What do we know about change in alpine systems and its drivers?

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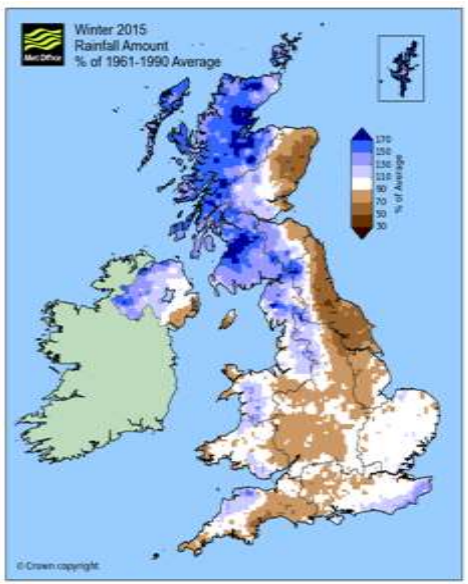
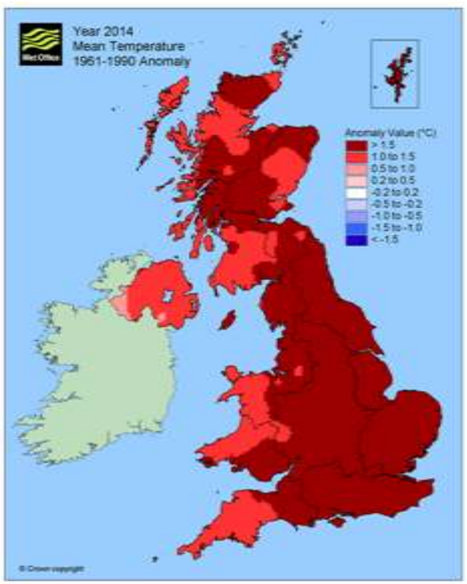
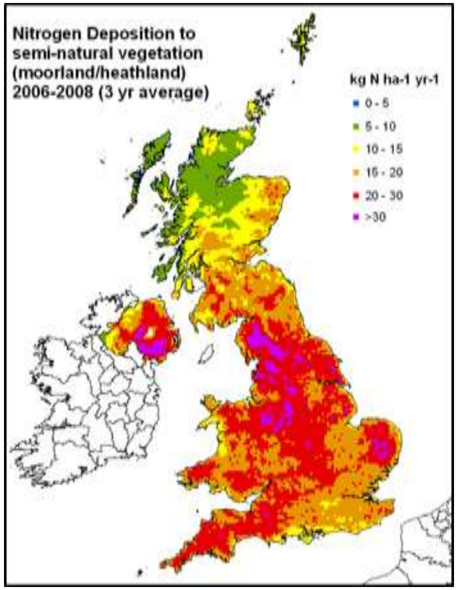
The James Hutton Institute

Drivers of change – large scale

- Climate change: increasing air temperature, increasing/decreasing rainfall, altered amount and seasonality of snowpack.
- Pollutant deposition: NHy, NOx and SOx. High rainfall and cloud cover result in high pollutant loads







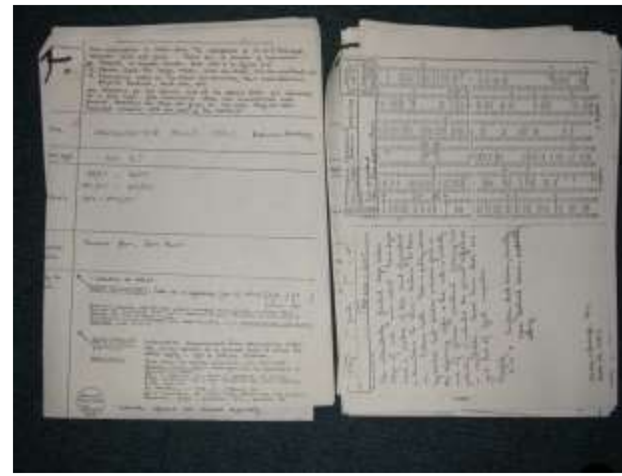
Drivers of change – local scale

- Grazing: wild herbivores and domestic stock
- Recreation: hillwalking, skiing, mountain bikes
- Development: hill tracks, energy generation
- Hunting: wildlife management, raptor persecution




What do we know about change in UK?

