High-montane habitats: the sharp end

Dave Genney

Bryophytes, Fungi and Lichens Adviser

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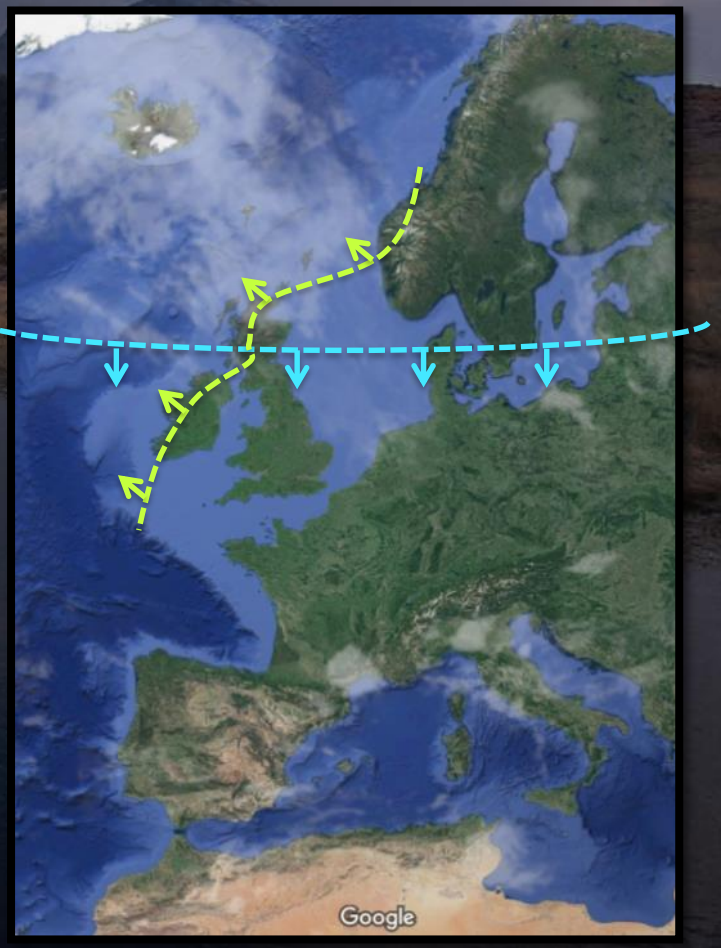
Scottish mountains

- At the front-line of climate change impacts
- Southern extent of arctic species
- Western/altitudinal extent of alpine species
- Decreasing snow-cover UKCP09 scenarios project decline in snowfall of 65-80% by the 2080s



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A focus on bryophytes and lichens

- A large component of Scotland's biodiversity
- Strongly regulated by climate
- Respond to small-scale/micro-climatic variation
- Occupy a diverse range of niches
- Immobile – poor adaptation capacity?

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Some key questions

- How do we monitor climate change impacts?
- Are there any management options to help species adapt?

Scottish Snowbed Vegetation Monitoring Network

Assisted Colonisation of immobile species

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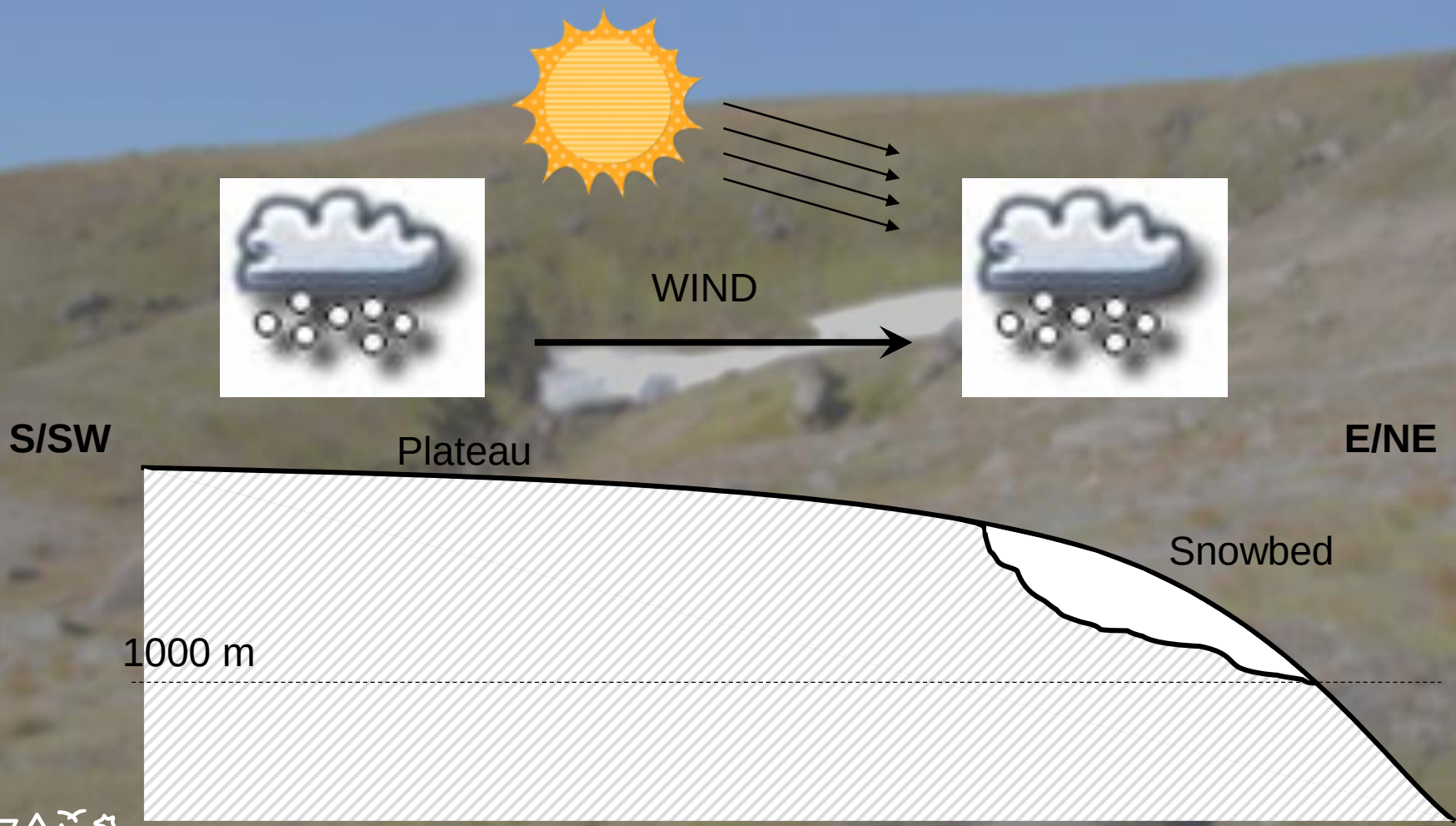
Factors contributing to snowbed formation



