The role of grazing in the ecology of the uplands

Robin Pakeman

The James Hutton Institute

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Introduction

- Background
- How grazing influences the uplands – experimental studies on grazing
- Using knowledge to establish management strategies – NE Upland Evidence review, a personal experience
- Some reflections about grazing management

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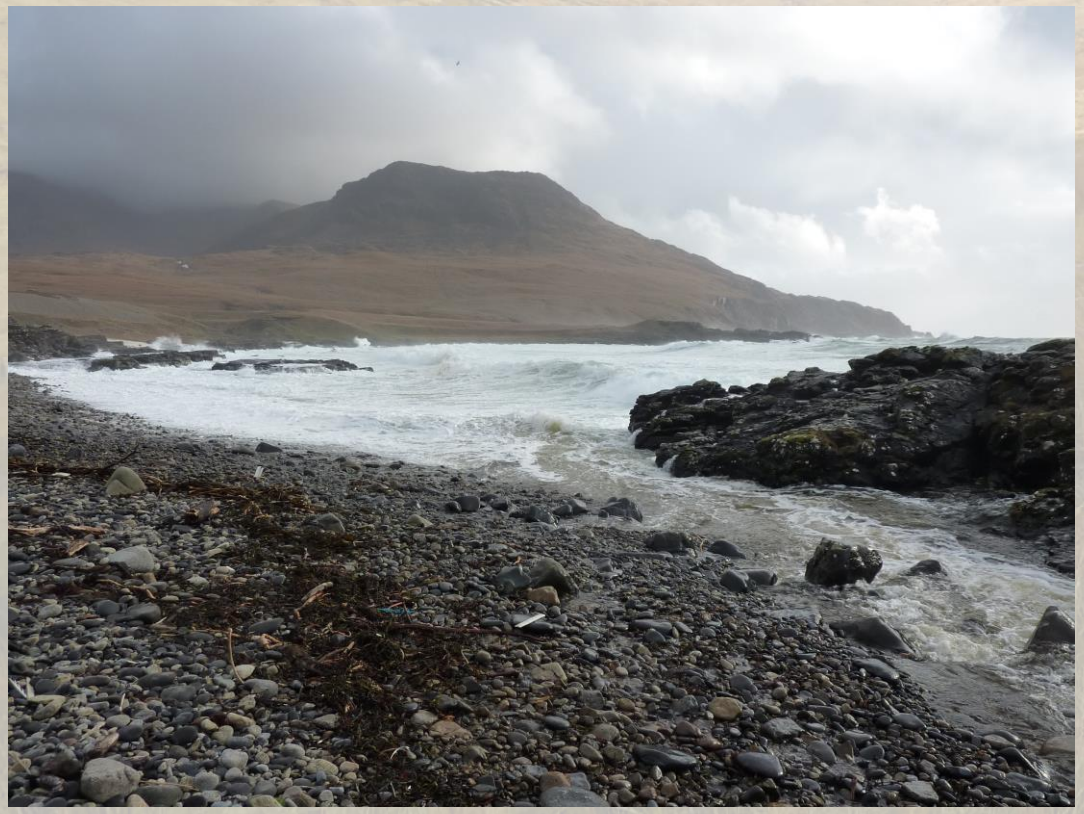
The Uplands

- Many, many definitions



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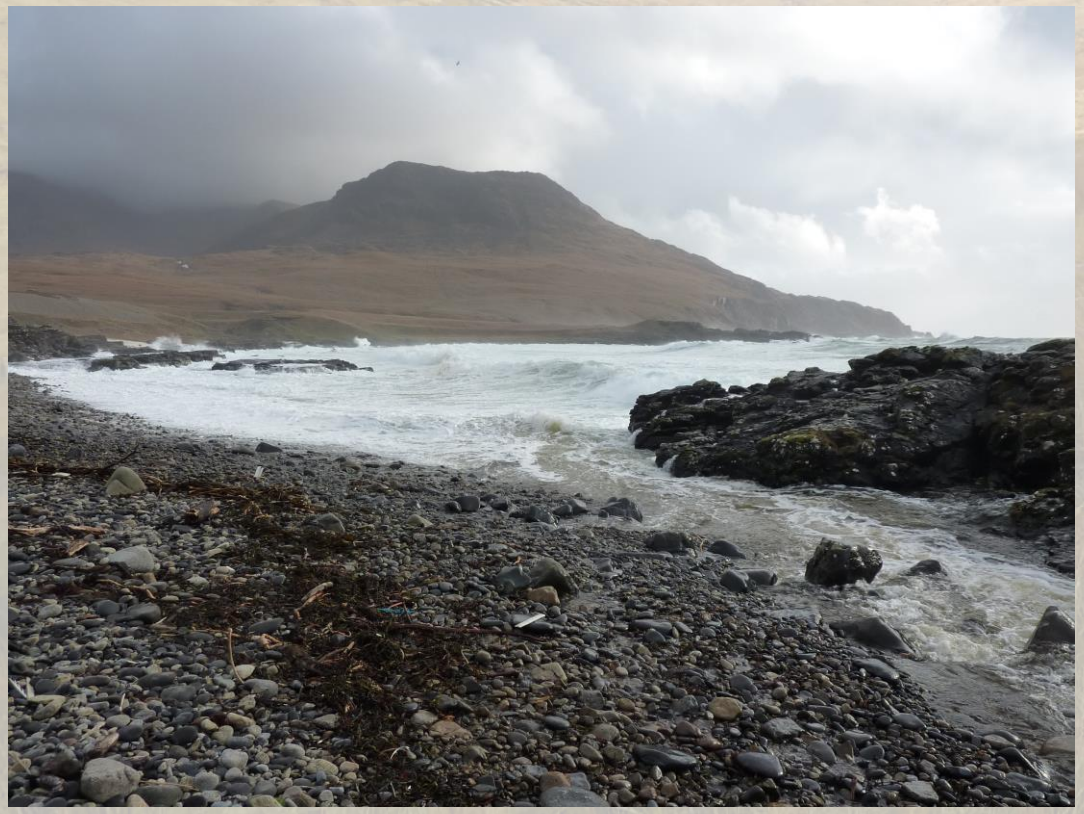
The Uplands

- Many, many definitions
- But we know it when we see it



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The Uplands

- If you can't grow crops then economic return has to come from:
  - Fuel

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The Uplands

- If you can't grow crops then economic return has to come from:
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The Uplands

- If you can't grow crops then economic return has to come from:
  - Fuel
  - Food
  - (Fibre)

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The Uplands

- If you can't grow crops then economic return has to come from:
  - Fuel
  - Food
  - (Fibre)
  - Fun

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The Uplands

- Dominant factors affecting them
  - Climate
  - Geology
  - Grazing or not (woodlands v. grassland/moorland)

- Questions to address in this talk
  - How does grazing affect biodiversity
  - How does grazing impact ecosystem carbon
  - How should we graze the uplands?

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Understanding the impacts of grazing

- Often information based on grazing exclosures

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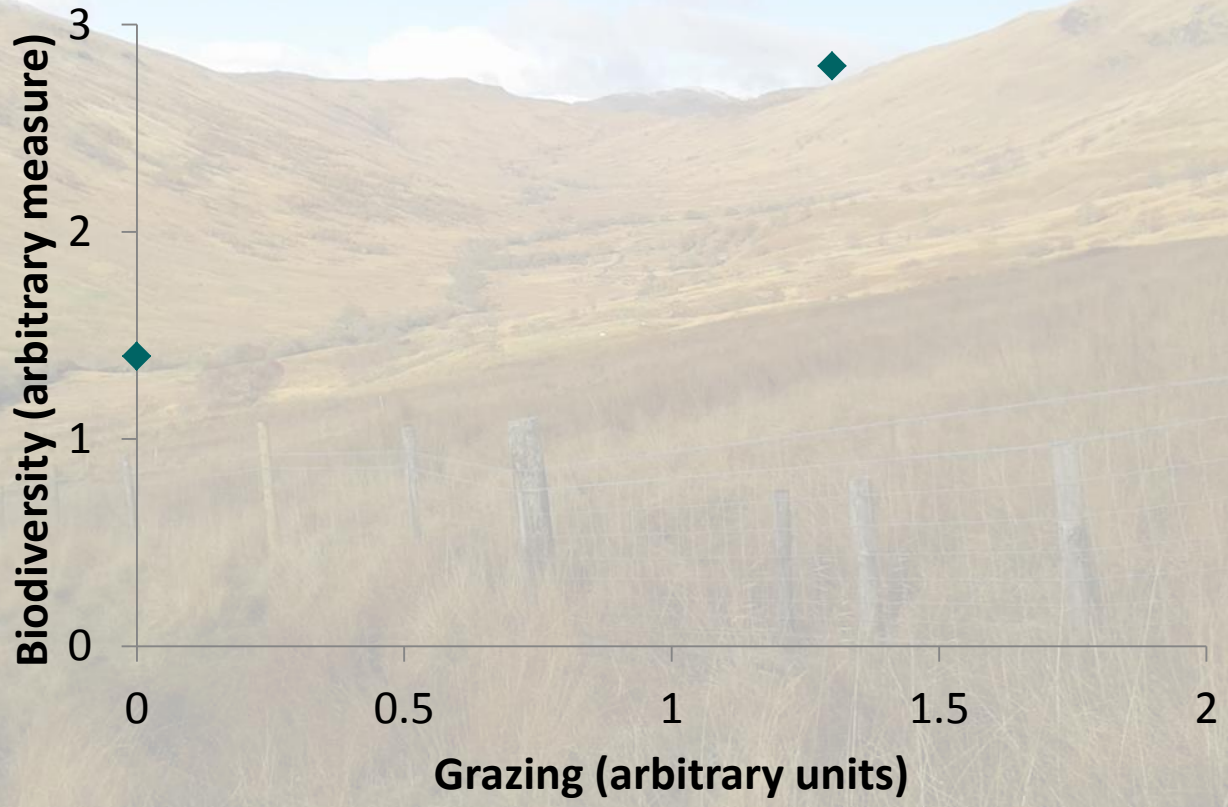

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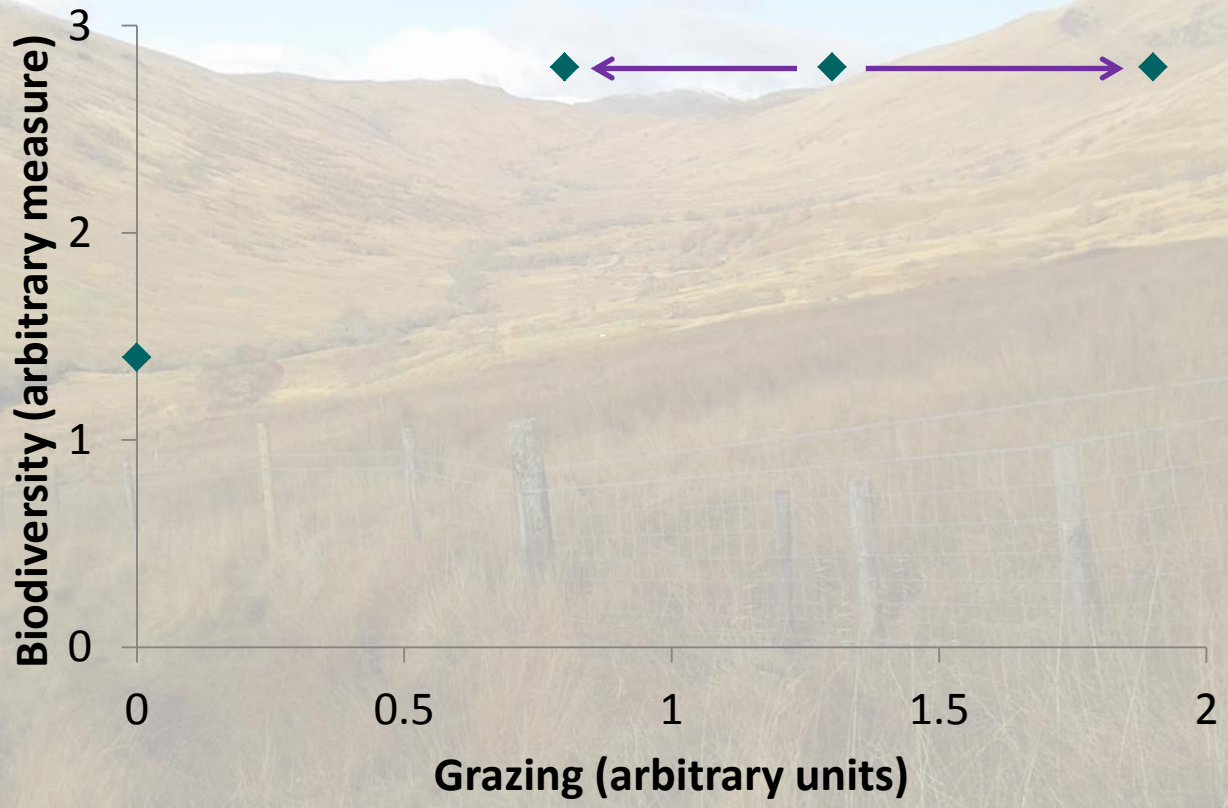
Understanding the impacts of grazing

- Often information based on grazing exclosures
  - We usually don't know the level of grazing outside



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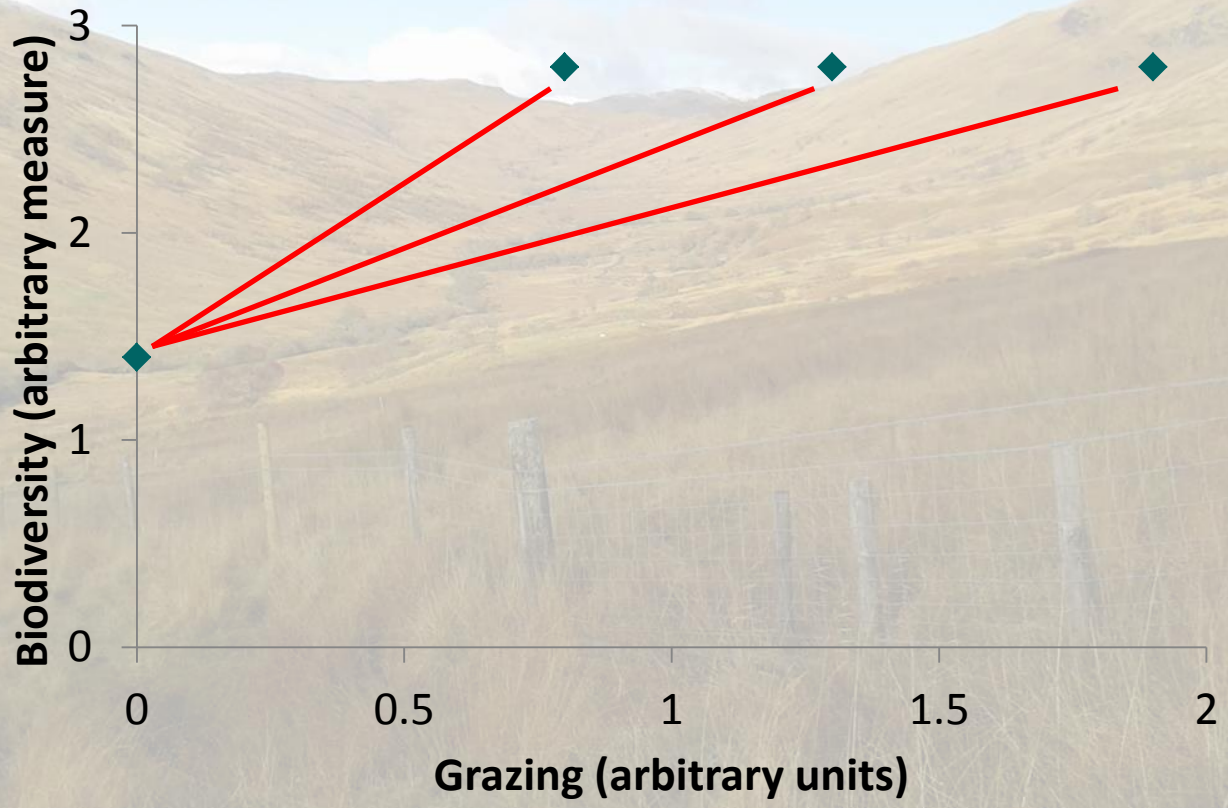
Understanding the impacts of grazing