- **Assessment of change needs a baseline**
- 1940s & 50s: early studies of vegetation-environment relationships in Cairngorms
- 1950s – 70s: description & classification of plant communities
  - Poore & McVean
  - McVean and Ratcliffe
  - Birse and Robertson
- Current: patchy distribution of mapping data, often confined to protected areas



‘Resurvey’ studies

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- Use relevees collected 1950s-1970s as baseline for measuring change
- Grid references and descriptions allow plots to be relocated and resurveyed
- Two main Scottish studies:
  - Birse and Robertson - 205 alpine plots across Scotland, mainly 1970s, resurveyed 2004-6
  - McVean and Ratcliffe - 46 alpine heaths in northwest Scotland, 1956-8, resurveyed 2007-8

Results: composition change

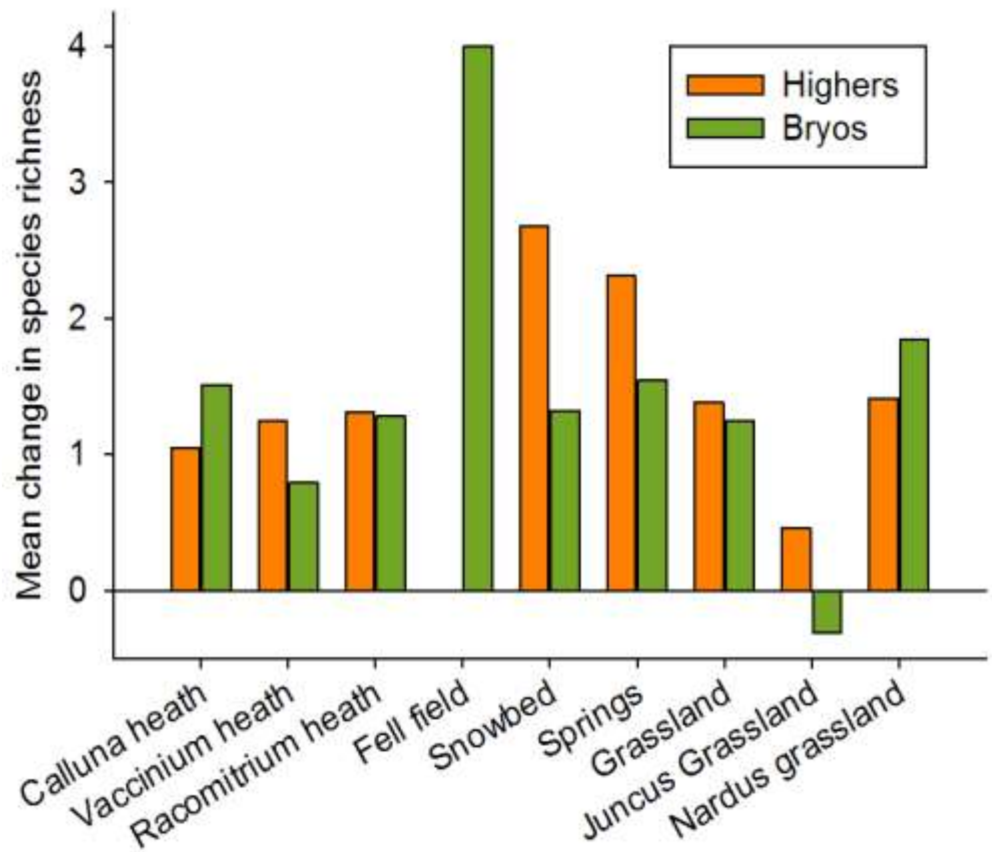
- Homogenisation: previously distinct communities become more similar
- Increased richness - Birse & Robertson
- Decreased richness - McVean & Ratcliffe
- Increasing species: upland generalists
- Decreasing species: arctic-alpine specialists






Results: composition change

- Changes are region/habitat specific
  - *Calluna vulgaris* cover declined in northwest but increased in eastern Scotland
  - Richness change pattern differs for higher plants and bryophytes
  - Higher plant richness increase in snowbeds and springs
  - Bryophyte richness increased most in fell field



Results: linking change to drivers

	Alpine heaths	Alpine summits	Snowbeds
Shannon diversity	↑ S; ↓ N	↓ S; ↓ N	↓ N
Graminoid cover	↑ N	↑ N; ↑ Temp	↑ N
Forb cover		↑ S; ↓ N	
Bryophyte cover	↑ S; ↓ N	↓ N	↑ Temp
Total sp. richness	↓ N	↓ S; ↓ N	↓ N
Graminoid richness		↑ Rain	
Forb richness	↓ Rain		↓ Sheep
Bryophyte richness	↓ N; ↑ Rain	↓ N	↓ N