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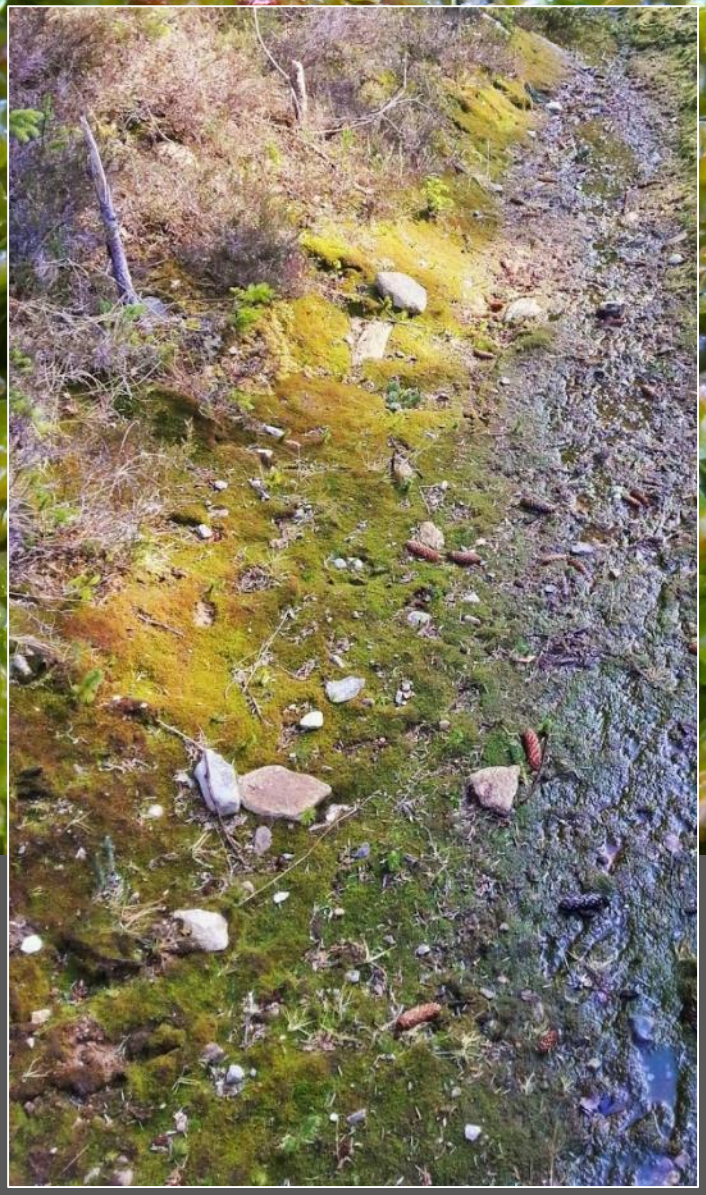
5th July



Nardia scalaris (Ladder Flapwort)

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Conostomum tetragonum
(Helmet-moss)

Polytrichum sexangulare (Northern Haircap)

Marsupella brevissima (Snow Rustwort)

Pohlia ludwigii (Ludwig’s Thread-moss)

Scottish Snowbed Vegetation Monitoring Network

1989/90 first snowbed survey (58 sites)

c. 18 years

2007/8 second snowbed survey
(22 sites, 115 plots)