- Often information based on grazing exclosures
  - Affects the slope of any relationship



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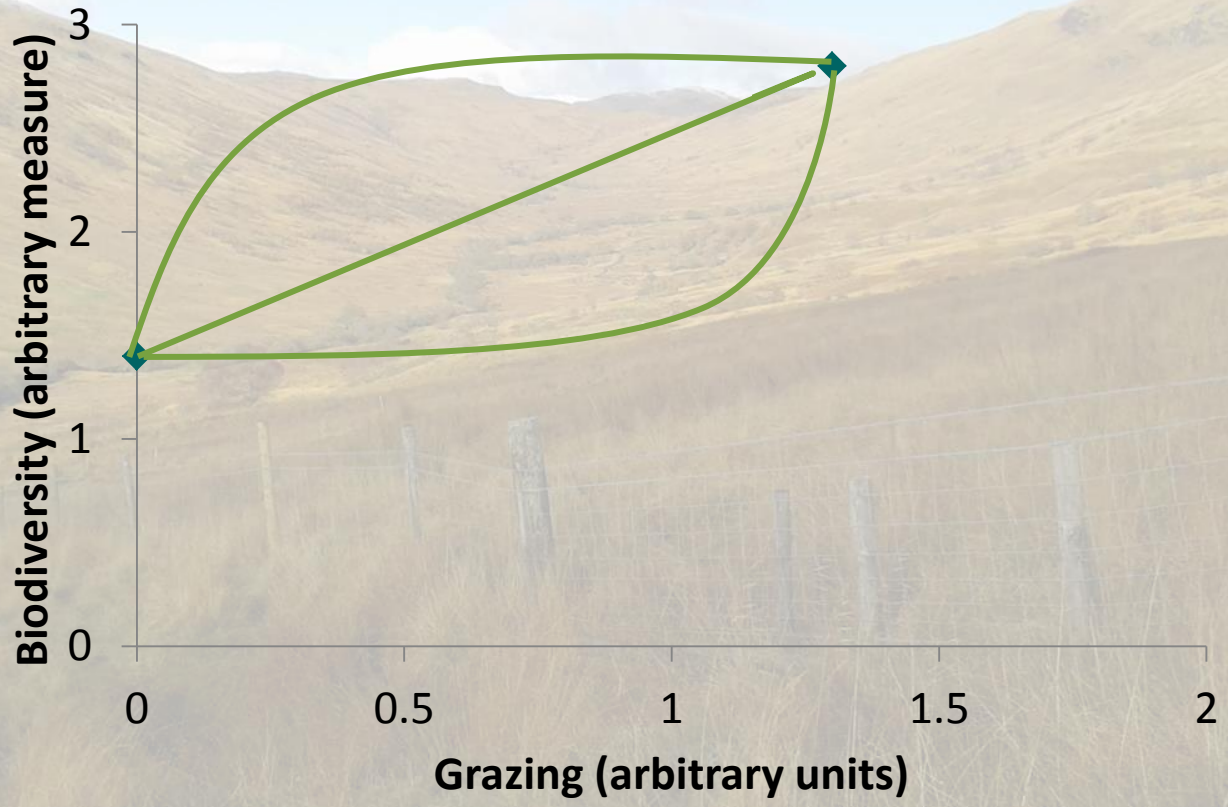
Understanding the impacts of grazing

- Often information based on grazing exclosures
  - Don’t know the shape of the relationship



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Understanding the impacts of grazing

- Often information based on grazing exclosures
  - Don’t know the slope of any relationship
  - Don’t know the shape of the relationship
  - But sometimes the only information

- Therefore need experimental approaches to understand how grazing impacts on ecosystems

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A long history of grazing experiments

- Hill Farming Research Organisation and the Macaulay Land Use Research Institute

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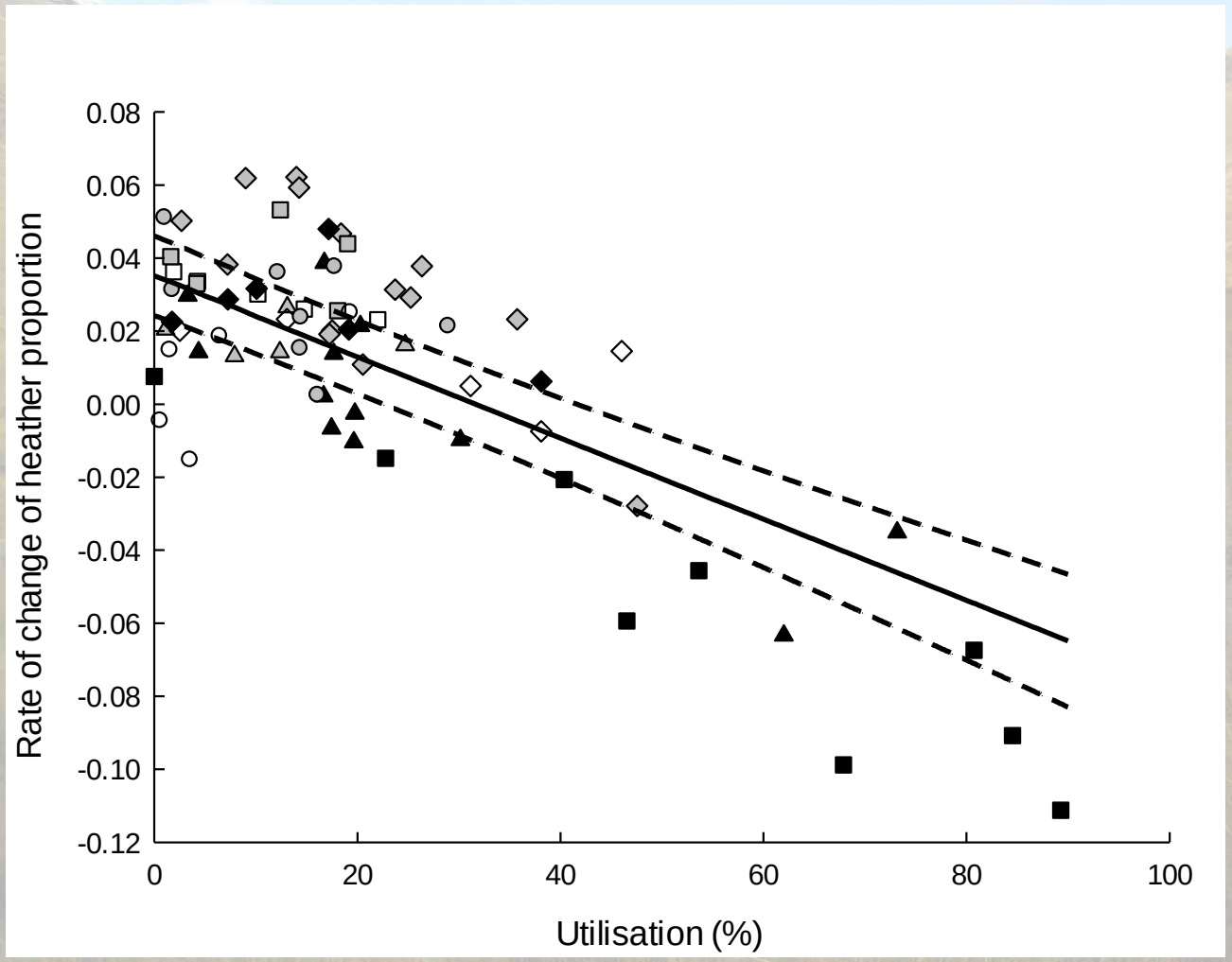
A long history of grazing experiments

- Results from ten experiments on grazing heather moorland



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A long history of grazing experiments

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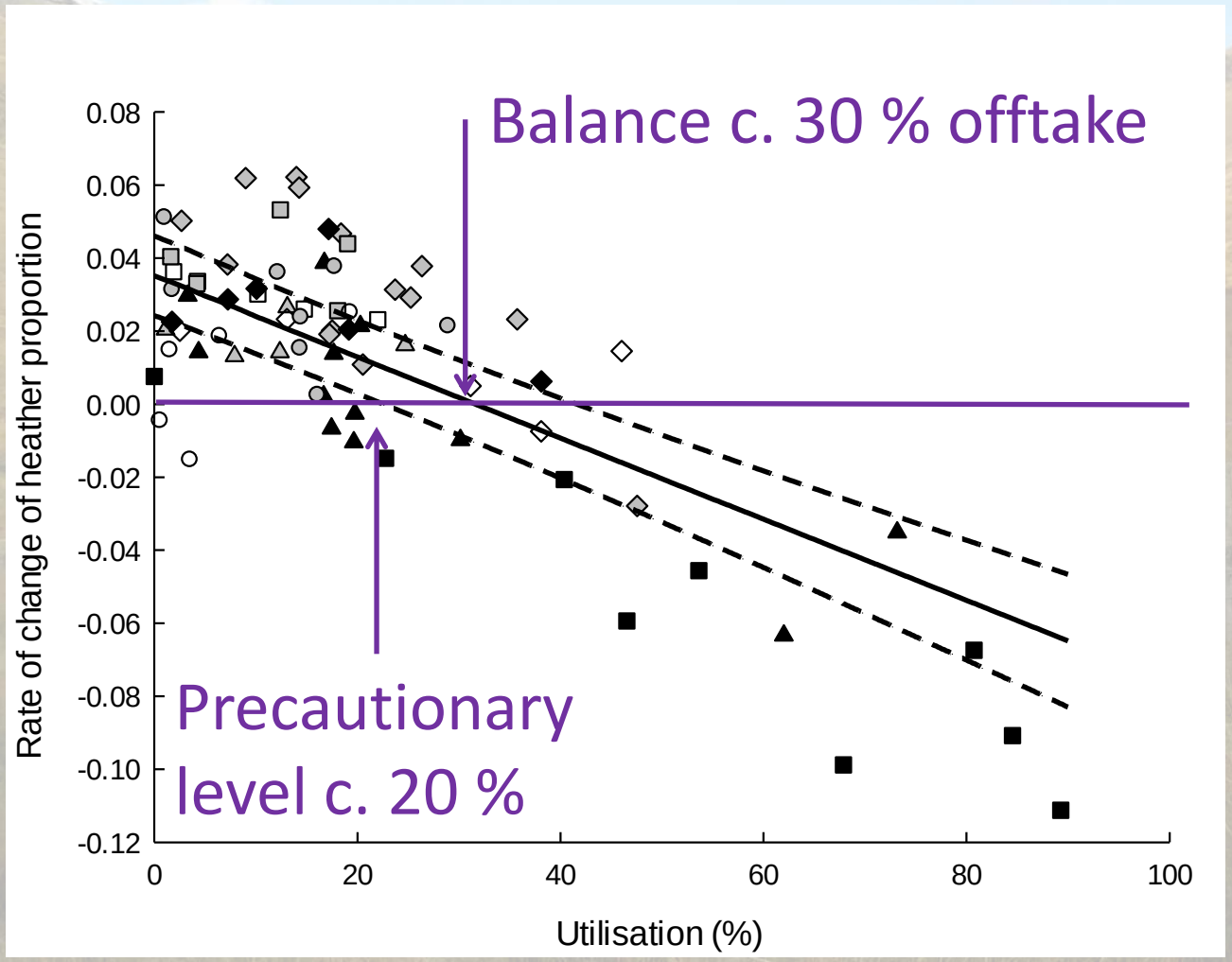

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The Glen Finglas Experiment

- Originally part of the Grazing and Upland Birds project (GRUB), with CEH, SRUC, RSPB and Stirling University
- Established 2002
- To investigate how grazing cascades through a system from plants to invertebrates to birds
- Focus on impacts of CAP reform cascading through upland ecosystems

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Glen Finglas

- Owned by the Woodland Trust (since 1996)
- 4000 ha of woodland, moorland, grassland and bog
- Noted for parkland and wood pasture
- Former royal hunting forest
- Previously used for sheep and cattle grazing

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The experiment

- 24 plots, 3.3 ha each
- Six replicates
- Four treatments

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The experiment

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  - II – Low sheep (0.9 sheep ha^{-1})

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  - I – Commercial sheep stocking (2.7 sheep ha^{-1})
  - II – Low sheep (0.9 sheep ha^{-1})

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The experiment

- 24 plots, 3.3 ha each
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The experiment

- 24 plots, 3.3 ha each
- Six replicates
- Four treatments
  - I – Commercial sheep stocking (2.7 sheep ha^{-1})
  - II – Low sheep (0.9 sheep ha^{-1})
  - III – Low sheep and cattle (≈0.9 sheep ha^{-1})
  - IV – No grazing