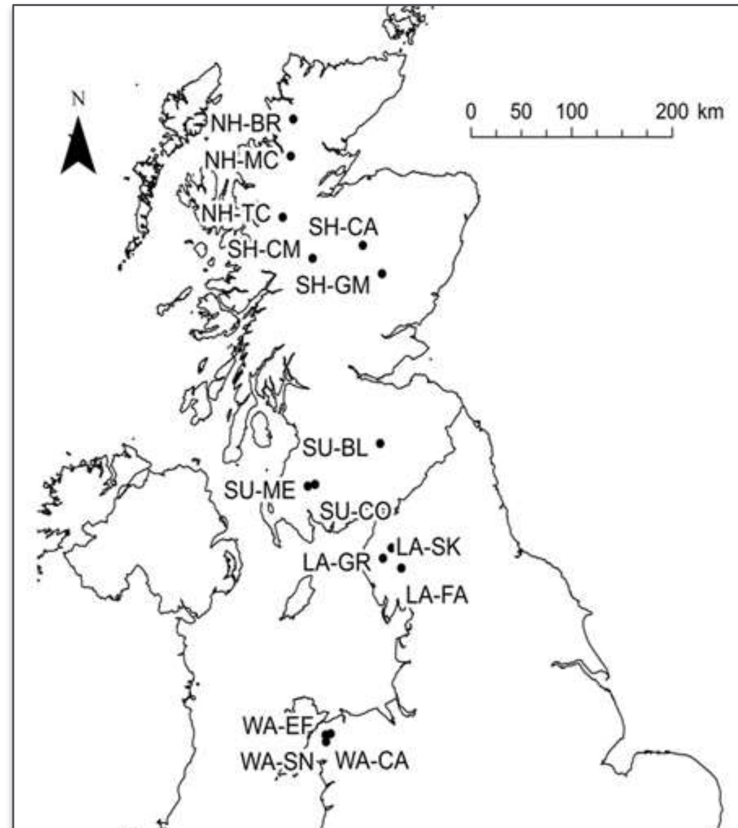
- Change in vegetation metrics tested against change in pollution (N & S), temperature, rainfall, sheep grazing

Summary

- Resurvey studies give us clear evidence of change in Scottish alpine vegetation over 30-50 year period
- Changes can be linked to pollution deposition, but also to climate and grazing
- Limitations: only vegetation composition –
  - Other species groups?
  - Ecosystem function and services?

Case study: *Racomitrium* heath

- Probably most studied alpine habitat
- Dominated by *Racomitrium lanuginosum* - both living moss and decomposing shoots
- Declined in areas with high N deposition – how & why?