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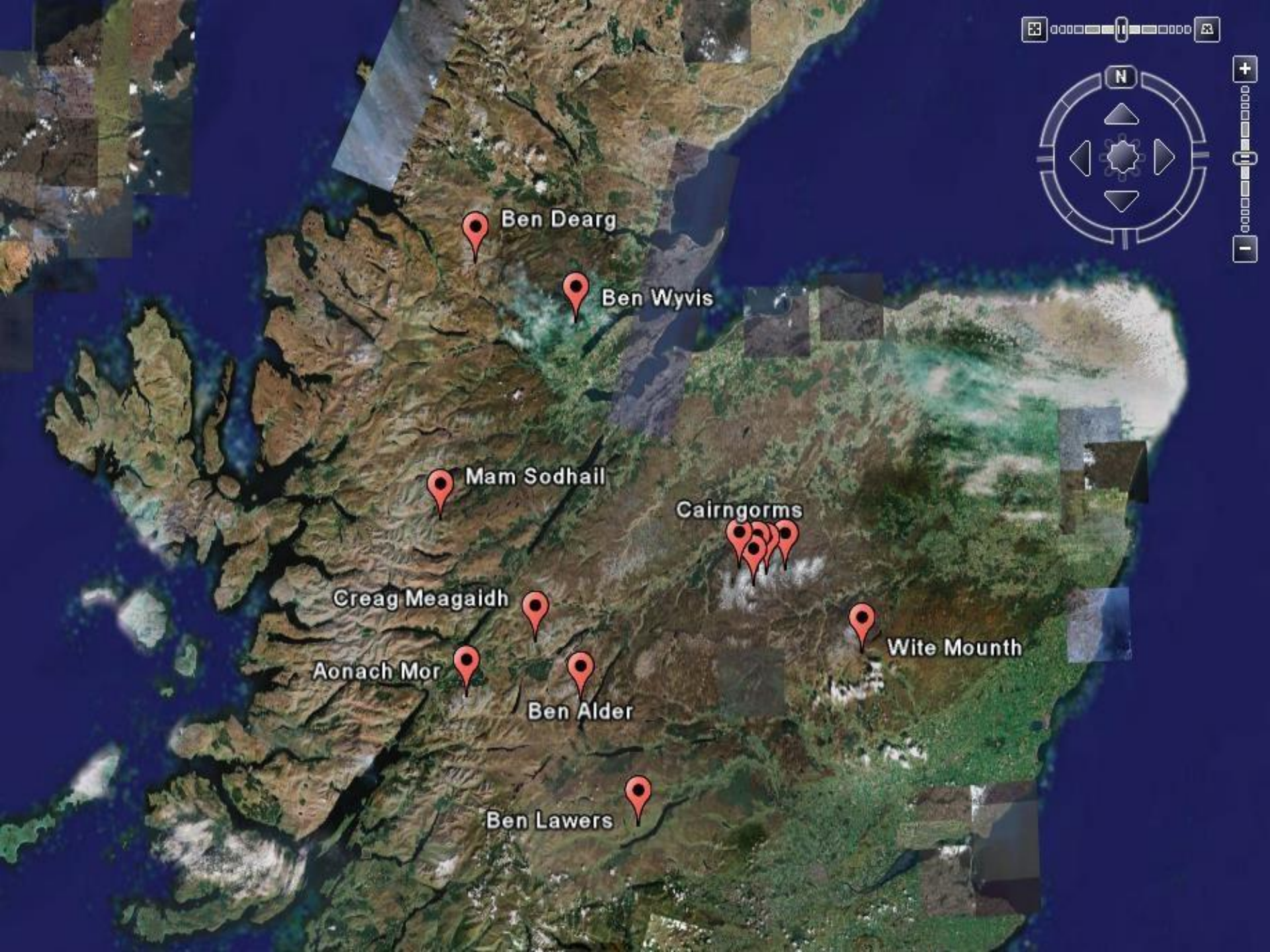
Ben Dearg
Ben Wyvis
Mam Sodhail
Cairngorms
Creag Meagaidh
Wite Mounth
Aonach Mor
Ben Alder
Ben Lawers

Species	Difference in frequency	p-value	Difference in $\bar{x}$ abundance	p-value
Oligotrichum hercynicum	25	0.001	1.80	0.003
Pohlia nutans	23	0.002	0.36	0.092
Ditrichum zonatum	18	0.004	0.71	<0.001
Juncus trifidus #	17	0.002	0.69	0.008
Kiaeria falcata	17	0.008	1.34	0.118
Saxifraga stellaris #	16	0.002	0.15	0.054
Racomitrium lanuginosum	15	0.016	0.29	0.092
Lophozia sudetica	11	0.111	1.30	0.036
Scapania uliginosa	10	0.006	0.74	0.016

Diplophyllum albicans
Pleurocladula albescens
Polytrichum alpinum
Huperzia selago #
Gnaphalium supinum #
Marsupella condensata -4 0.578 0.03 0.815
Pohlia ludwigii -5 0.425 0.33 0.619
Salix herbacea # -5 0.483 0.97 0.438
Marsupella stableri -7 0.147 0.10 0.497
Gymnomitrion concinnatum -8 0.055 -0.06 0.610

Marsupella sphacelata	-9	0.099	-0.11	0.762
Moerckia blyttii	-13	0.002	-2.40	0.020

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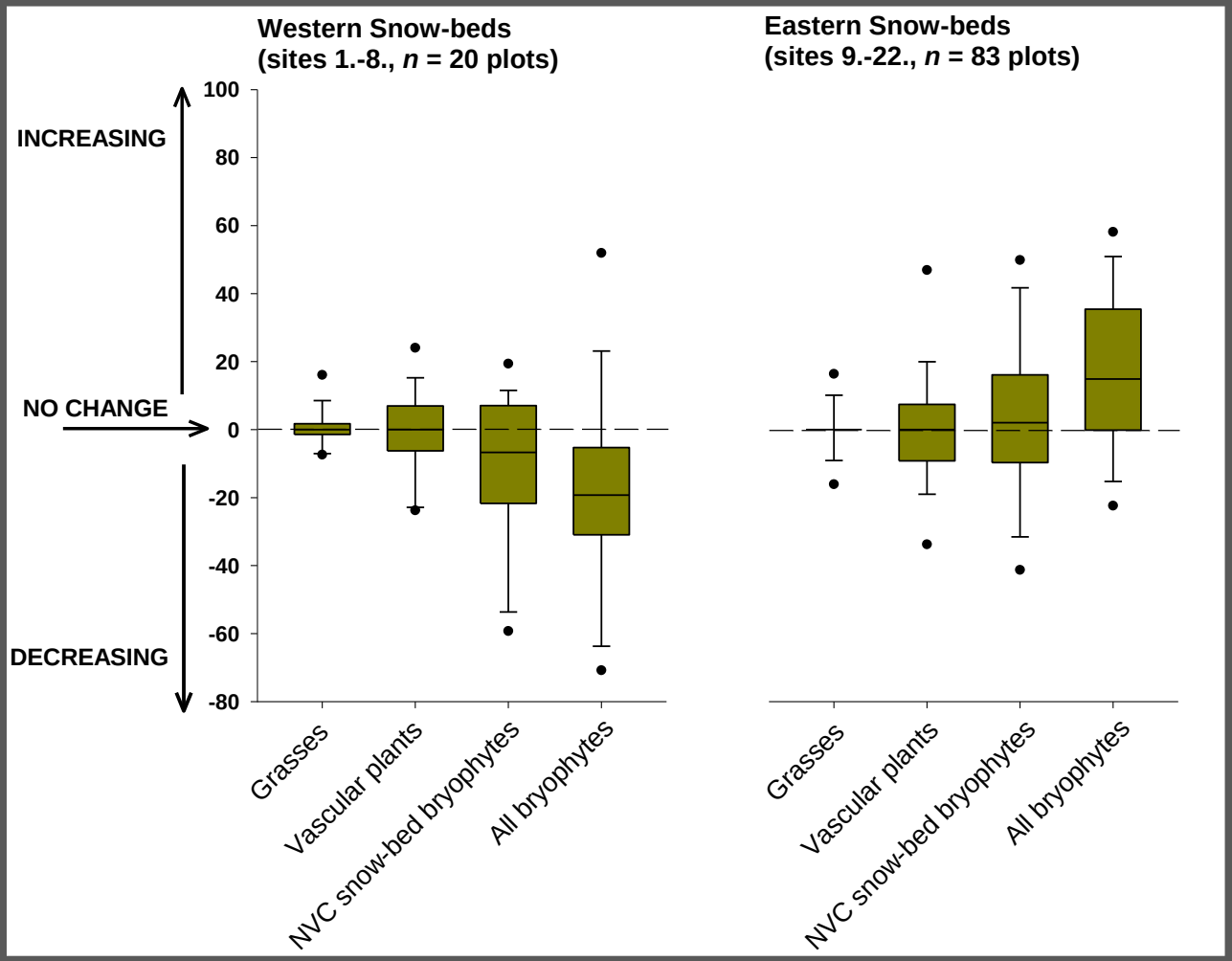

