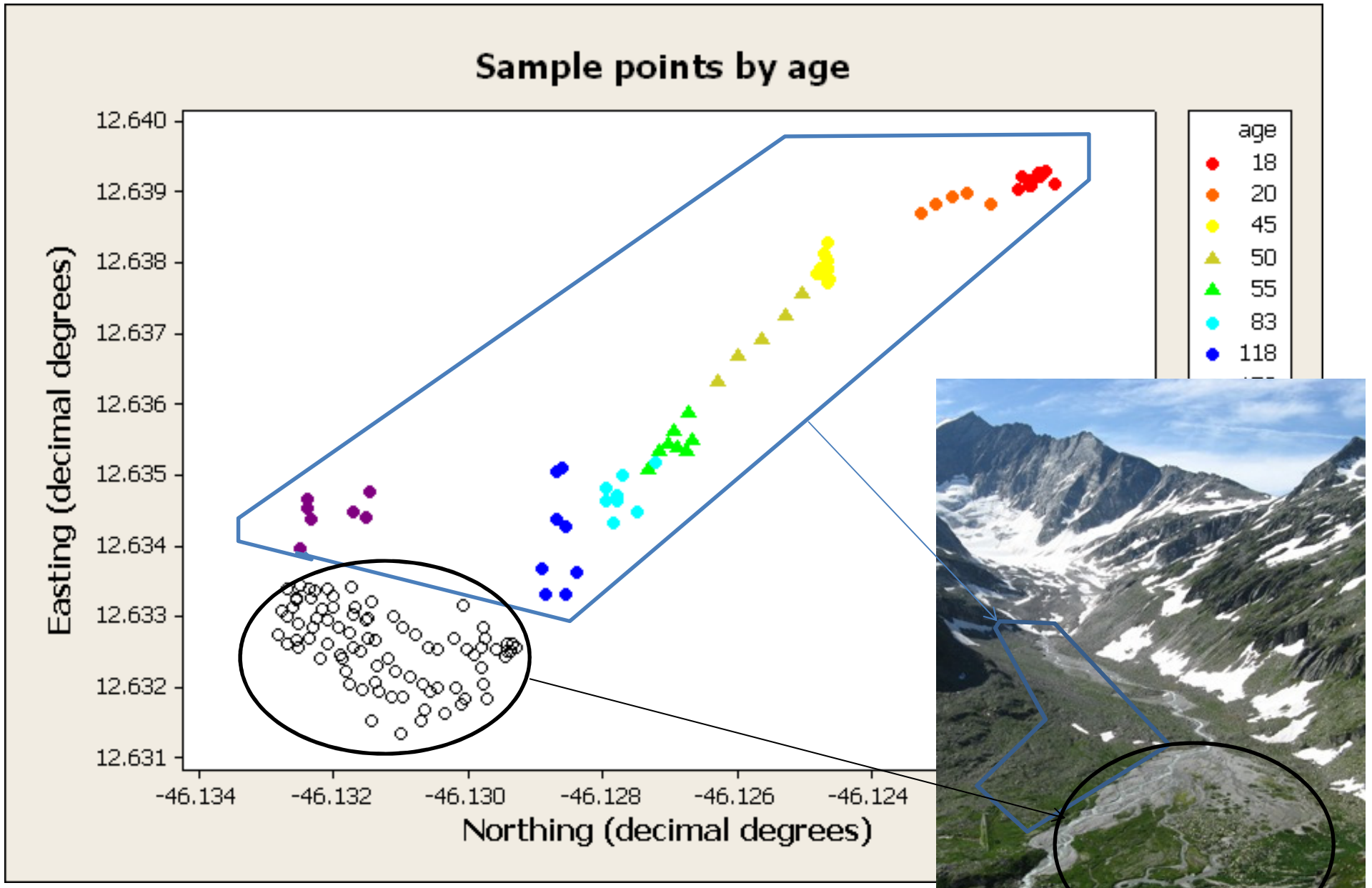
Results - community



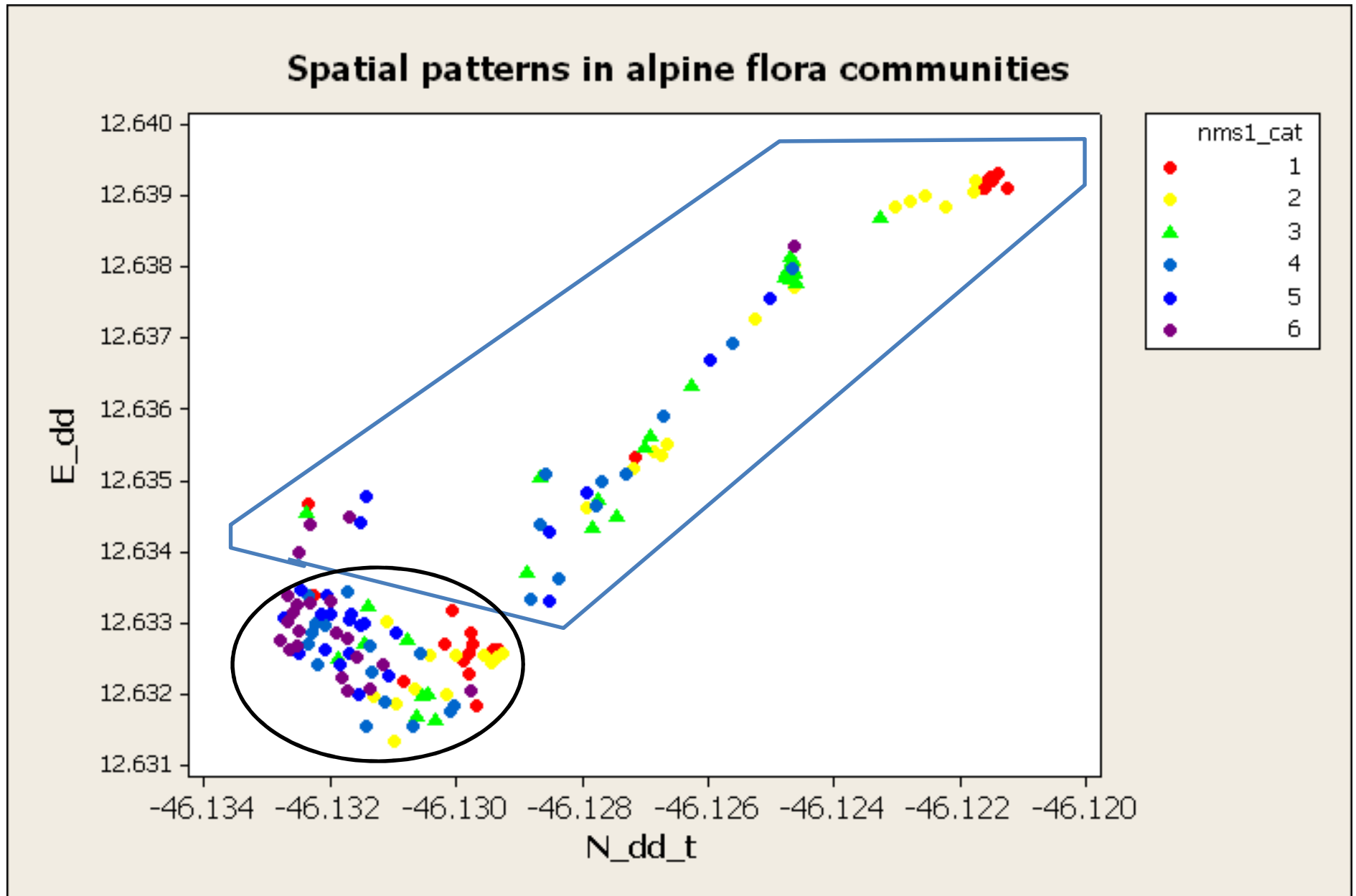
	nms1	nms2	nms3
vegetation height	0.727***	0.240***	0.132
age	0.591***	-0.303*	0.551***
elevation	-0.468***	0.222***	0.230***
slope	-0.071	0.071	0.006
aspect	-0.008	-0.123	0.040
% fine sediment	-0.005	-0.148	-0.360***
% sediment <1cm	-0.205*	-0.239***	-0.404***
% sediment 1-5cm	-0.429***	-0.164*	-0.371***
% 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