Vegetation composition

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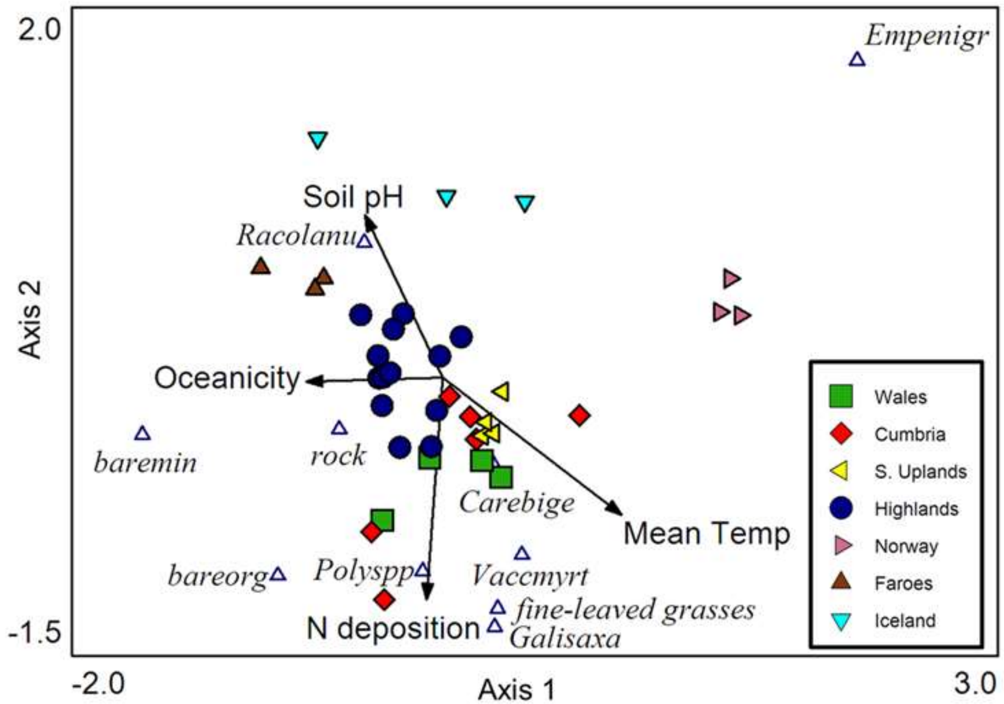
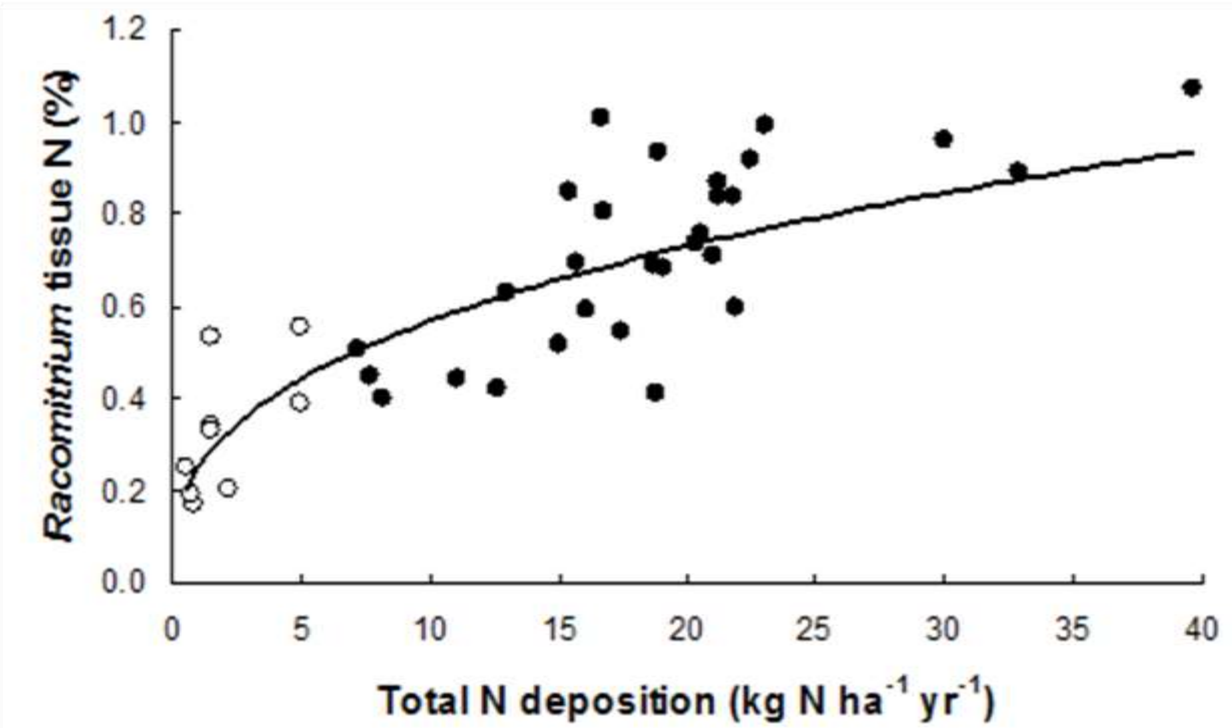