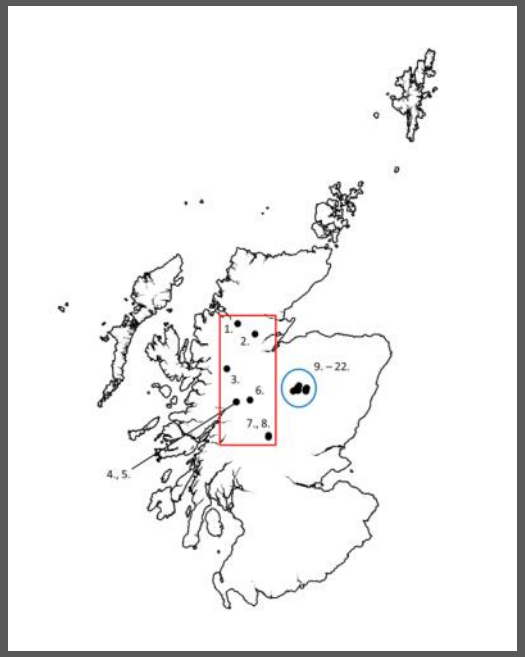

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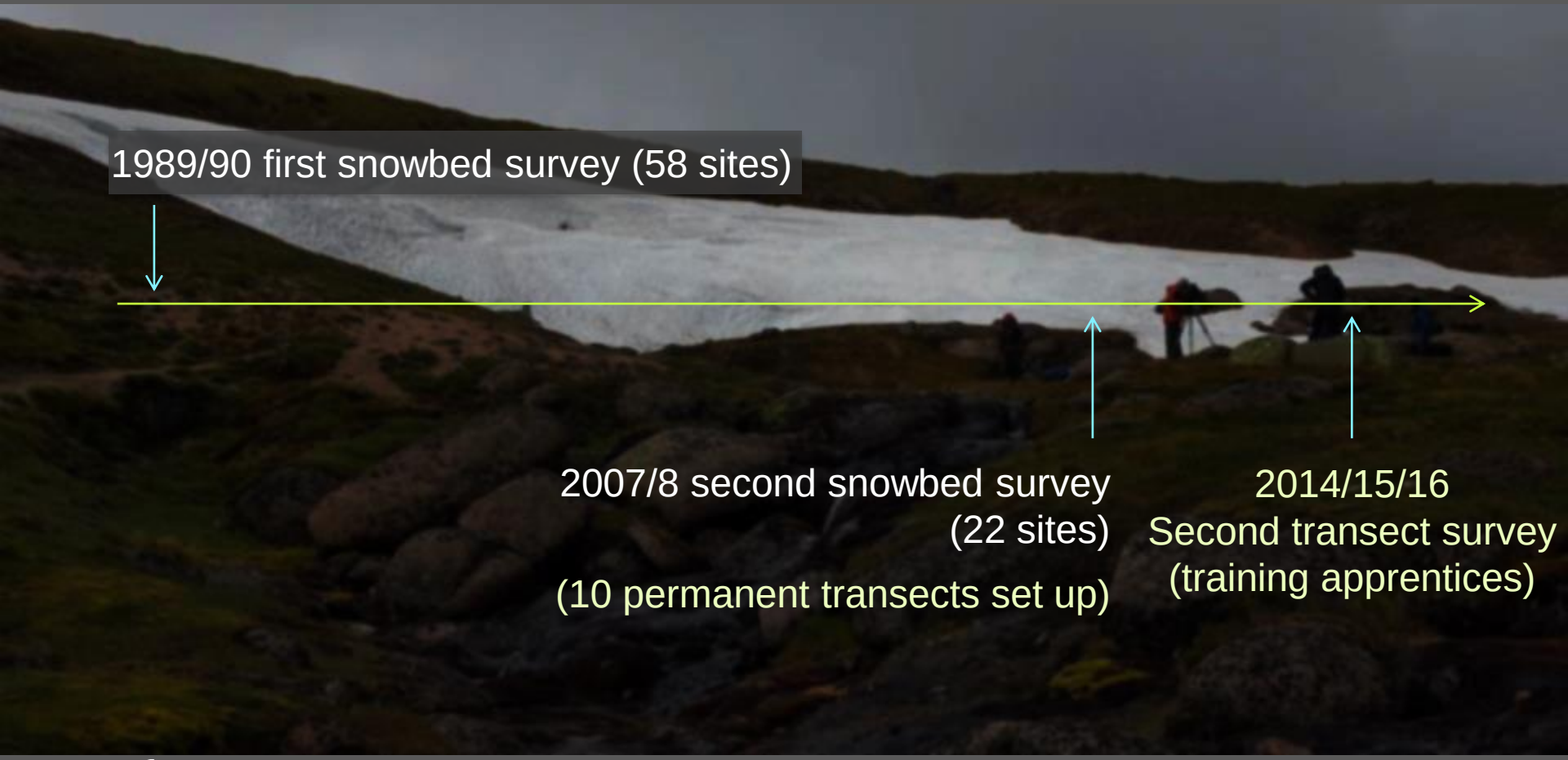
Scottish Snowbed Vegetation Monitoring Network