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The experiment

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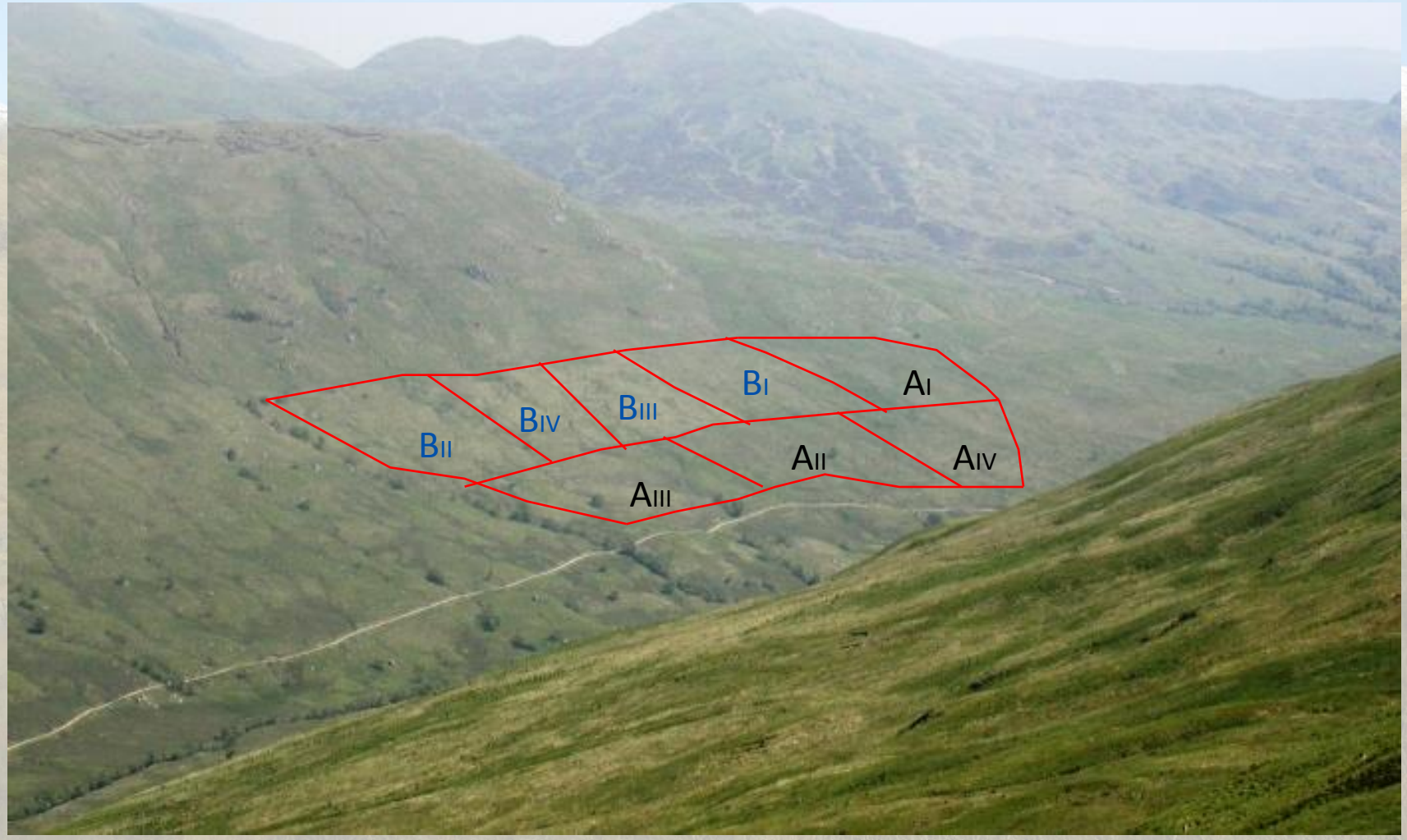
The experiment (one third of it)



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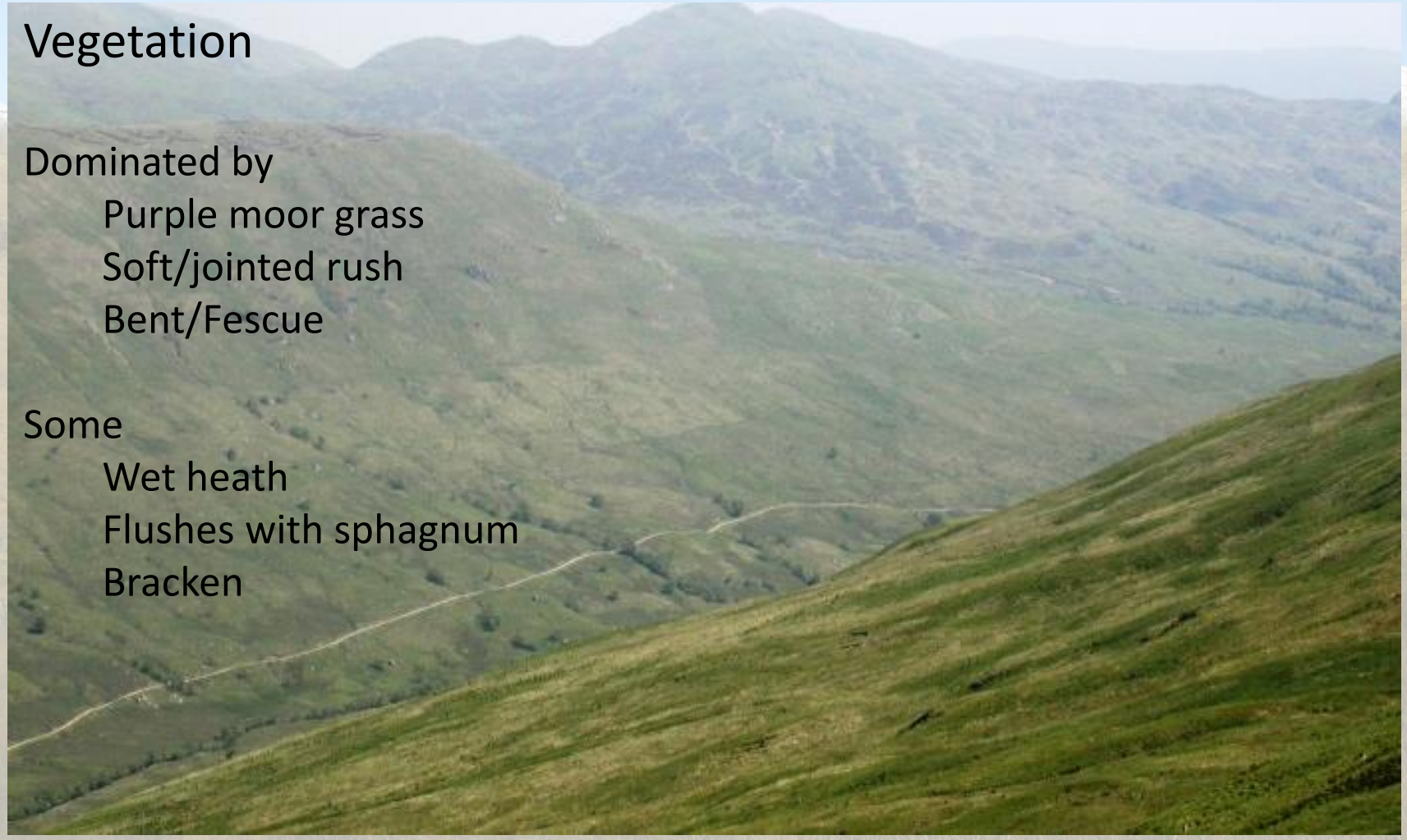
The experiment



Vegetation

Dominated by

- Purple moor grass
- Soft/jointed rush
- Bent/Fescue

Some

- Wet heath
- Flushes with sphagnum
- Bracken

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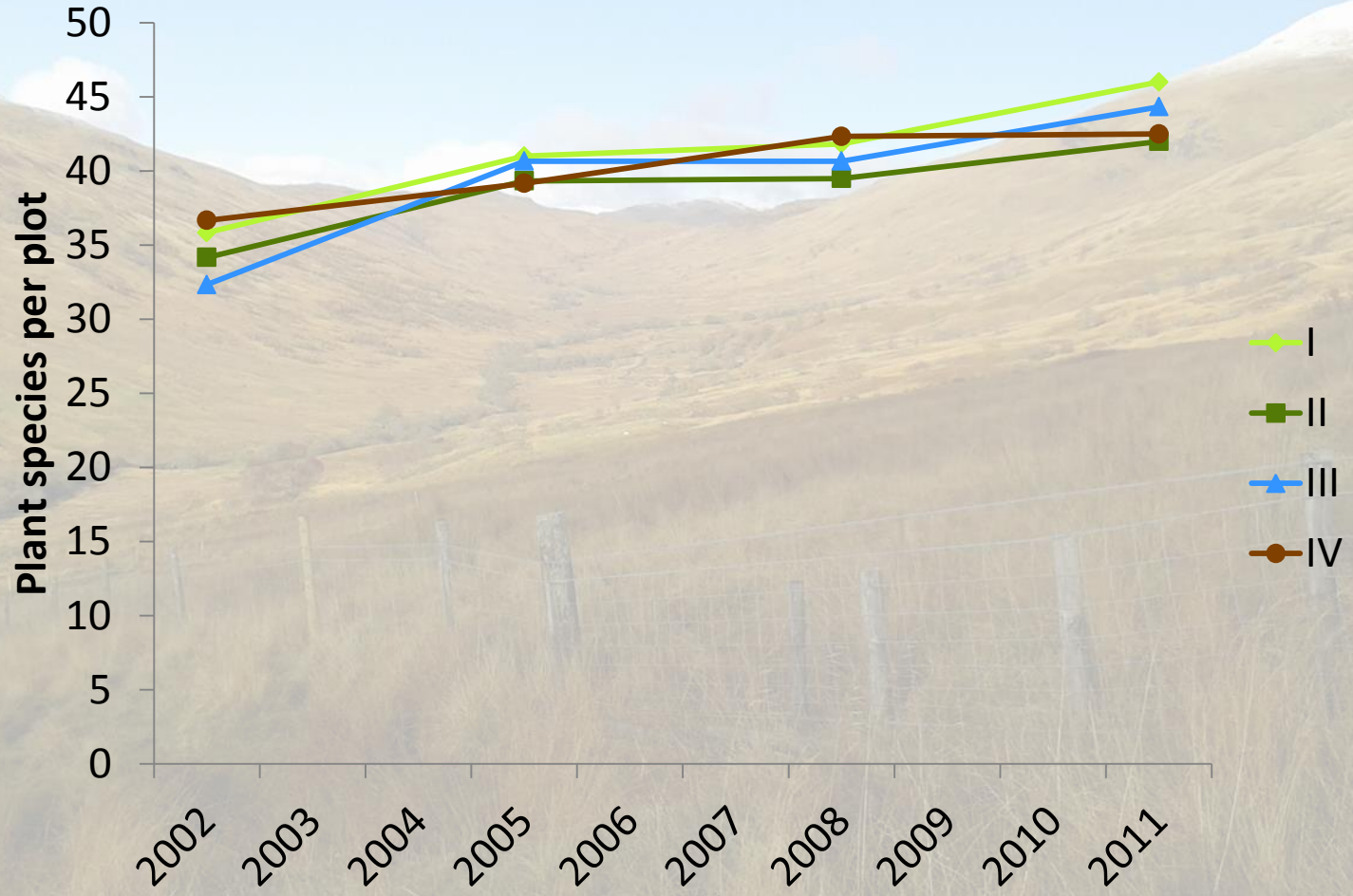
Impact of grazing

- Vegetation diversity



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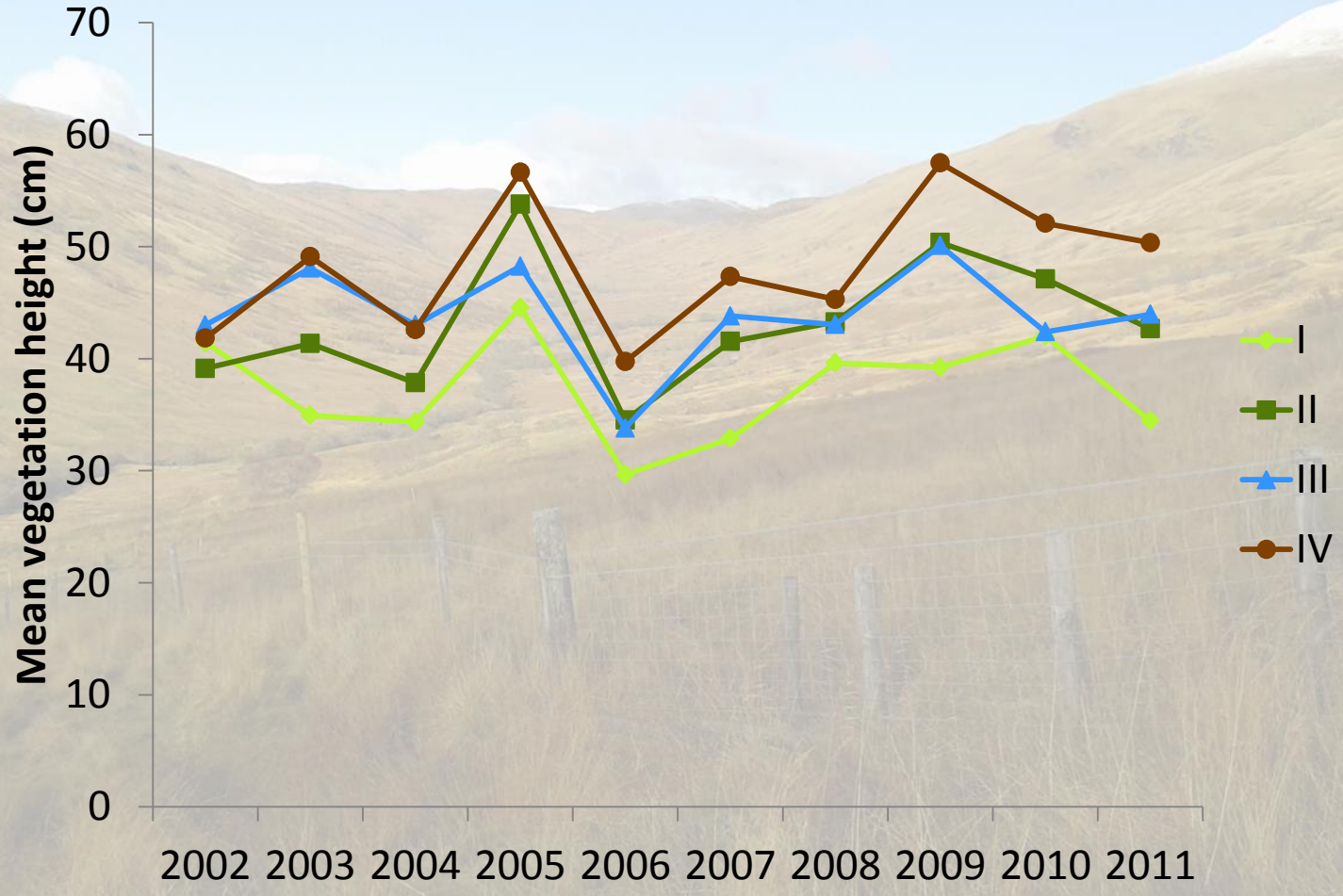
Impact of grazing