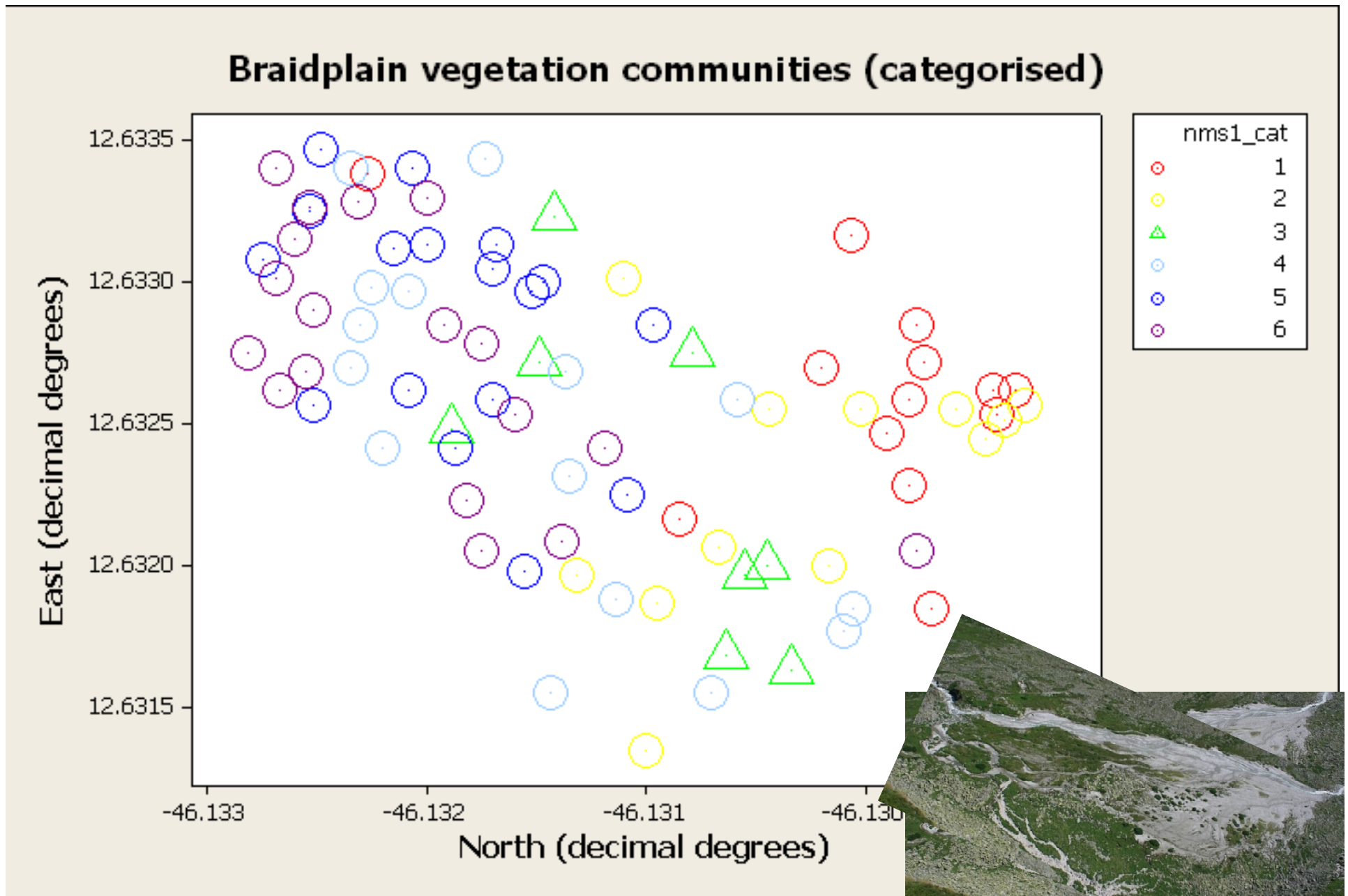
Results – age of moraine



Results - community



Categorised NMS score (-1.5 to 1.5)