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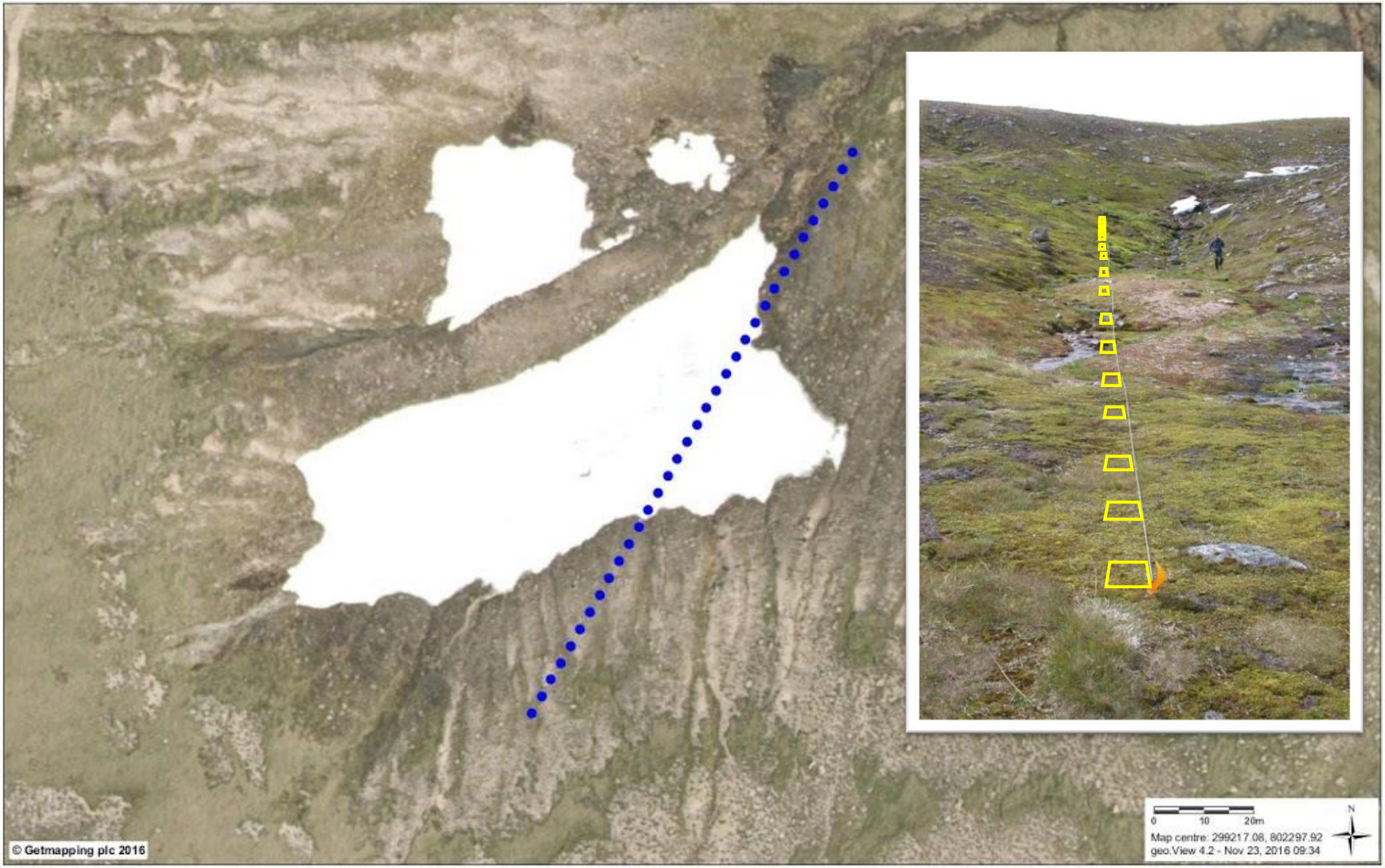
Transect 3 - Coire Domhain