- Vegetation height



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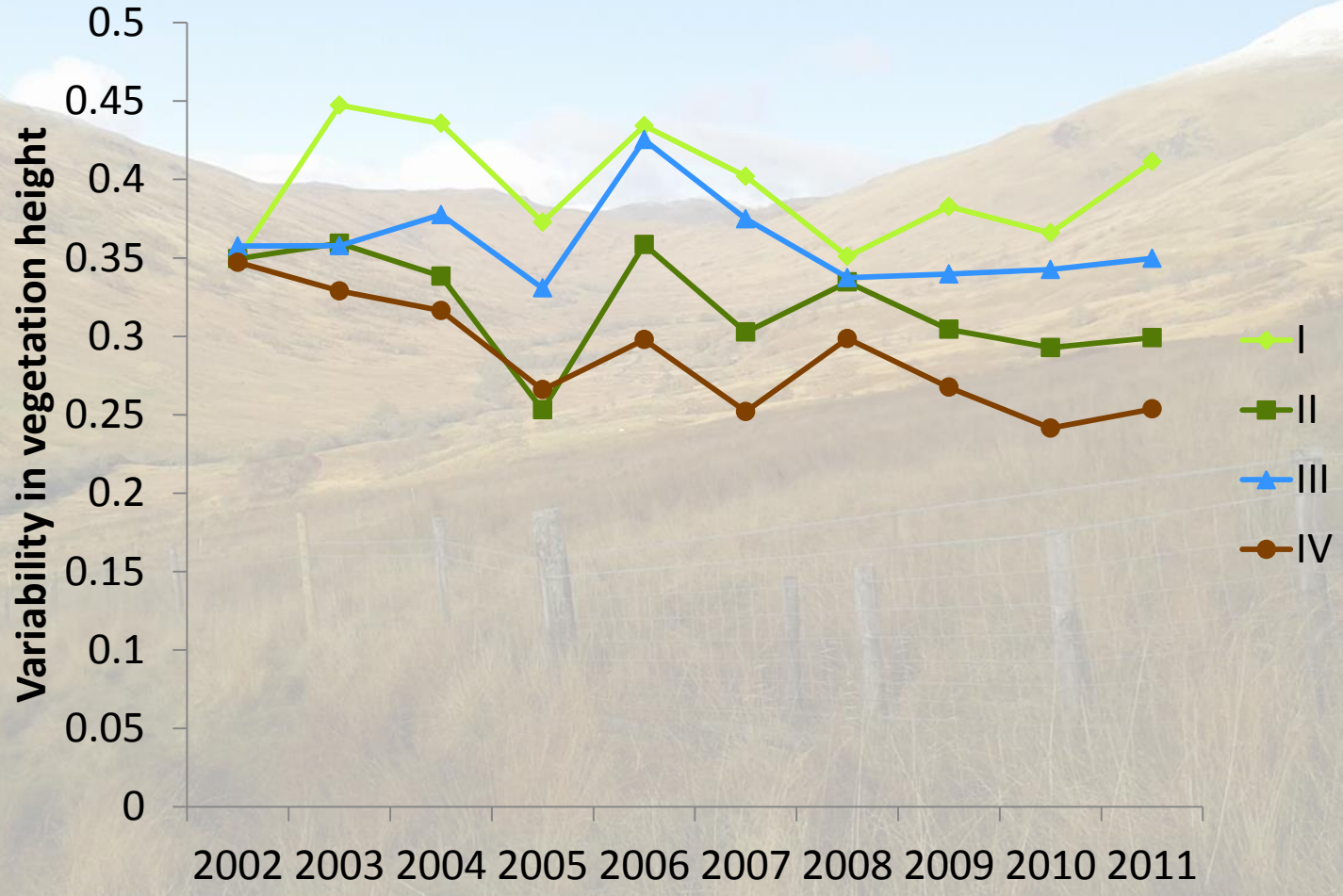
The impact of grazing

- Variation in vegetation height



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The impact of grazing

- Variation in vegetation height

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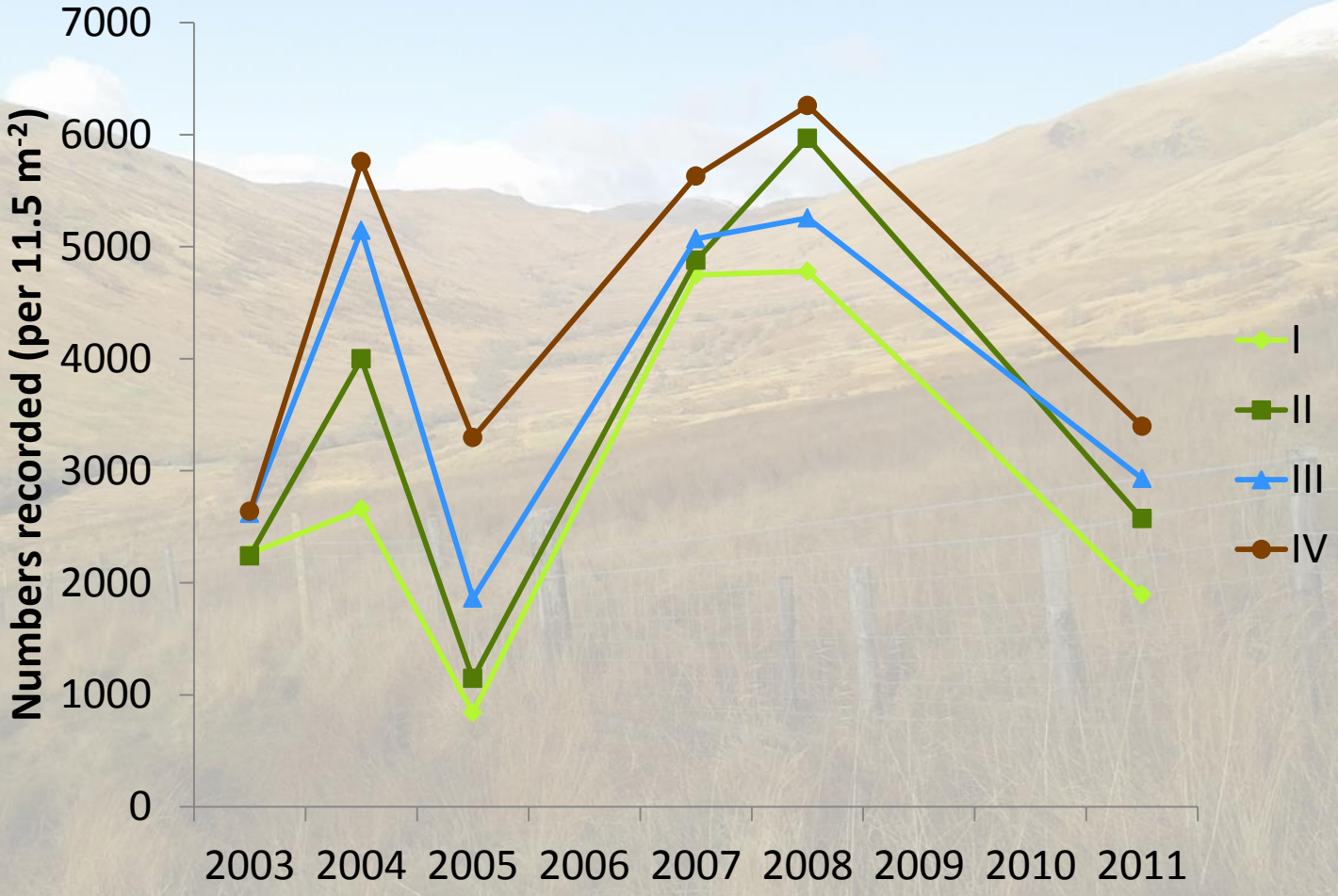
Impact of grazing

- Invertebrate numbers



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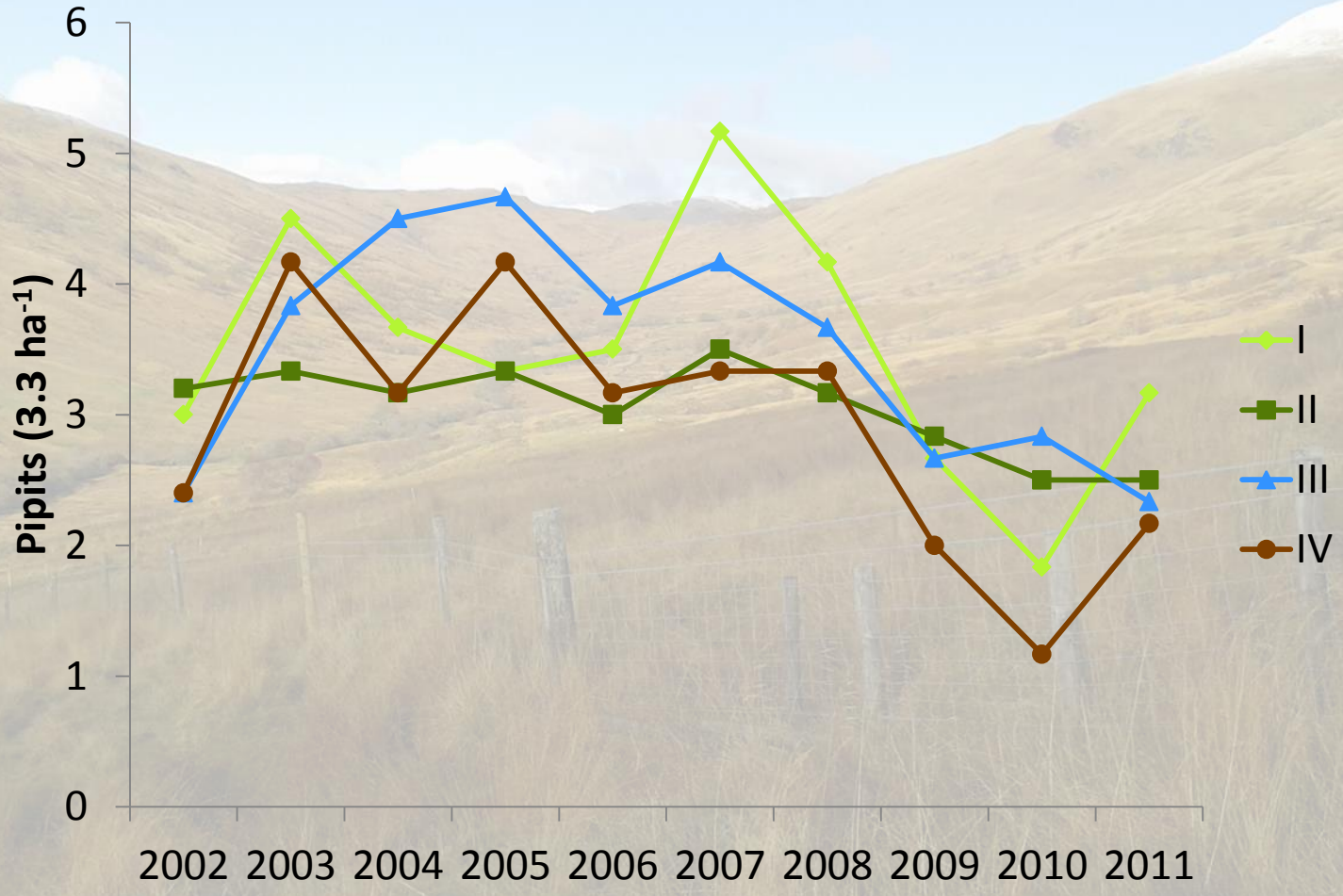
Impact of grazing

- Pipit territories per plot



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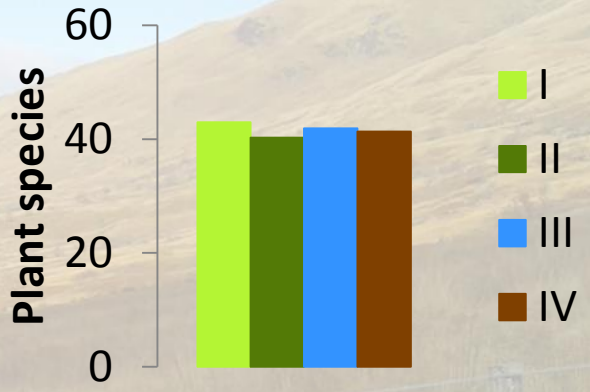
Complex pattern

- Large year to year variation
- Grazing has no impact on vegetation composition



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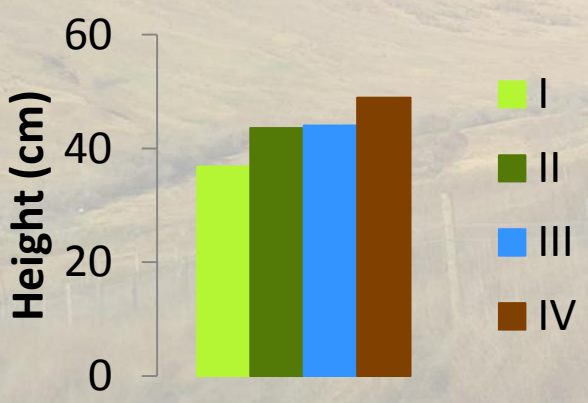
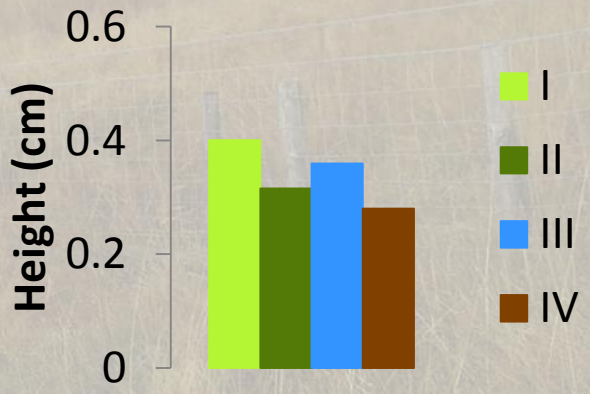
Complex pattern

- Large year to year variation
- Grazing has no impact on vegetation composition
- Grazing reduces vegetation height and increases variability





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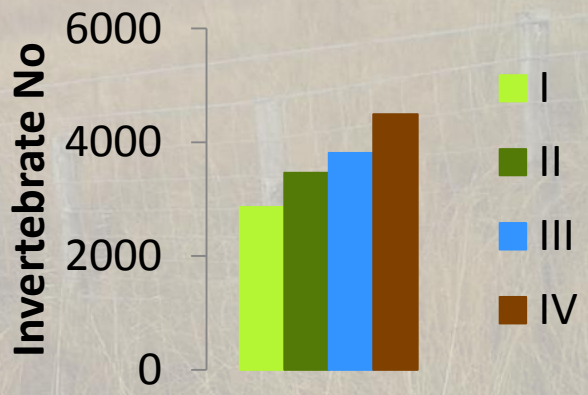

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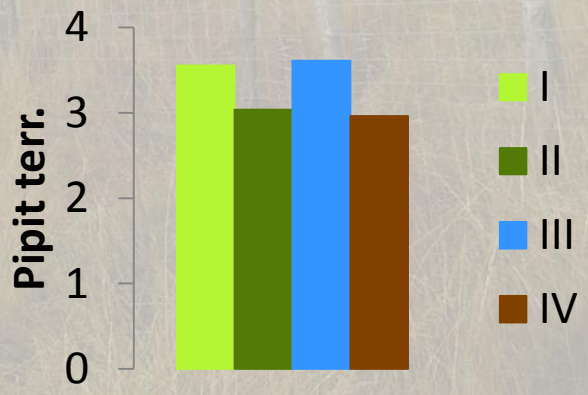
Complex pattern