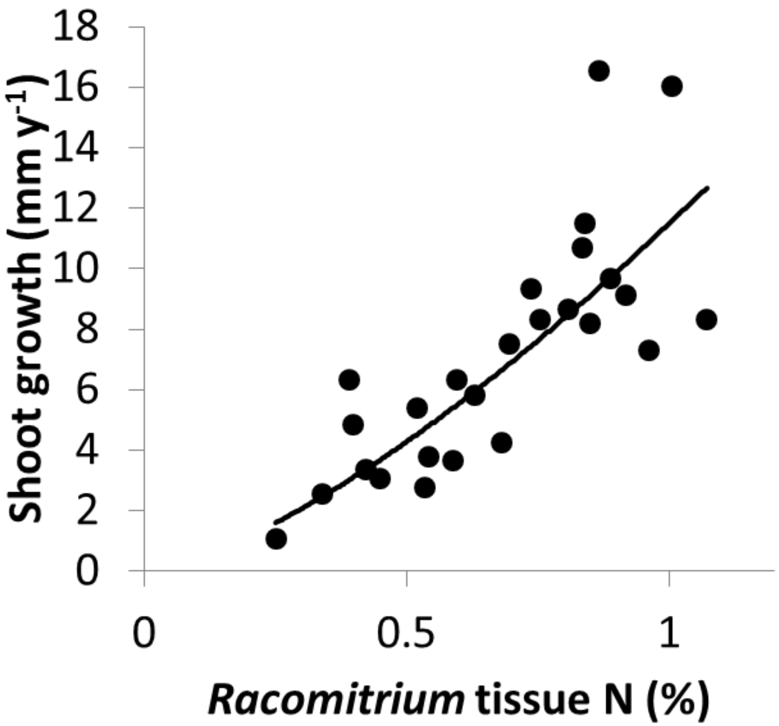
- Climate and N deposition main drivers of current vegetation composition

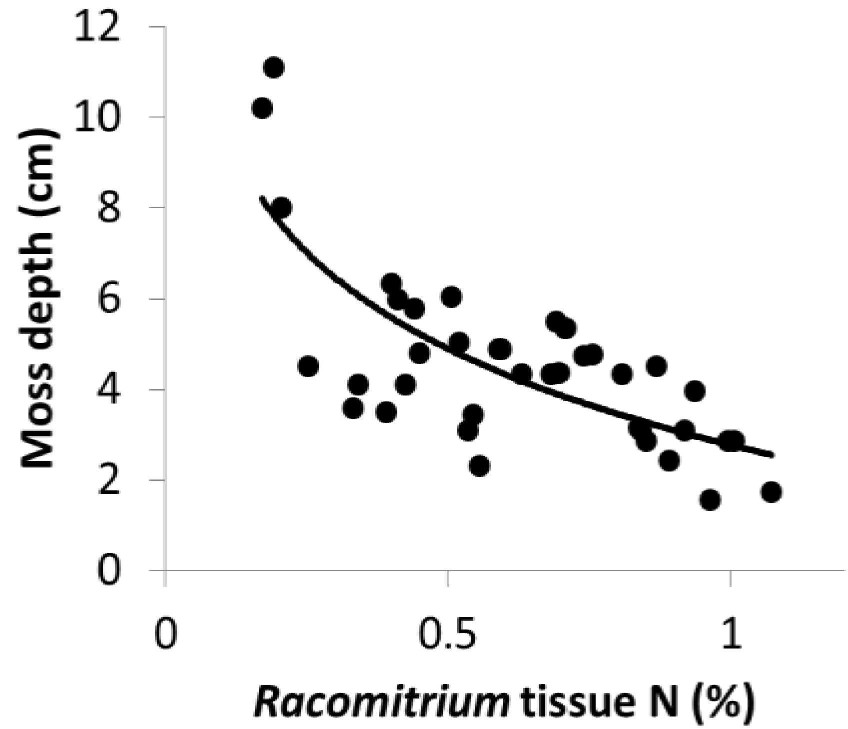
Impact of N on *Racomitrium*



- *Racomitrium* absorbs nutrients from rainfall
- Adapted to low nutrient conditions
- Efficient uptake → tissue N content increases with N load