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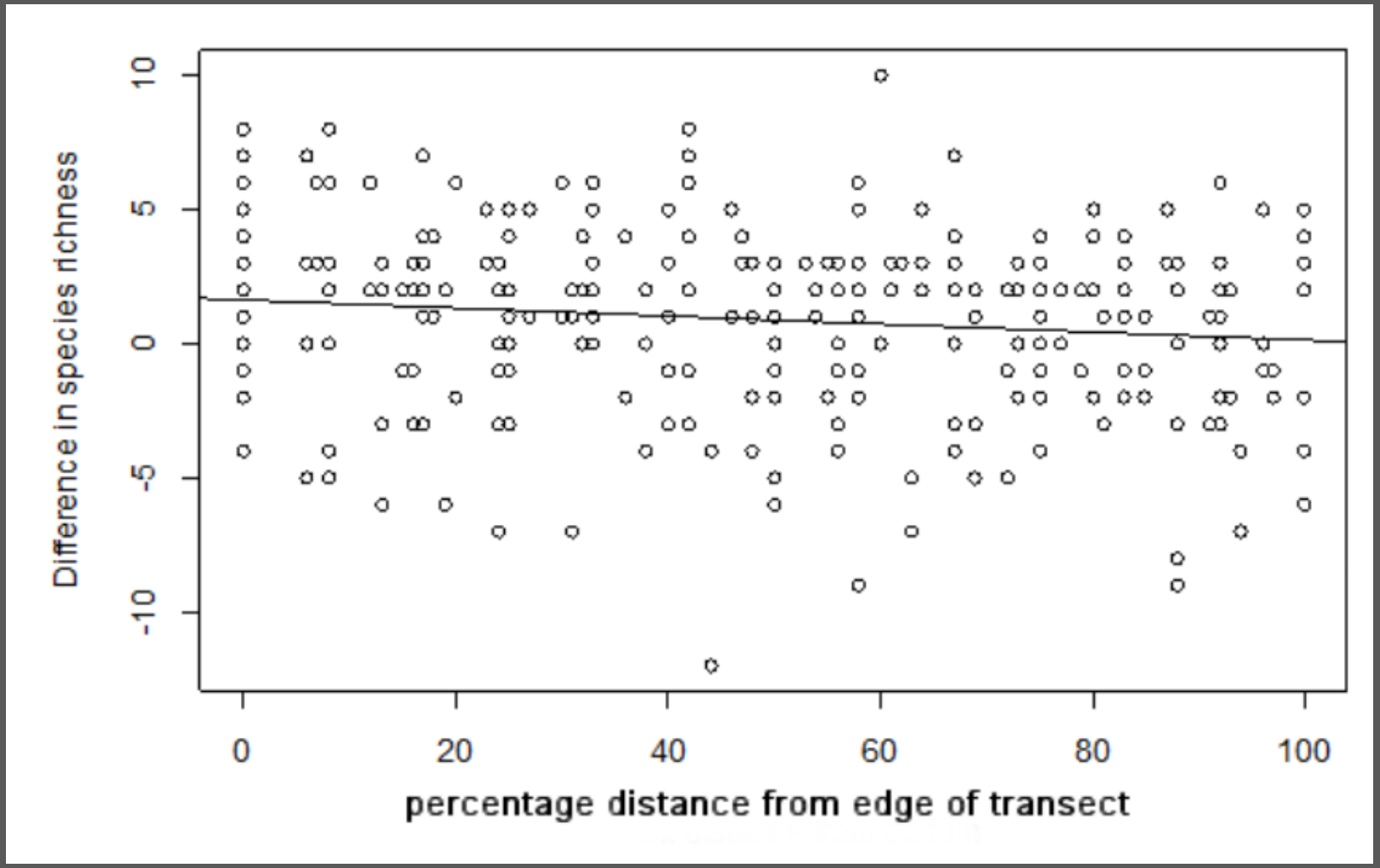

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Practical challenges

- Unpredictable weather
- Long-term funding
- Continuity of EXPERTS!

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Can we help species adapt to climate change?

Management options:

1. In-situ conservation
2. Allow/enable species range shifts
3. Active translocation

Increasing intervention and controversy

- Ethical debate
- Is it even possible, especially for mountain species?

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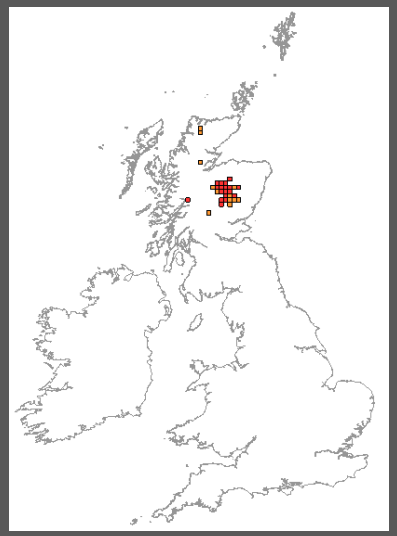
Can we predict where to put species now?

Flavocetraria nivalis

- Easily identified
- Distinct altitudinal distribution
- Arctic/alpine species– (relatively) limited biotic interactions



The approach

- Large-scale field survey and modelling of current distribution
- Translocations to an independent site within current range
- Test ability of the model to predict translocation success

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Field survey

Recorded:

- Vegetation composition
- Vegetation height
- Aspect, slope

Added from extrapolated climate data:

- Altitude
- Climate parameters (e.g. max/min T; precipitation)

Training model based on field survey data

Parameter	Field survey data
Intercept	*
Minimum temperature, February	*
Minimum temperature, July	*
Minimum temperature, February*Minimum temperature, July	NS
Aspect	***
Altitude	**
Vegetation height	†
% of total deviance explained	27.2%

Reasonable fit of model to field survey distribution (abiotic parameters are key)

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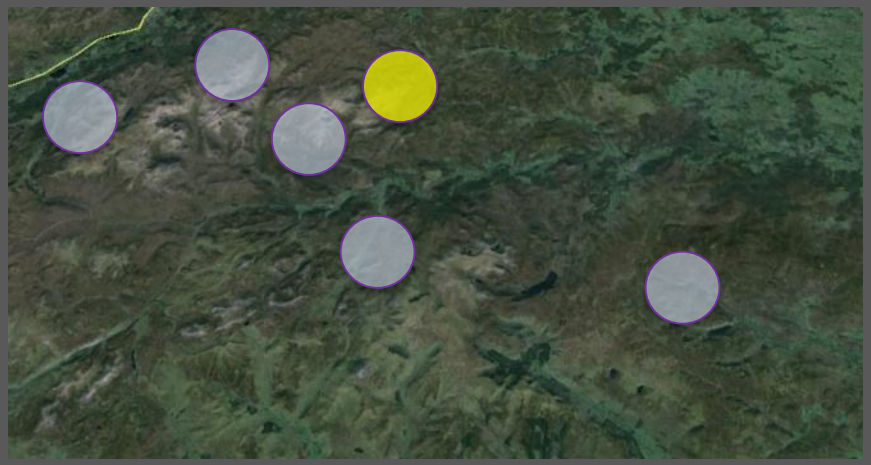
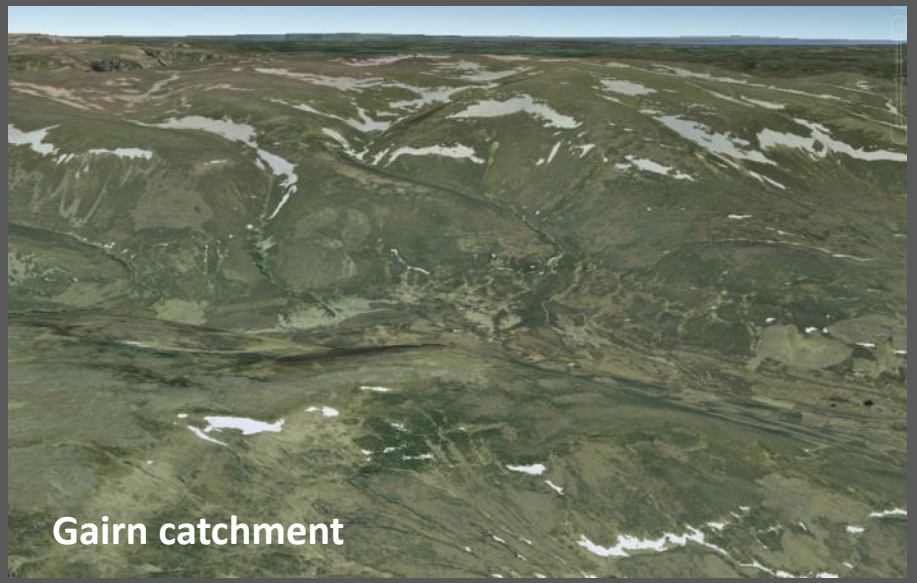
Translocation trials