- Large year to year variation
- Grazing has no impact on vegetation composition
- Grazing reduces vegetation height and increases variability
- Grazing reduces invertebrate numbers
- No grazing plots have lowest pipit numbers



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Analysis across years

- Pipit numbers dependent on
  - Invertebrate numbers - food resources
  - Variability in height – foraging success

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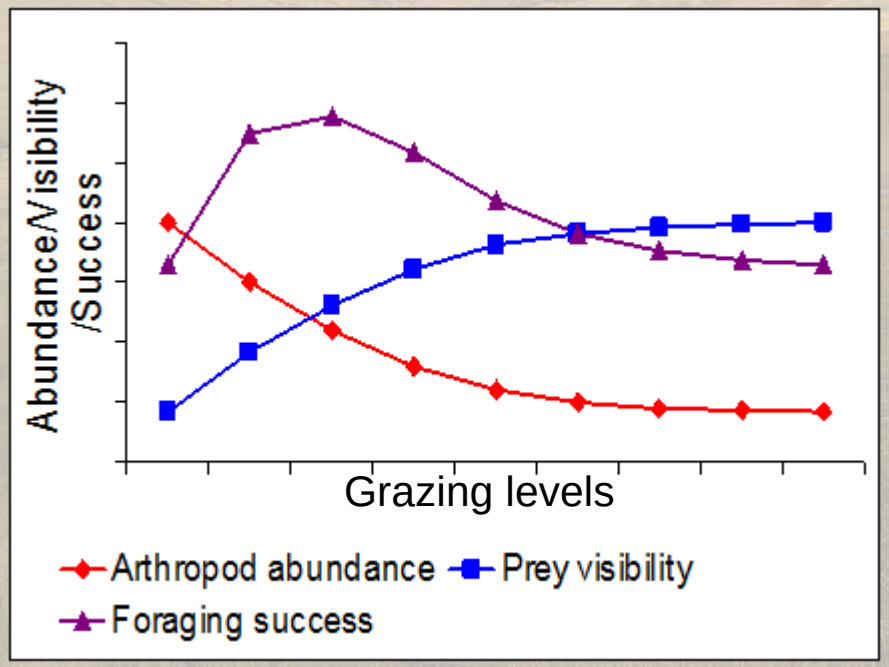

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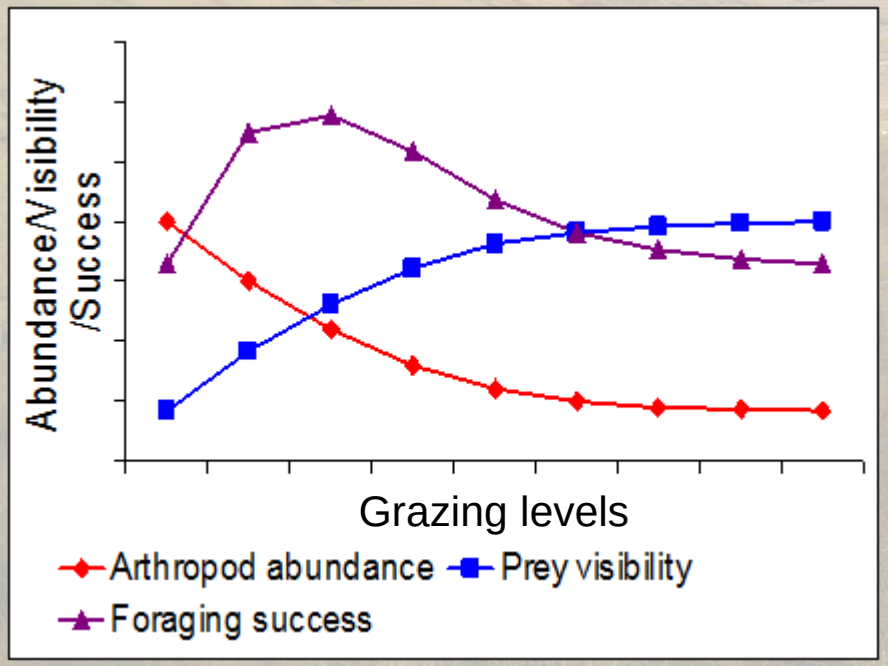

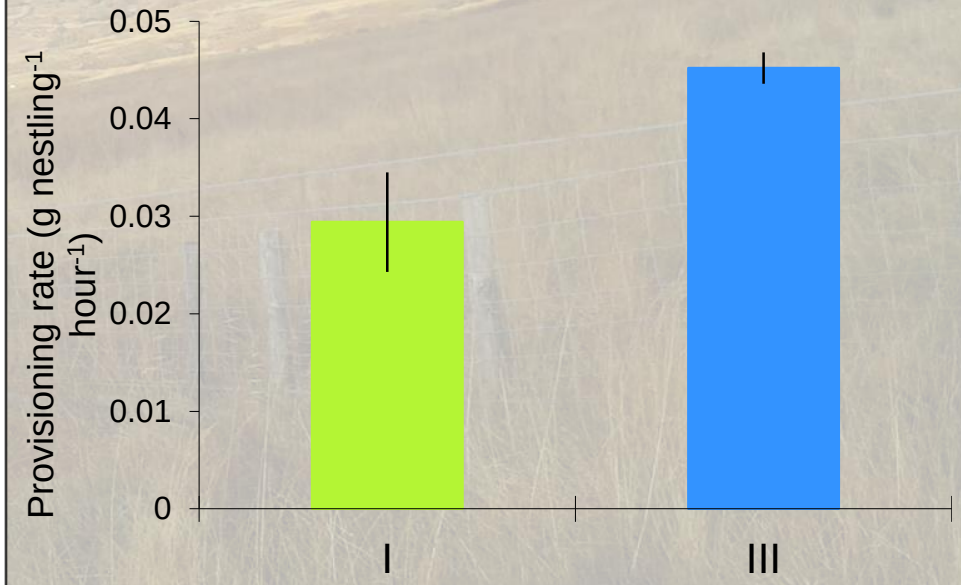

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Initial conclusion

- Grazing good for pipits
- Best treatment is mixed cattle and sheep grazing at low density, closely followed by high sheep
- Within the experiment – best trade-off between prey numbers and prey availability

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Initial conclusion

- Grazing good for pipits
- Best treatment is mixed cattle and sheep grazing at low density, closely followed by high sheep
- Within the experiment – best trade-off between prey numbers and prey availability
- However -

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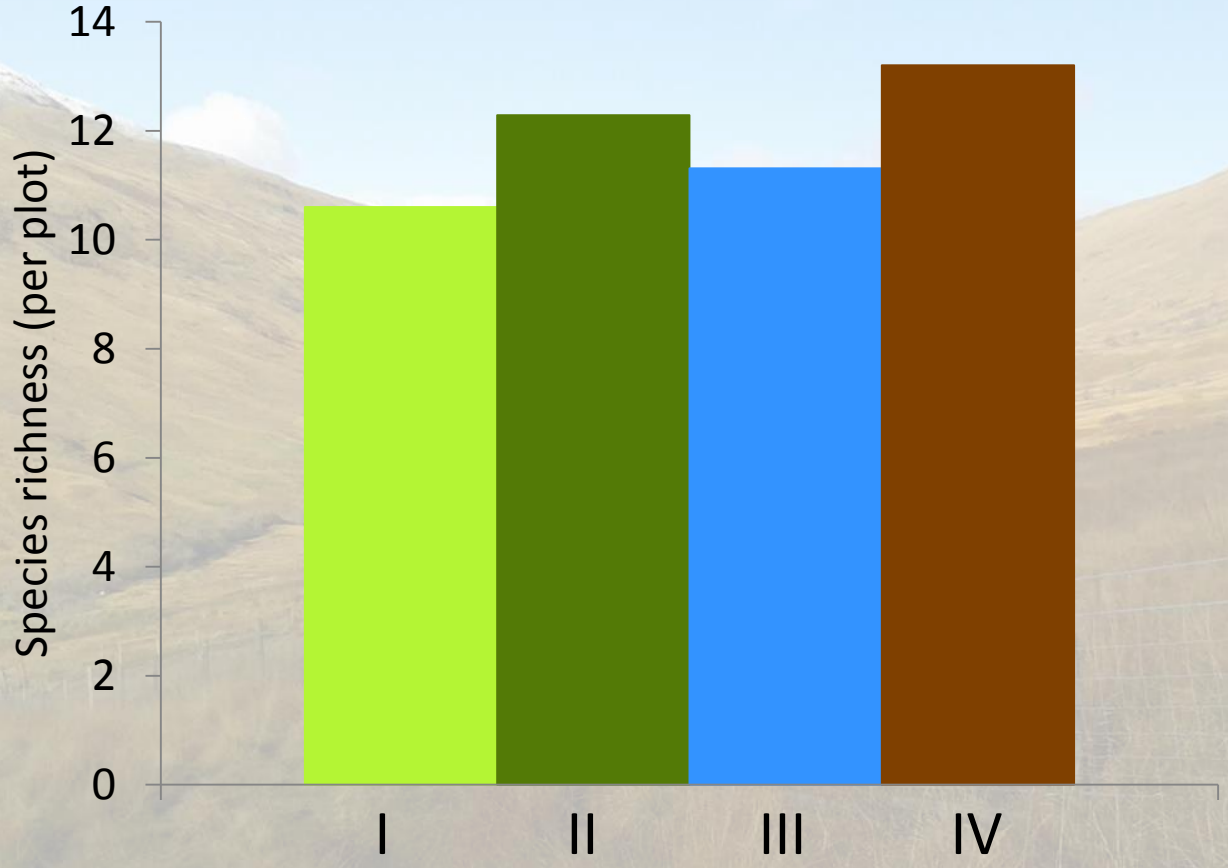
Moths

- Opposite pattern to pipits



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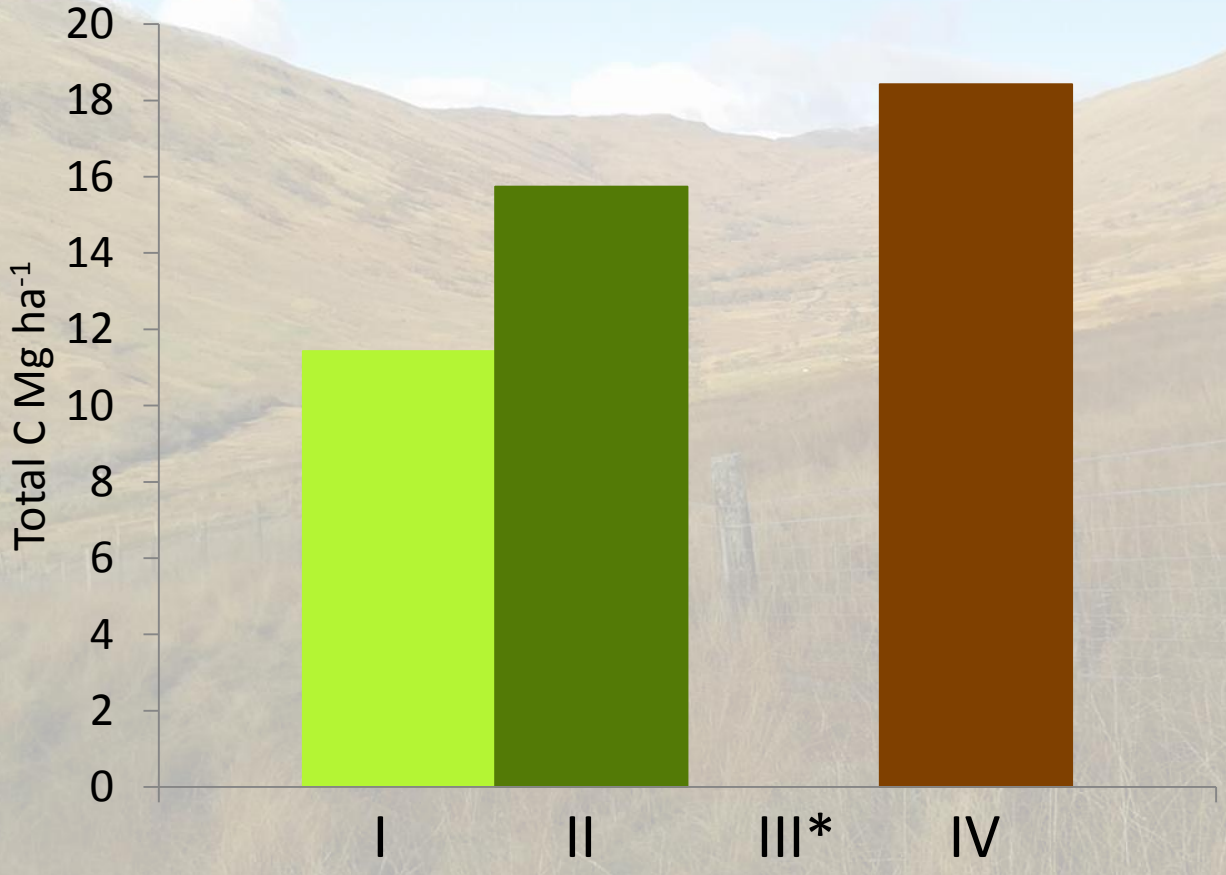
Carbon

- Above-ground storage of carbon – less sheep = more carbon stored in the vegetation