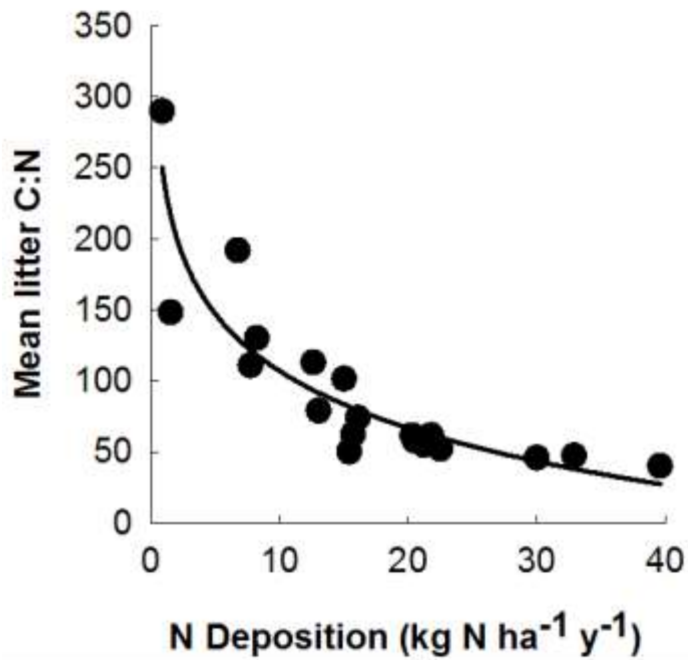
Impact of N on *Racomitrium*

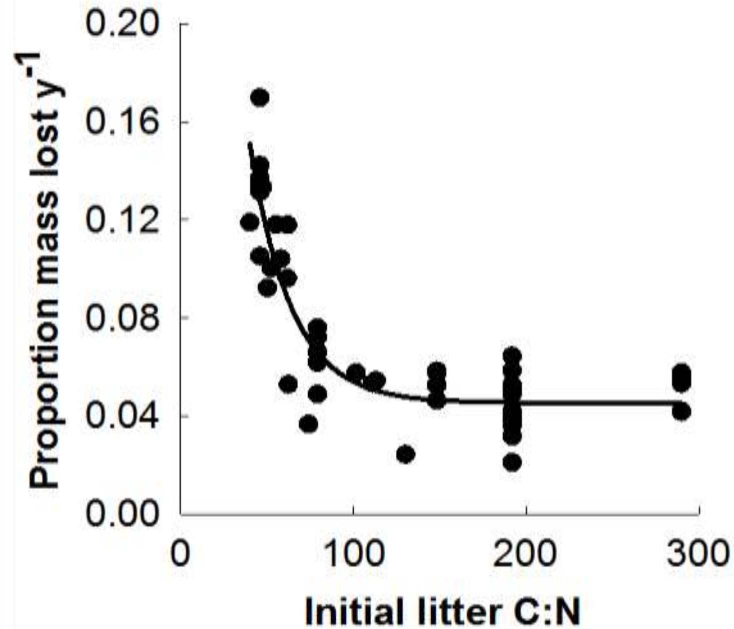




- Shoot growth increases with N deposition
- **BUT** moss carpet depth declines

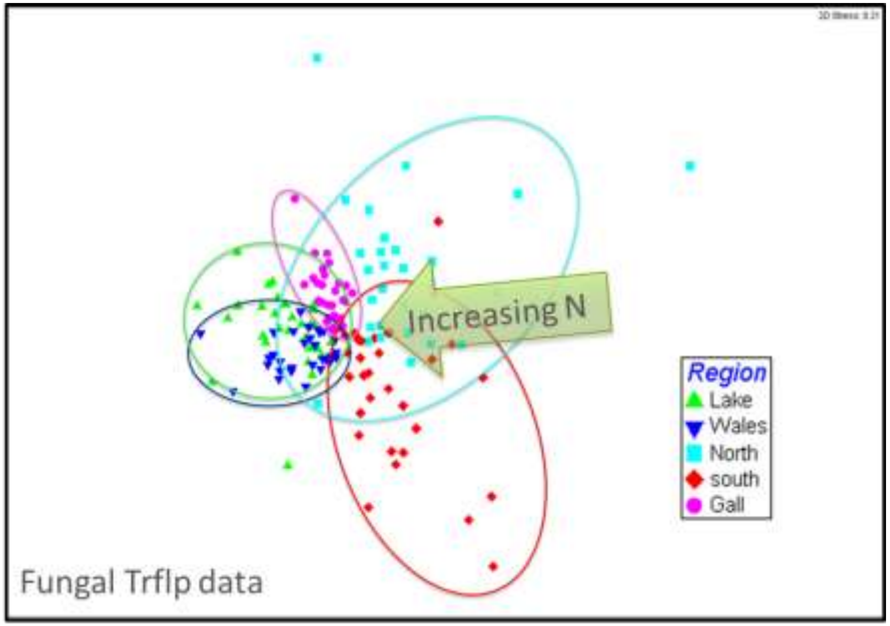
Decomposition





- Litter quality increases with N deposition (C:N declines)
- Reduction below C:N=100 → rapid increase in mass loss
- N deposition significantly impacts decomposition via altered litter C:N