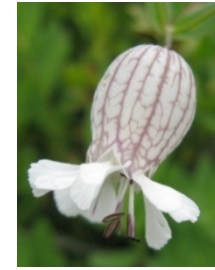




Linaria alpina



Gentiana nivalis



Silene vulgaris



Saxifraga aizoides



Saxifraga bryoides

Aconitum napellus tauricum



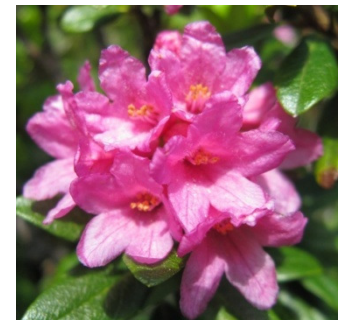
Oxyria digyna



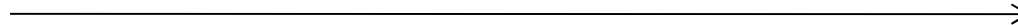
Campanula scheuchzeri



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

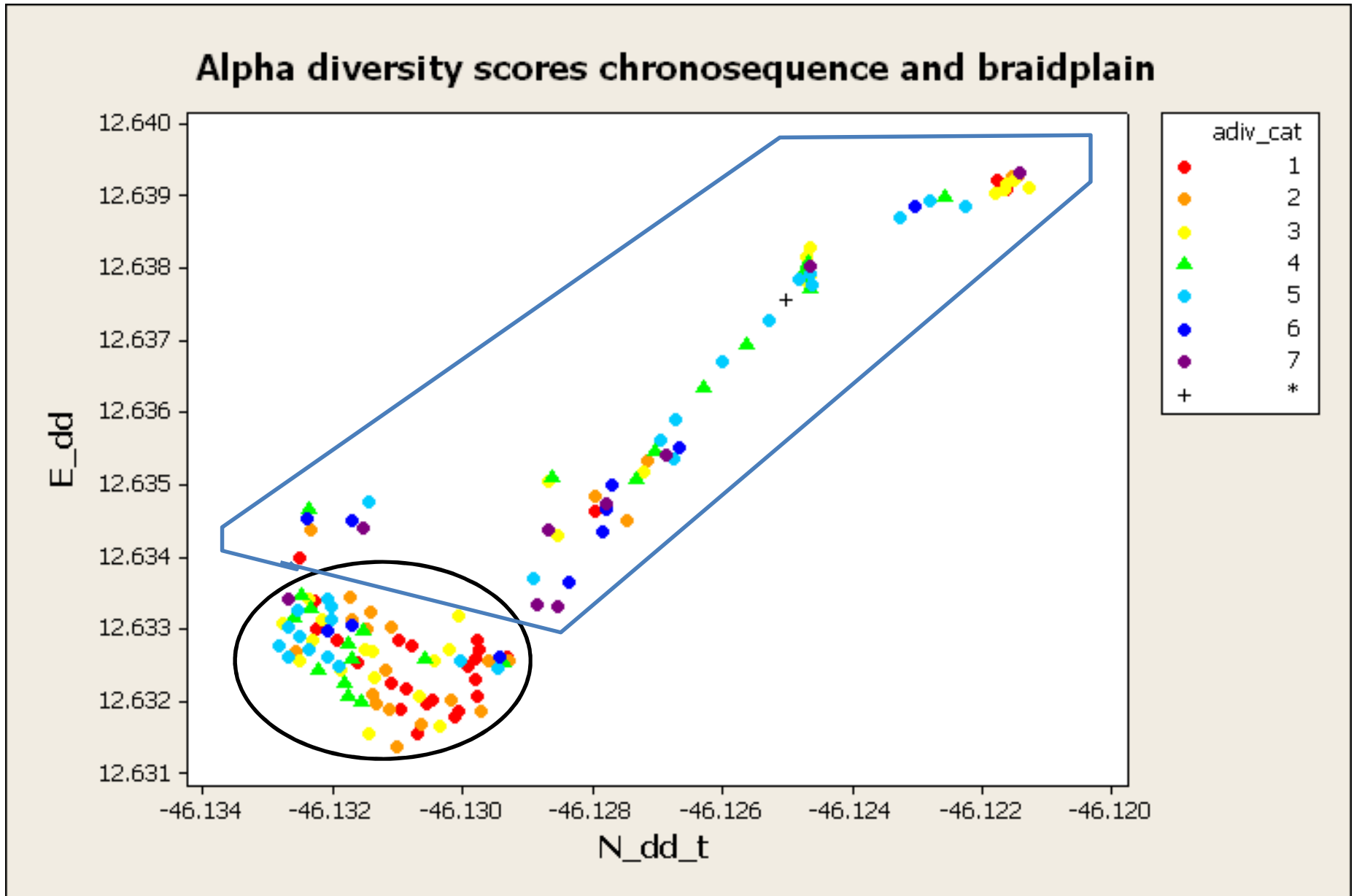
3 = 9 to 12

4 = 13 to 16

5 = 17 to 20

6 = 21 to 24

7 = 25 to 30



Species richness categories

1 = 1 to 4

2 = 5 to 8