*Not done

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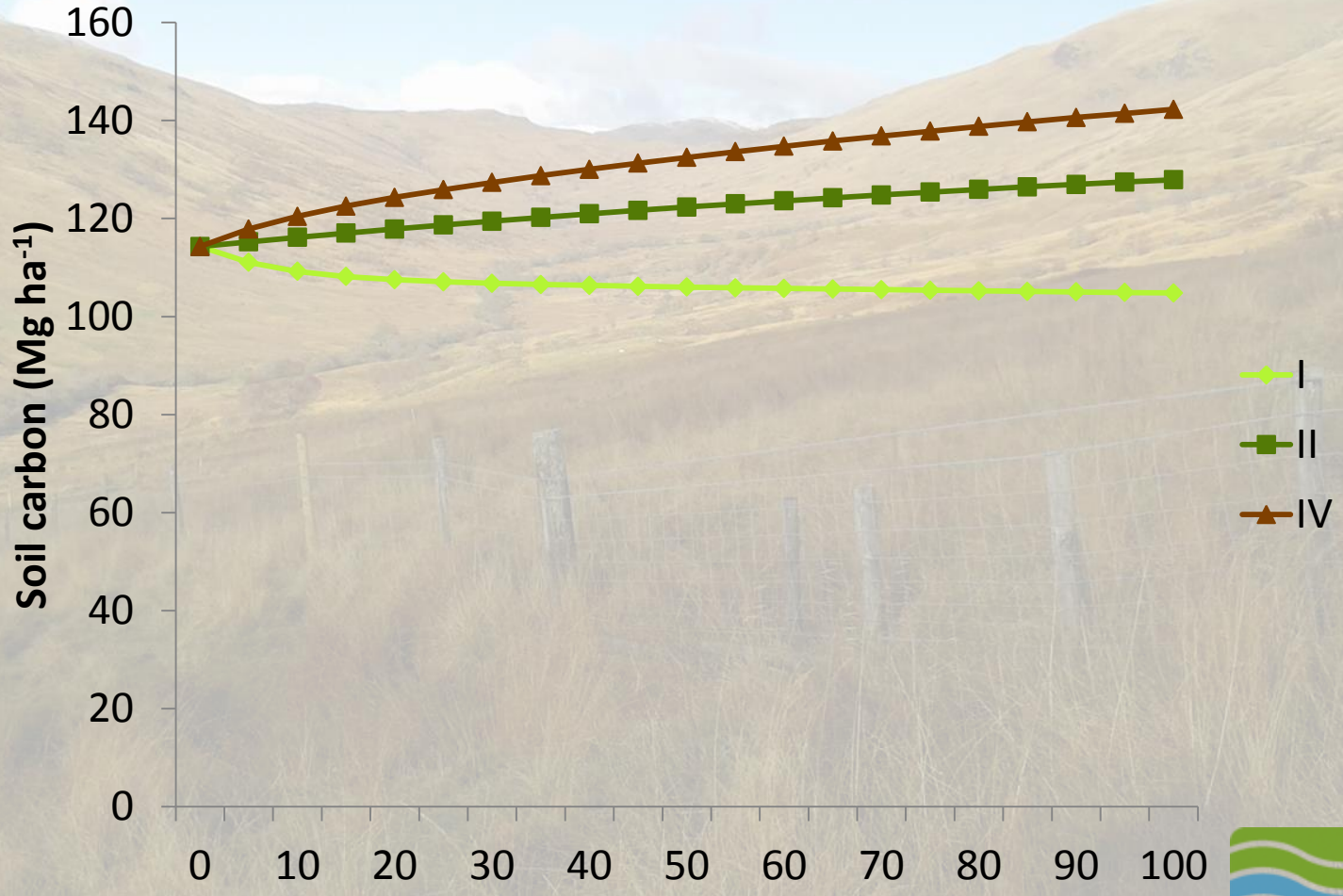
Carbon

- Soil sequestration takes decades to detect – modelling indicates



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Lessons from Glen Finglas

- Management choice depends on what you want:
  - Meadow pipits, or
  - Carbon and Moths?

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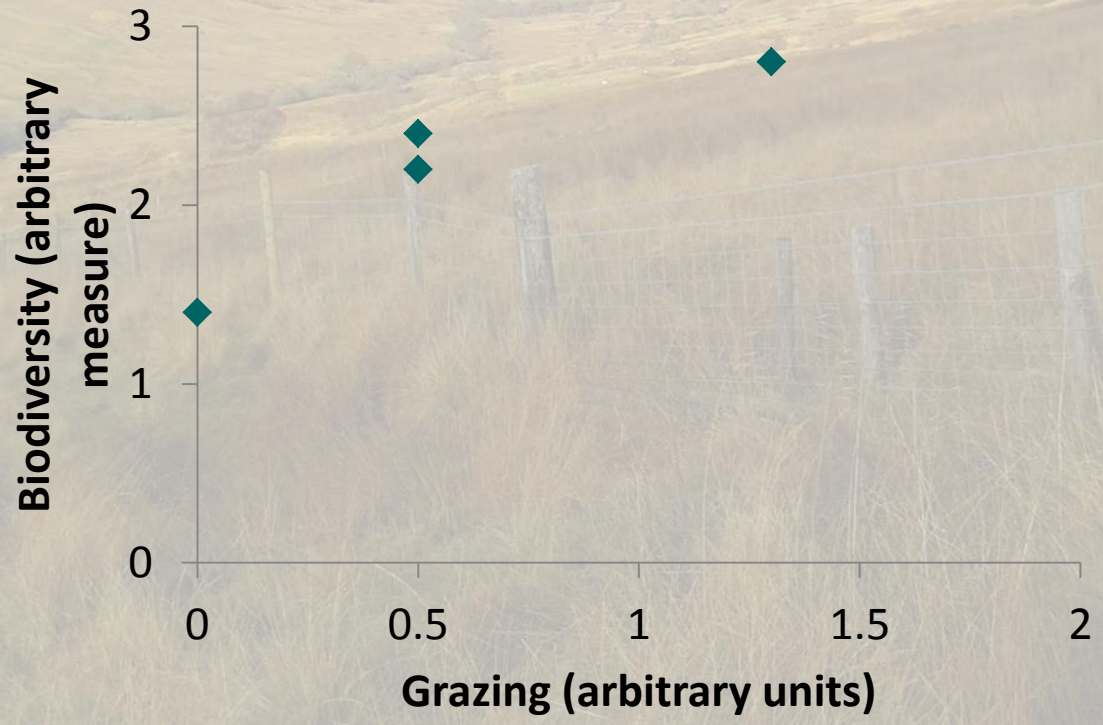
Lessons from Glen Finglas

- Management choice depends on what you want:
  - Meadow pipits, or
  - Carbon and Moths?
- Large experiment, but still only four points on graph from wide range of combinations (exclosures = 2)



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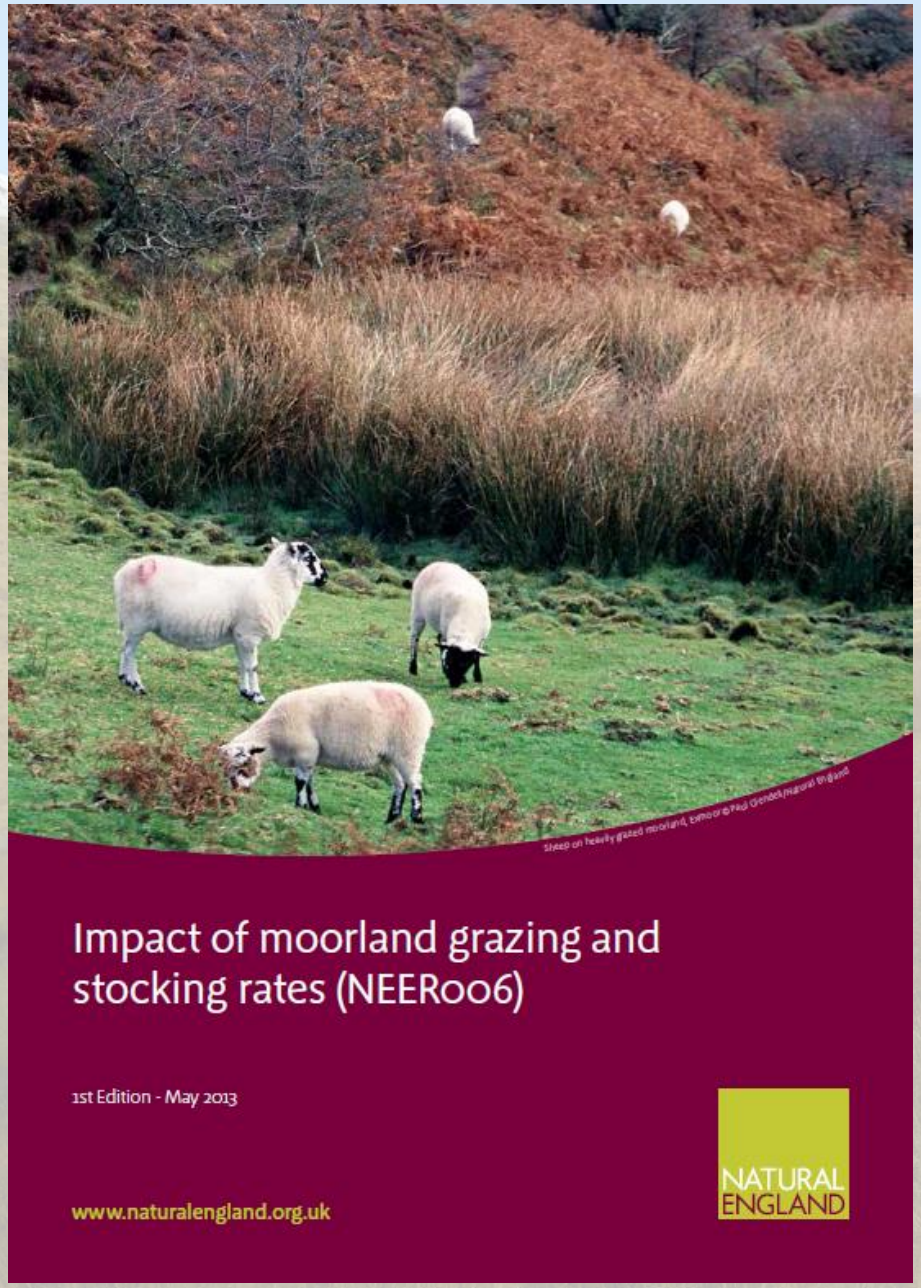
NE Upland Evidence Review - Grazing



MARTIN, D., FRASER, M.D., PAKEMAN, R.J. & MOFFAT, A.M. 2013. *Natural England Review of Upland Evidence 2012 - Impact of moorland grazing and stocking rates.* Natural England Evidence Review, Number 006.

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Personal reflections

- Evidence review?
  - Systematic review addresses specific question and does meta-analysis of data
  - Literature review – synthesis of results from a wide range of available information
  - Evidence review
    - Comprehensive literature search
    - Review of information relevance and quality
    - Wider question than can be done by systematic review
    - Less subjective than literature review

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Overarching question

- “What are the effects of grazing regimes and stocking rates on the maintenance and/or restoration of moorland biodiversity and on ecosystem service delivery?”

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The process

- Studies captured using search terms in all sources (including duplicates) 1763
- Studies captured using search terms in all sources (excluding duplicates) 1192
- Studies remaining after title/abstract filter 316
- Studies used in review 106

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Study appraisal

- Types

  1 Meta-analyses, systematic reviews of Randomised Controlled Trials (RCTs) or RCTs.

  2 Systematic reviews of, or individual, non-randomised controlled trials, controlled before-and-after (CBA) or comparative studies, correlation studies.

  3 Non-analytical studies, for example, case reports, case series studies.

  4 Expert opinion, formal consensus.

- Quality

  ++ All or most of the methodological criteria have been fulfilled. Low risk of bias.

  + Some of the criteria have been fulfilled. Risk of bias.

  – Few or no criteria have been fulfilled. High risk of bias or high likelihood of change given further study.

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Synthesis

- The strength of evidence for an individual conclusion (117 of them) was defined as follows:

  S Strong - evidence from a number of studies, or one or two very high quality studies.

  M Moderate - evidence from two or three studies, of which at least one must be a minimum of **2+**.

  W Weak - evidence from one study or a small number of low quality studies, usually includes **–** scores.

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Random selection from the many conclusions

- The spatial impacts of grazing on heather are influenced by the size and distribution of grass patches, with greatest impact in the heather zone closest to grass. **S**
- Productivity of Agrostis-Festuca grassland, preferred by grazing livestock, can vary markedly, and consistently, between sites of different soil fertility. **M**
- Competition between sheep and deer can occur at the grazing-unit scale with the grazing impact of deer greater after sheep have been removed. **W**

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Review conclusions

- "The quality of evidence was however found to be variable, with only 21% of the individual conclusions ……. based on evidence judged as '**strong**'. There is a relative lack of good quality studies on which to base management decisions."
- "Overall, the evidence we have to allow us to manage the uplands appropriately is incomplete."

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Gaps!

- Need for better evidence on grazing impacts including:
  - distribution of grazing
  - response of habitats and species
  - impacts of undergrazing
- Improved methods to ensure that ecologically meaningful measurements are made quickly and efficiently.
- More evidence on grazing impacts on carbon budgets and water quality in different soils
- Need to devise ways that can set (approximate) stocking levels for rangelands (i.e. mosaics and patches of different vegetation with different grazing requirements)

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My take home messages from the review

- Embarrassingly poor evidence base
  - Numerically (106 papers reviewed)
  - Quality (21 % of conclusions based on strong evidence)
- Grazing management regimes should be based on clear, site-specific objectives (tailoring)
- Adaptive management - modify decisions in the light of monitoring

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Grazing management of the uplands

- Choice of three type of income – livestock (food security), wood (energy security), tourism
- Changing grazing management will change biodiversity
- Complex trade-offs at range of scales

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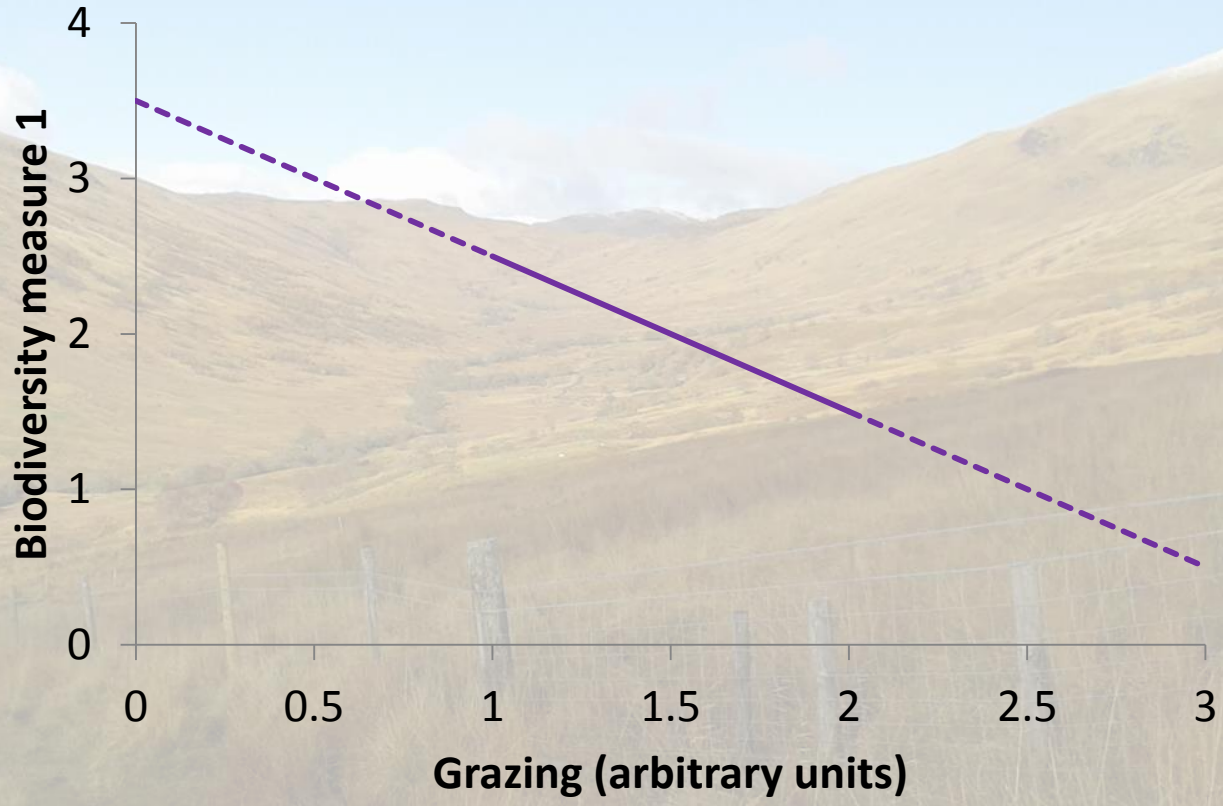
Trade-offs