Fungal community

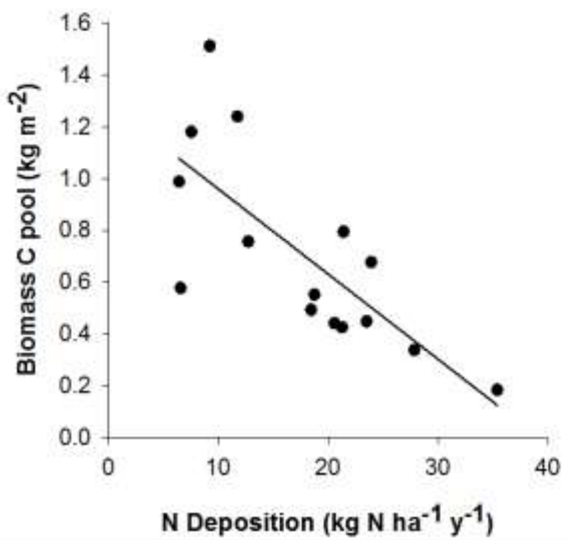


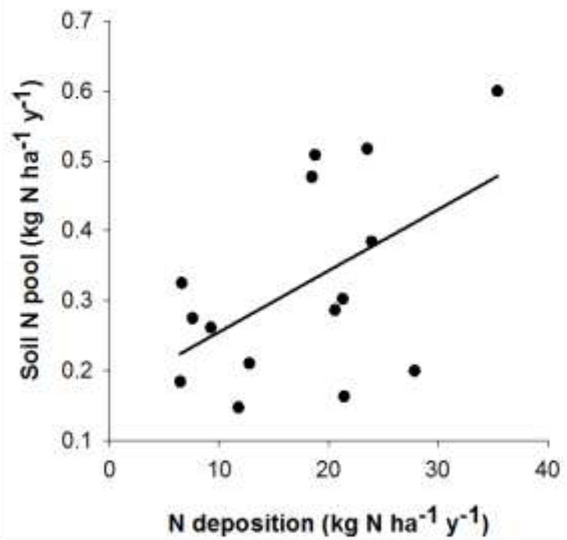
- Fungal community within moss carpet is highly diverse: average 36 species in 3 moss shoots (using TRFLP)
- Community composition reflects observed vegetation change
- Homogenisation with high N deposition

Microarthropod community

- Microarthropod density increases as moss depth and cover decline
- Collembolla:mite ratio increases → indicative of more rapid decomposition
- Microarthropod community composition responds to fine scale variation in moss mat condition and vegetation species composition