- Placed out from 650 m to 1100 m in range of vegetation types . ‘Good’ and ‘bad’ locations
- Recorded same data as per wider survey + iButton loggers
- Recorded survival 2011 and 2015

Predicting transplant success

Parameter	2010-2011 interpolated
Alititude	0.008
Vegetation Height	0.005
Slope	NS
T Average 01/12	N.A.
T Average 04/12	N.A.
T Average 05/12	N.A.
T Average 06/12	N.A.
T Average 07/12	N.A.
% of total deviance explained	10.7%

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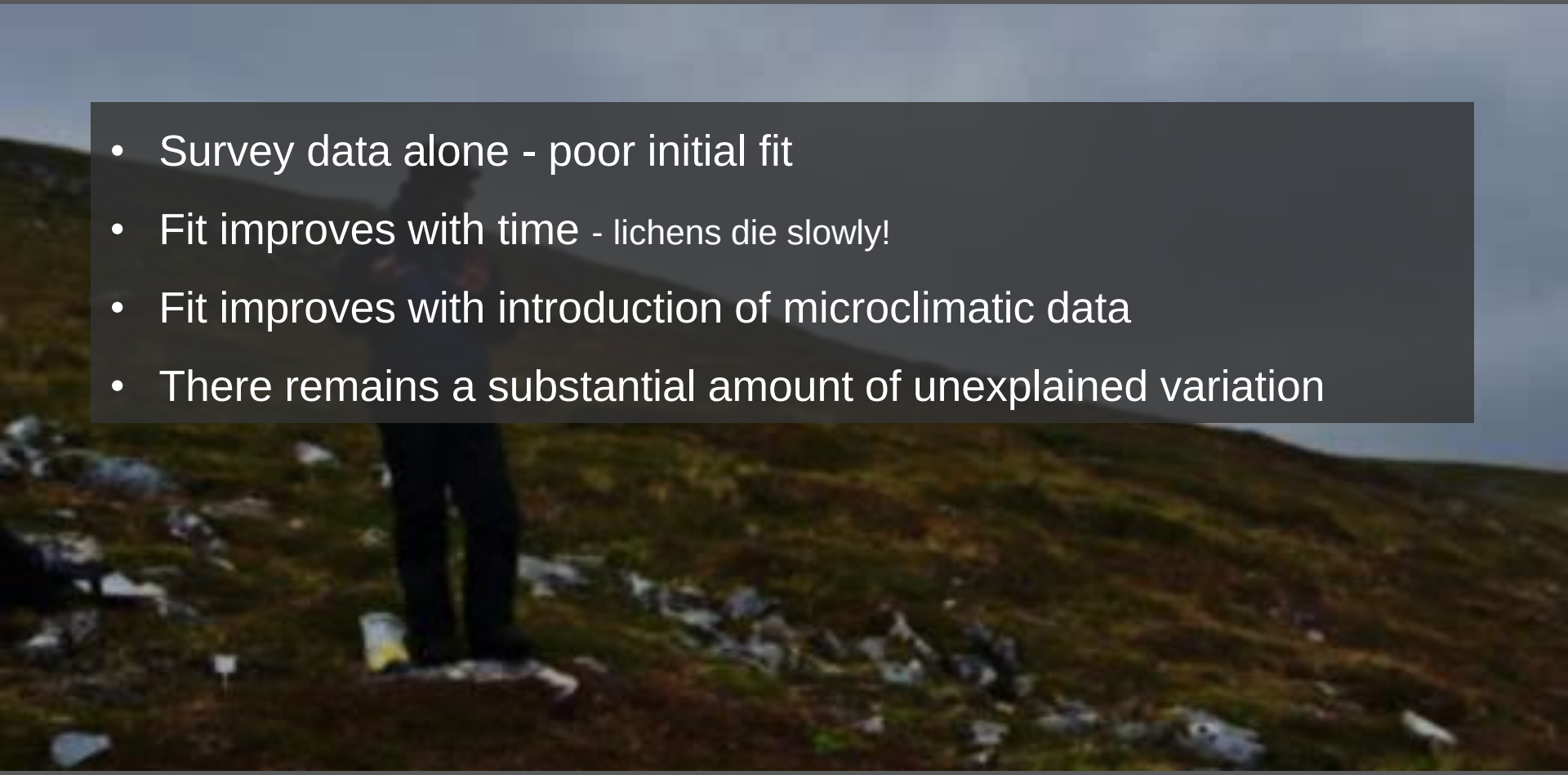
- Poor predictive power for first year survival of transplants
- Inclusion of microclimatic data did not improve model fit
- Model still poor after five years with interpolated climate
- Model greatly improved with microclimate data

Key results



- Survey data alone - poor initial fit
- Fit improves with time - lichens die slowly!
- Fit improves with introduction of microclimatic data
- There remains a substantial amount of unexplained variation

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Conclusions

The slow mortality of lichens emphasises the need for long-term monitoring when assessing the success of translocations.