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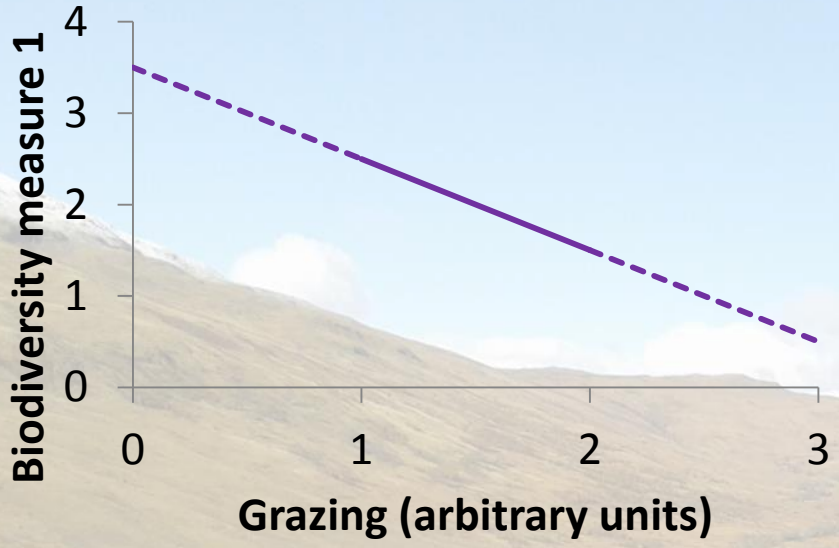
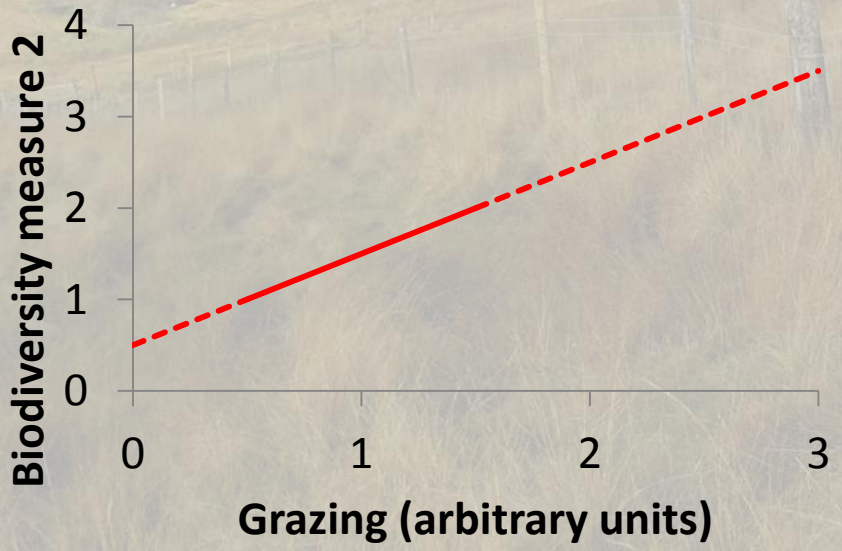
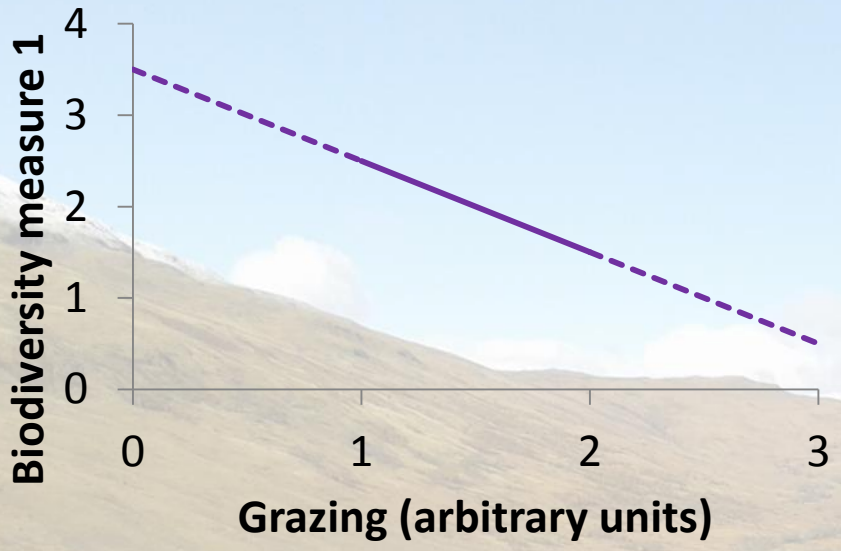
Trade-offs


Biodiversity measure 1
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)


Biodiversity measure 2
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

Trade-offs


Biodiversity measure 1
4
3
2
1
0
0
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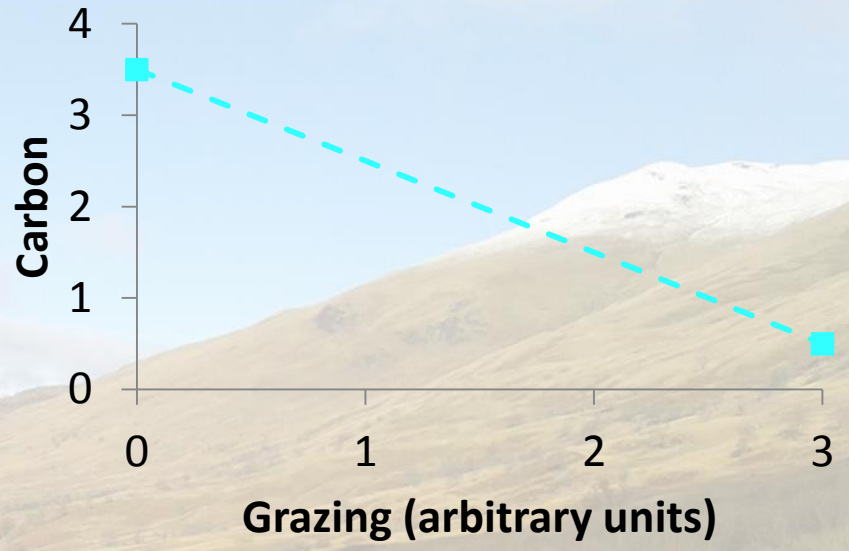
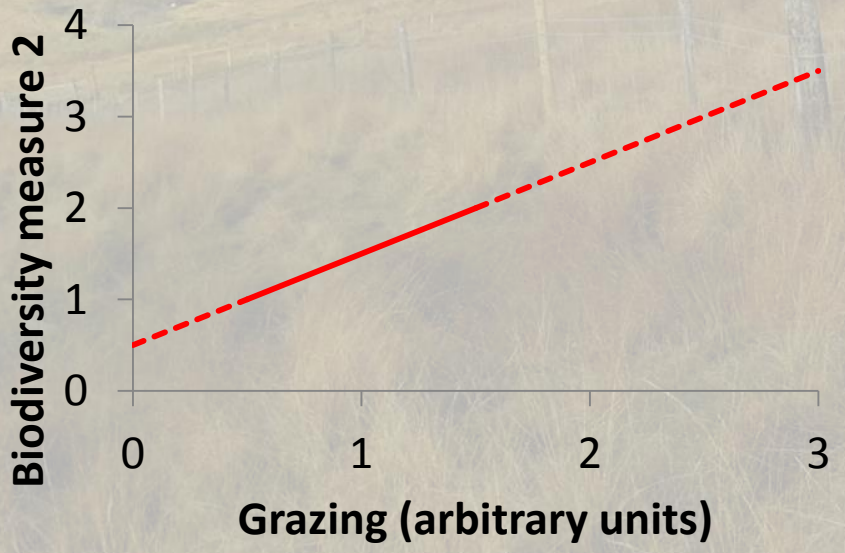
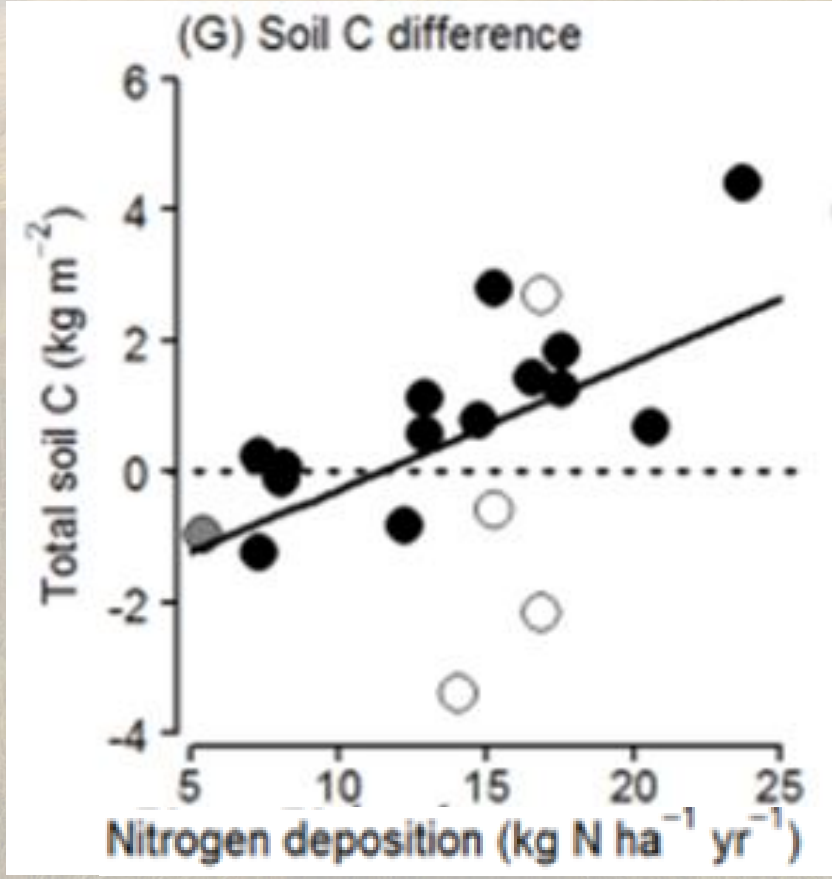
2
3
Grazing (arbitrary units)


Carbon
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)


Biodiversity measure 2
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

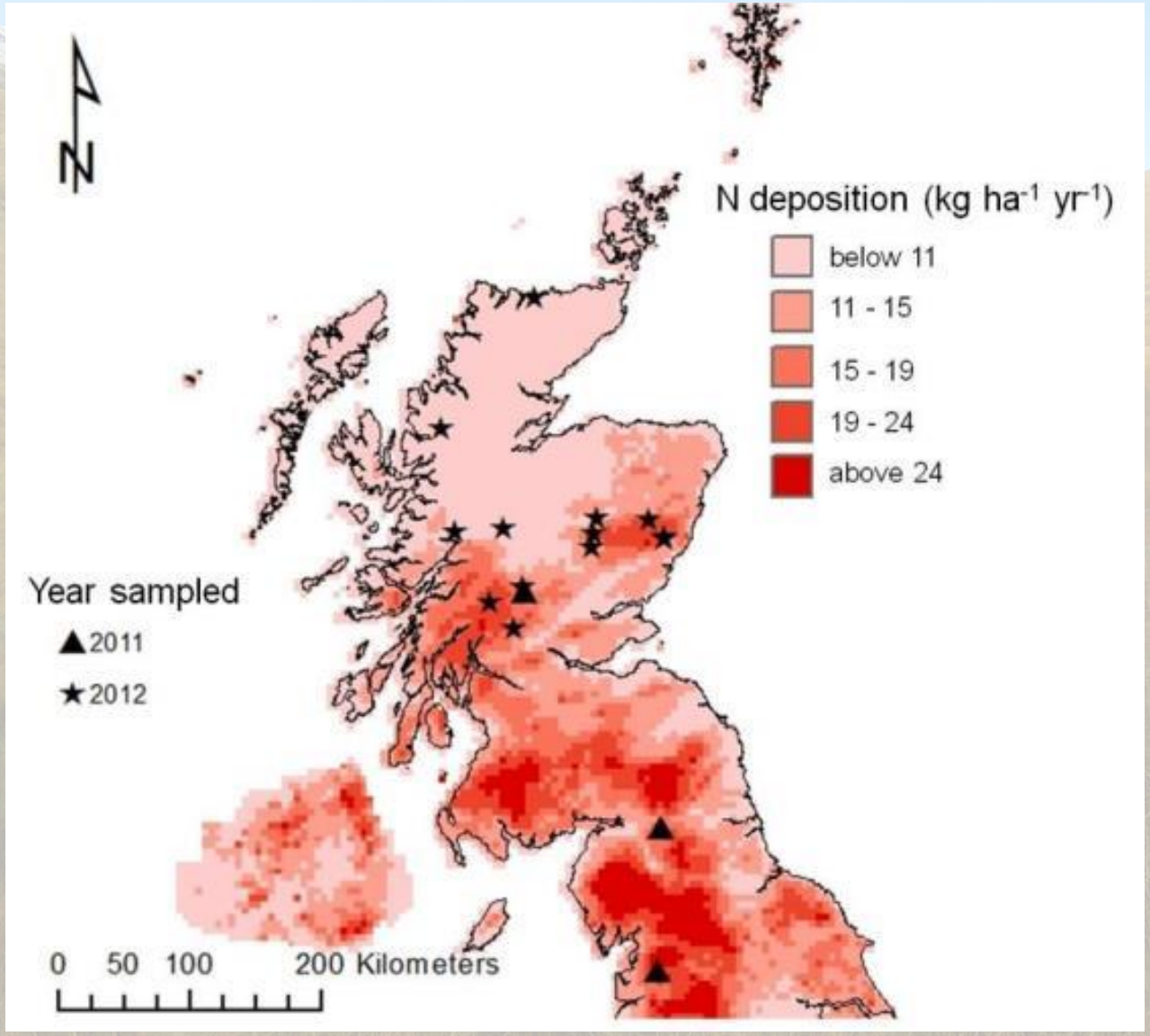
Trade-offs (an aside)

- Study of upland exclosures
- Points represent difference between inside and outside (i.e. positive means no grazing increases soil carbon)
- > 11 kg N ha^{-1} yr^{-1} get C accumulation
- Context sensitive