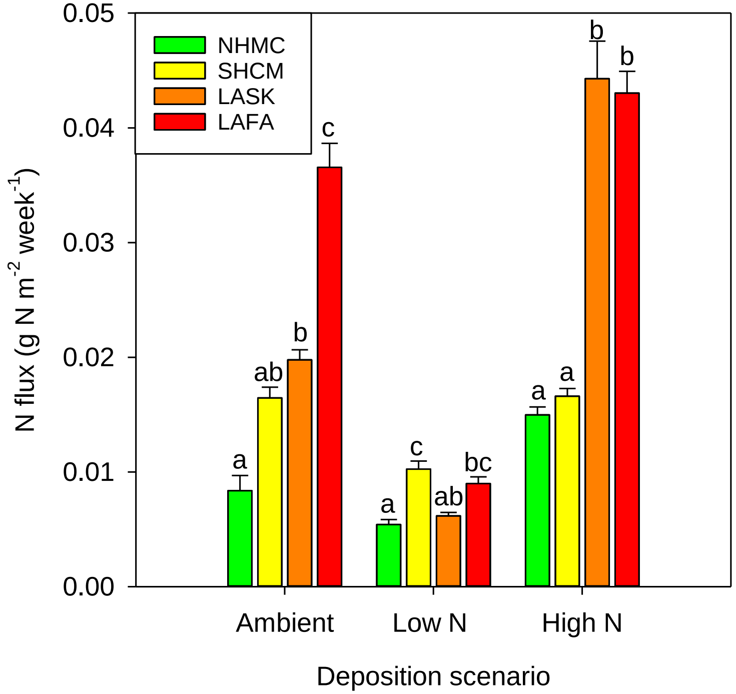
Biogeochemistry – nutrient stocks





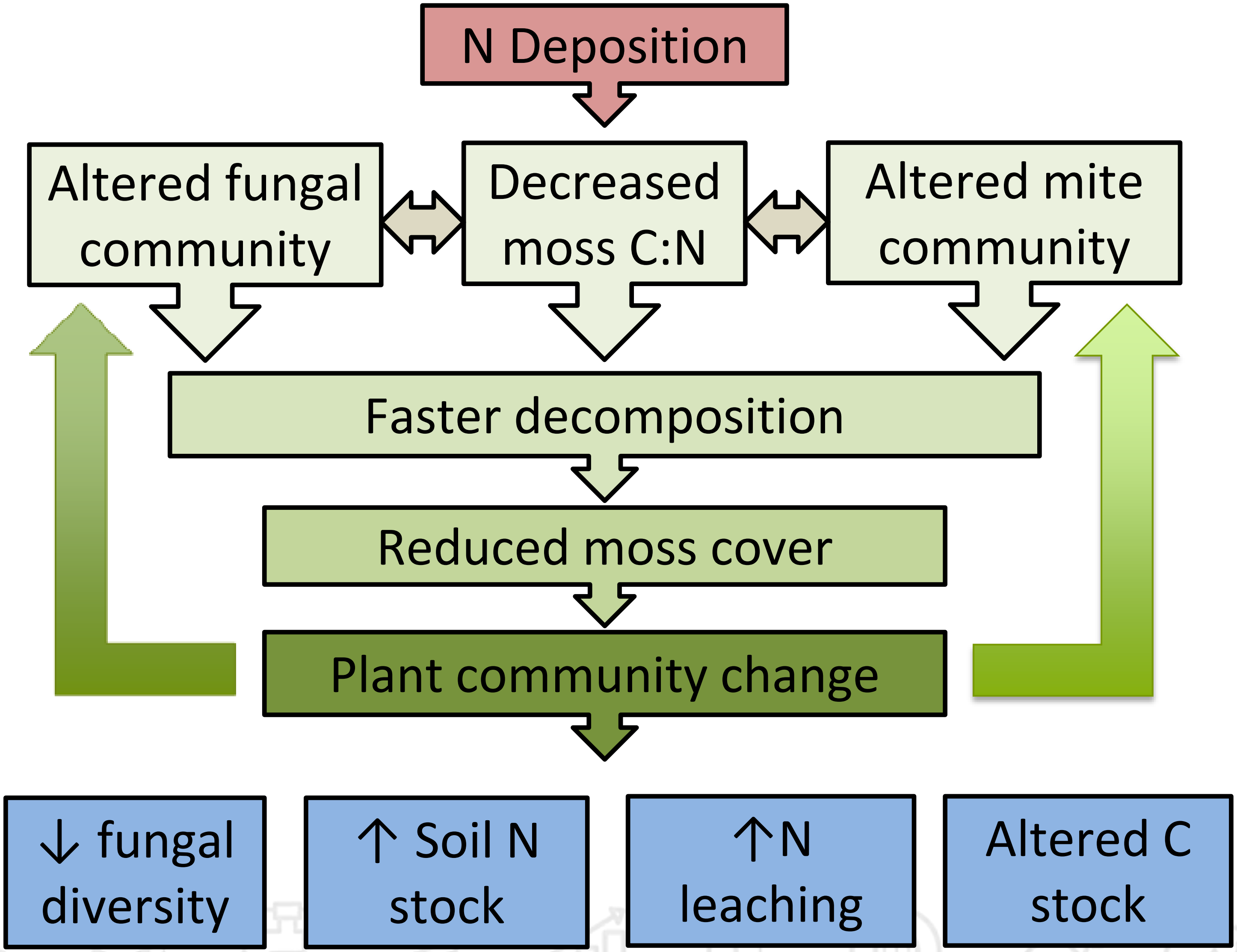
- Reduced C stocks above ground but no change to total
- Increased N stock below ground and total

Biogeochemistry – water quality



- Leaching of N increases with increasing N deposition
- Vegetation & soils from sites with high N deposition have reduced capacity to retain deposited N

Summary


N Deposition
Altered fungal community
Decreased moss C:N
Altered mite community
Faster decomposition
Reduced moss cover
Plant community change
↓ fungal diversity
↑ Soil N stock
↑N leaching
Altered C stock

Conclusions

- Alpine plant communities in Scotland have changed over last 30-50 years
- Vegetation change can be linked to drivers – pollution, climate & grazing
- Habitats and locations for which we can explore change limited by available baseline data
- Limited (or no) data availability for most organism groups
- Changes in vegetation composition indicative of changes in wider biodiversity and ecosystem function
- Changes in ecosystem structure and function have consequences for ecosystem services supply
- Modern molecular methods are opening up new avenues in exploring biodiversity and ecosystem function

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Further reading:

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