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Conclusions

Location, location, location

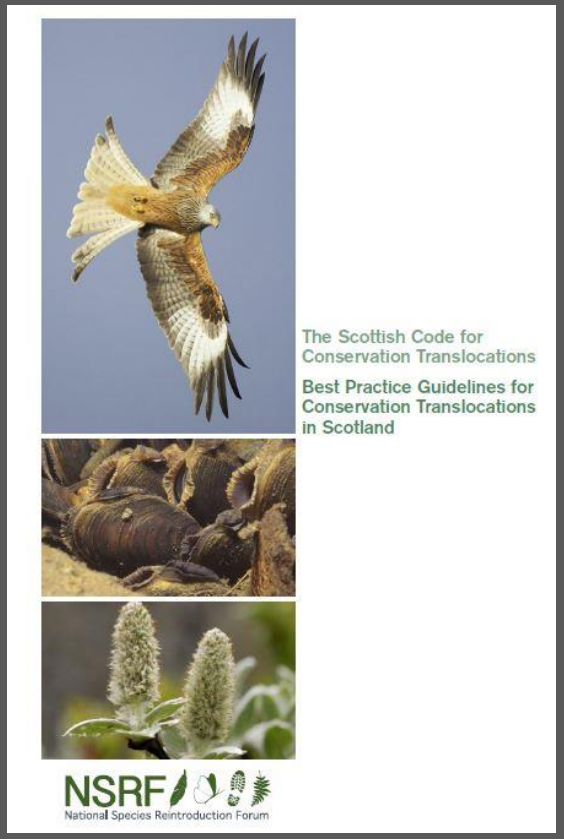
Micro-climate can be extremely important with a few centimetres perhaps making the difference between survival and death.

Options

Very detailed survey of a species' microclimate niche at recipient sites.
Very time-consuming and expensive.

Combine coarse-scale predictive models with expert-led judgement on the ground.
Another case for investing in specialist field-ecologists.

Accept a high-level of transplant mortality
The minimum number of transplants may be much higher than we currently expect – early intervention required.



Scottish Code for Conservation Translocations

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Thank you

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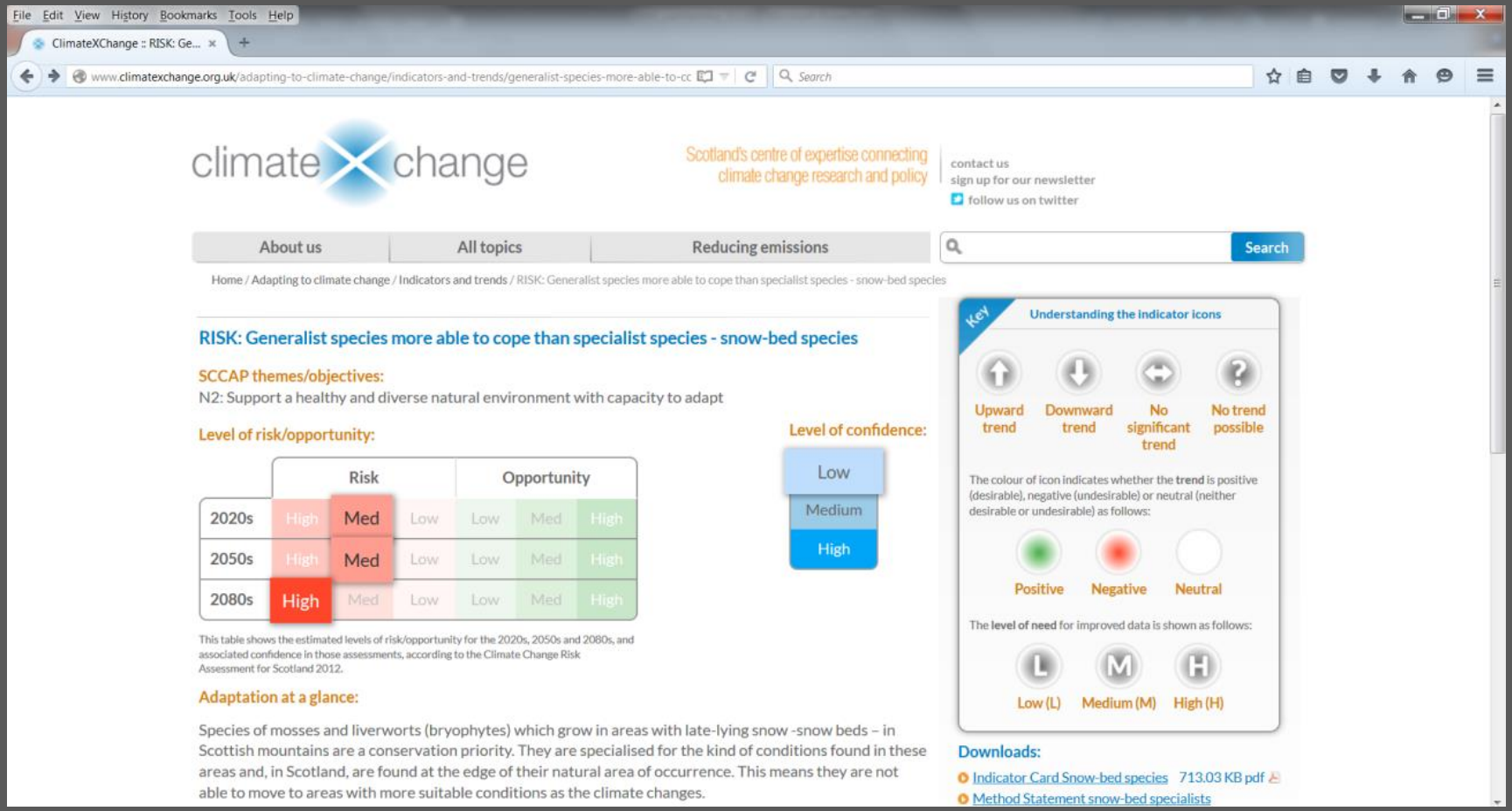
1989

N slope of Ben Macdui

2008

N slope of Ben Macdui



Ellis, C & Genney, D.R. **Climate change adaptation in Scotland Programme. Indicator Card** 2014 - Generalist species more able to cope with climate change than specialist species