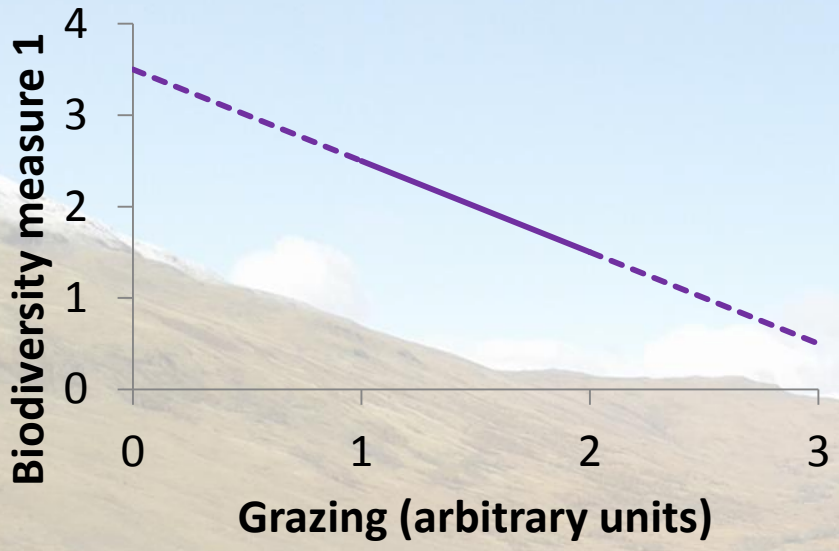


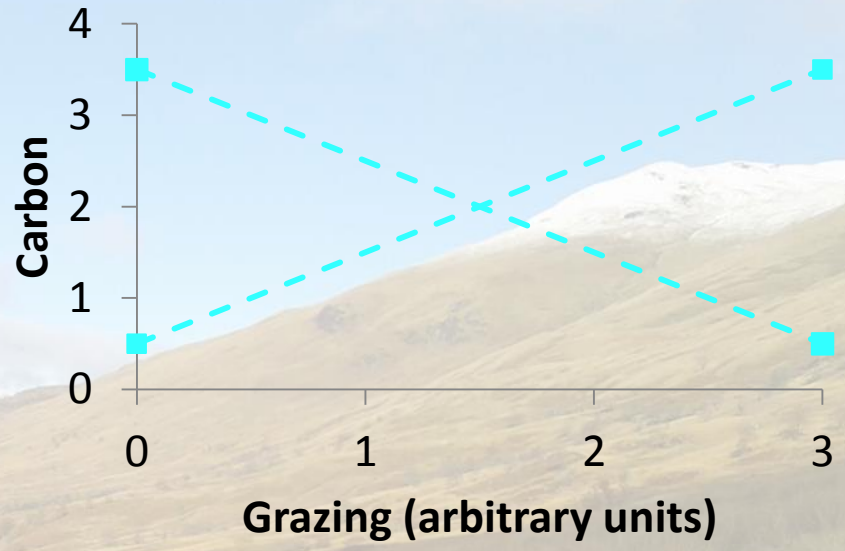
Trade-offs (an aside)

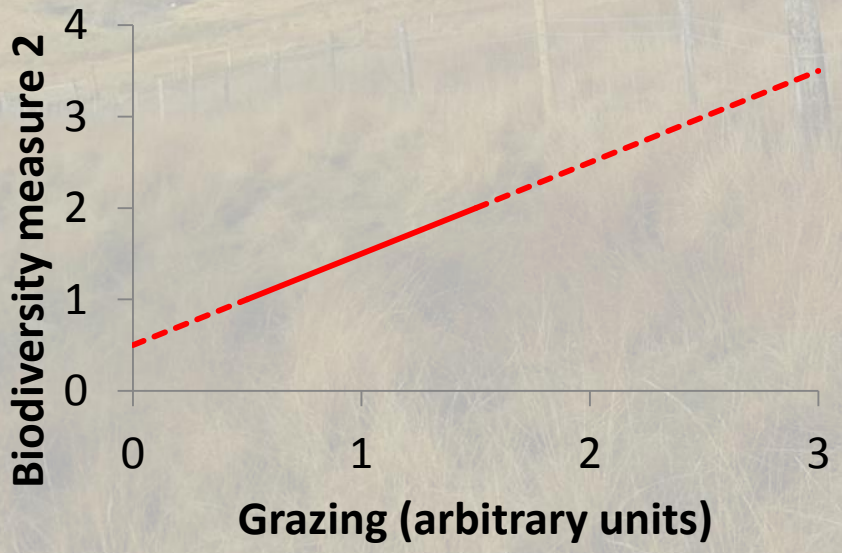
- Nitrogen deposition



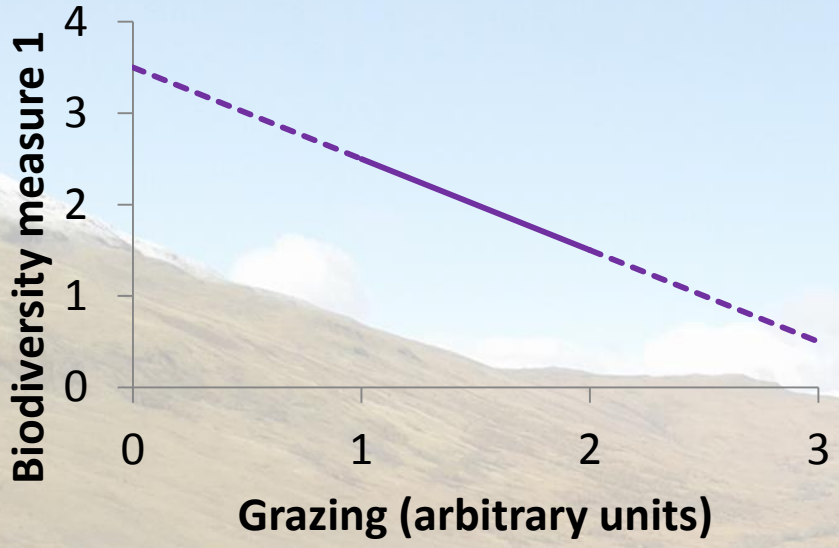
Trade-offs

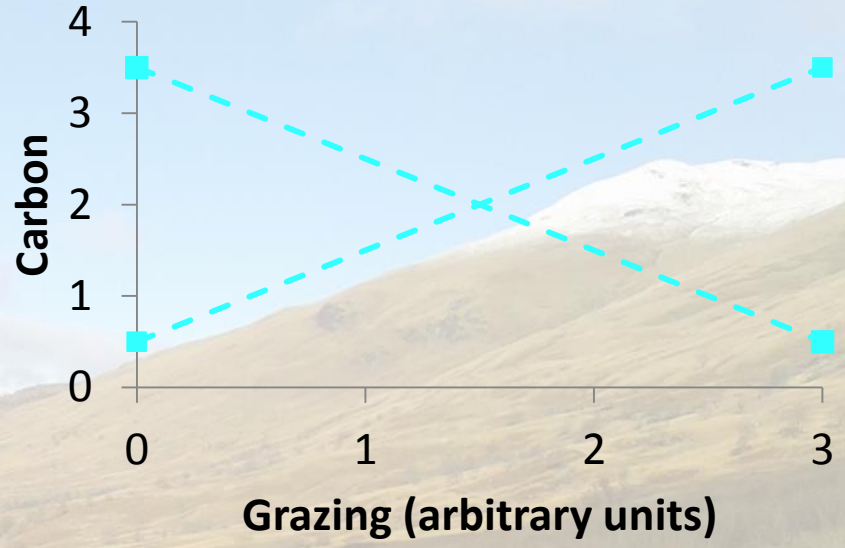

Biodiversity measure 1
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

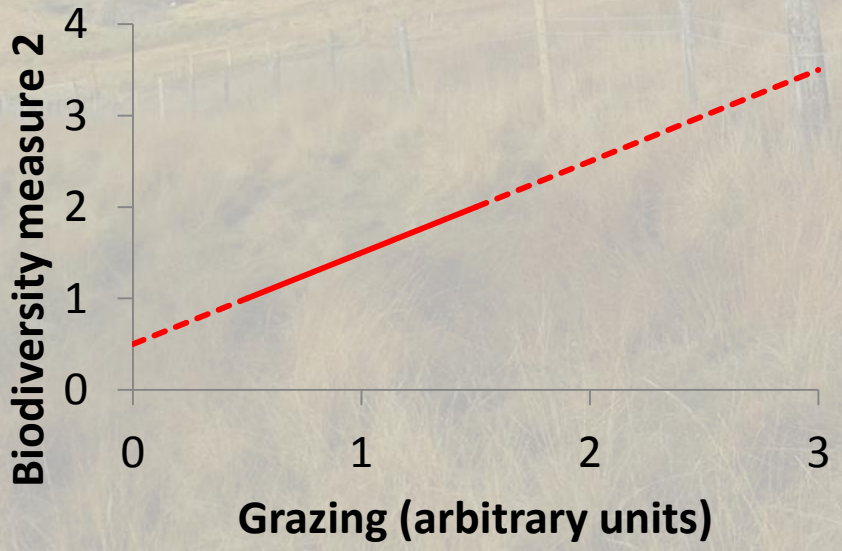

Carbon
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)


Biodiversity measure 2
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

Trade-offs

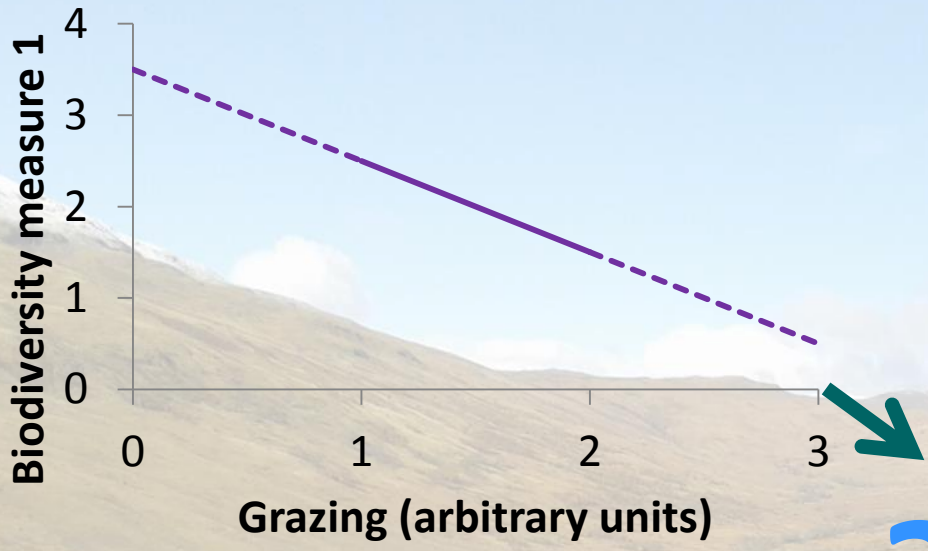

Biodiversity measure 1
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

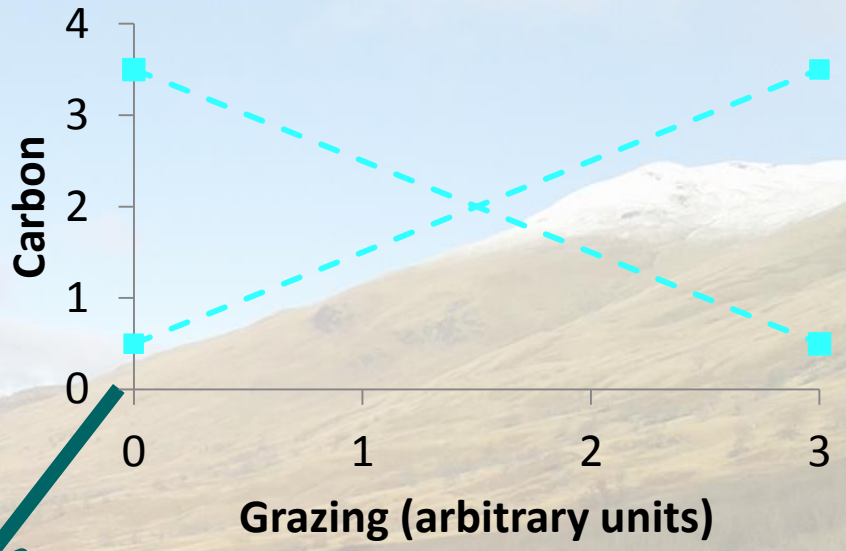

Carbon
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)


Biodiversity measure 2
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

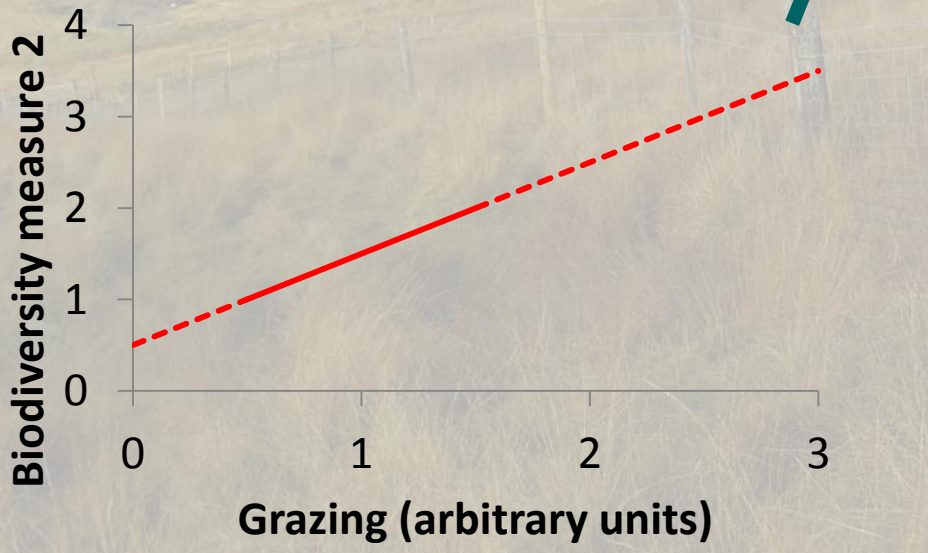

Cultural value
4
3
2
1
0
?
0
1
2
3
Grazing (arbitrary units)

Trade-offs


Biodiversity measure 1
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)


Carbon
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

?


Biodiversity measure 2
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)


Cultural value
4
3
2
1
0
0
1
2
3
Grazing (arbitrary units)

?

Solutions

- Ecosystem Approach and Ecosystem Services framework may offer support for decision making if implemented properly
- However, data hungry and partial analysis may give wrong answers
- Need a spatial framework as impacts of decisions on a grazing unit may cascade up-scale as well as through trophic levels.

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Thank you

- The Woodland Trust
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The Scottish Government
Riaghaltas na h-Alba

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Questions