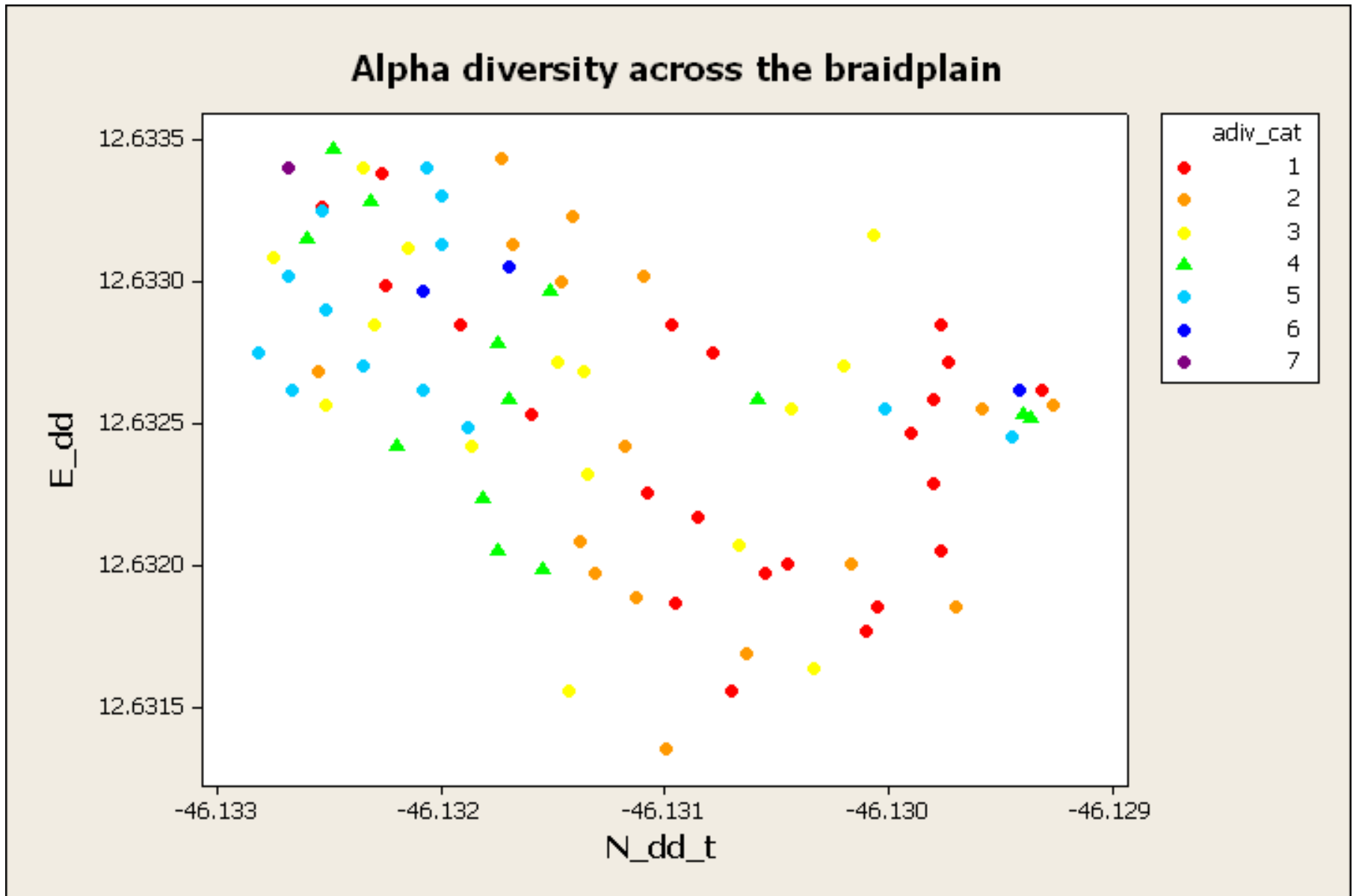
3 = 9 to 12

4 = 13 to 16

5 = 17 to 20

6 = 21 to 24

7 = 25 to 30





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, algae, and other species

Thanks to:

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River Basins Research Cluster

School of Geography, University of Leeds

Alpine Rudolfshütte, Zell am See, Austria





Achillea moschata



Adenostyles alliariae



Campanula scheuchzeri



Cerastium uniflorum



Aconitum napellus-auricum



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