



# Sustainable Upland Management

A summary of research outputs from the Scottish Government's "Environment – Land Use and Rural Stewardship" research programme



# Introduction

These articles are short summaries of some of the research undertaken by Scotland's Main Research Providers as part of the Environment – Land Use and Rural Stewardship research programme (2006-11). The work was co-funded by the Scotland's Rural and Environment Research and Analysis Directorate, the EU FP7 programme and UK Research Councils. Please get in touch with the authors if you would like more information.

These articles focus on managing the multiple services the Scottish uplands provide, and deal with issues relating to the management of game and grazing animals which are central to rural livelihoods and how this affects biodiversity. The research shows the potential for those with an interest in the uplands to work together for sustainable management and the importance of evidence for informing decision making.

The first article on *Collaborative frameworks in deer management* illustrates some of the valuable insights into factors affecting collaboration among stakeholders and the novel participatory tools that have been used to reconcile increasingly diverse public and private objectives. This work is fundamental to developing practical guidance on the implementation of the Land Use Strategy and policies that will arise from the Wildlife and Natural Environment Bill. The uplands provide livelihoods for remote communities through activities such as grouse shooting. The article on *The economic impacts of sport shooting in the highlands of Scotland* illustrates a wide variety of 'business models' which have complex interactions with the rural economy and the importance of this particular land use for rural livelihoods.

A pressing issue for many grouse moor managers is the control of ticks and tick-borne disease such as louping-ill. Mountain hares are also involved in the transmission of this disease but the article *Culling hares to boost grouse numbers* demonstrates that reducing hare populations is unlikely to be effective if deer, an effective tick multiplier, are present in any numbers. In support of this is, the article on *The impact of climate-wildlife interactions on ticks* indicates that tick abundances are higher at low altitudes coinciding with higher deer and lower grouse numbers whereas mountain hares and grouse are more abundant at higher altitudes. This evidence should be of value in deciding on tick control strategies, particularly on the lower grouse moors. The uplands feature many other species and habitats of conservation value. The article on *Bird diversity and upland management* demonstrates the positive effect of game management practices on bird species such as waders but also shows that passerines benefit from areas managed more for grazing.

Grazing by both deer and sheep is a major driver of upland landscape characteristics. The article *Livestock retreat from the hills – consequences for deer and plant diversity* shows that the trend for sheep removal in the uplands may lead to increased grazing pressure by deer reducing the condition of heather moorland. Additional experiments described in *Unravelling grazing impacts on biodiversity in the uplands* show that mixed grazing regimes are best for species such as meadow pipits because of the effect of grazing on vegetation structure which affects access to their favoured invertebrate diet.

Finally, there is increasing recognition of the need for evidence based policy (for example: Scotland's Wild Deer: A National Approach). The article on *Deer performance and health in the Scottish uplands* demonstrates the sort of information that can be used to assess how deer populations will respond to land-use and climate change allowing us to detect changes in their performance and health status as indicators of stresses in our upland ecosystems.

Justin Irvine  
j.irvine@macaulay.ac.uk

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# Collaborative frameworks in deer management



Stefano Fionni

## Background

**W**ild deer range freely across landscapes which can cause conflicts between neighbours with different management goals. Deer are highly valued, providing employment, venison and tourism income. Although they are a key component of the natural environment their grazing has consequences for plant growth and biodiversity in woodlands and heaths and they are a cause of road traffic accidents (RTAs). We investigated the benefits of, and barriers to, collaboration over this natural resource.

## Approach

We focussed on land managers and deer management practitioners to investigate collaboration over the management of wild deer

at the landscape scale. The study worked with a number of deer management groups in Scotland and England as well as government agencies, Non-Government Organisations (NGOs) and private sector organisations. Here we report on two specific topics:

### 1. What motivates stakeholders to collaborate?

Understanding managers' priorities and what motivates different stakeholders to collaborate provides insights into the obstacles to, and the potential for, incentives for collaboration. We used choice experiments to investigate the priorities and preferences of practitioners in ten deer management groups (DMGs) across the UK. The factors affecting their choices and their reactions to the scenarios shown on the choice cards (Fig. 1) were then discussed. Nationally,

participants had a strong aversion to increases in RTAs, a strong preference for increasing woodland regeneration and a significant preference for increasing deer numbers. Further analysis revealed that although collaboration was favoured in most areas, mandatory collaboration schemes were thought to be unreliable and result in loss of independence. Practitioners preferred a voluntary scheme tailored to specific areas but alternatives such as venison marketing were also suggested as mechanisms for encouraging more effective deer management<sup>1</sup>.

	RTAs	Woodland regeneration	Deer population	Tick preferred
Option A				<input type="checkbox"/>
Option B				<input type="checkbox"/>
Status quo				<input type="checkbox"/>

Fig. 1: Example of one choice card of a set of eight used to record manager preferences

## 2. Can a common understanding based on shared knowledge improve communication and negotiation?

Conflicting interpretations of evidence can hamper collaboration. Working in two case study areas we developed spatial models of deer habitat use based on both local stakeholder knowledge and scientific data to predict deer distribution across a landscape scale. The predictions fitted observed deer distributions much better than using scientific data alone and were therefore more credible to deer managers<sup>2</sup>. These models were then used to explore two areas of conflict. The first was the ‘vacuum effect’ (high culling levels in one area affecting a neighbour’s hunting opportunities). In this case the model demonstrated that there was evidence for the vacuum effect in some areas and that this may be due to differences in the amount of preferred habitat between the two areas. The second was reconciling the deer densities required for managing priority habitats with the densities required for private management objectives. In this case we demonstrated that

the model could be used to produce an ‘impact warning’ map of deer distribution and density in relation to maps of priority habitats. This identified that for most of their range, deer were unlikely to be in conflict with natural heritage objectives but highlighted some sensitive areas that deer might prefer, providing a focus for negotiation of management options at a landscape scale (Fig. 2).

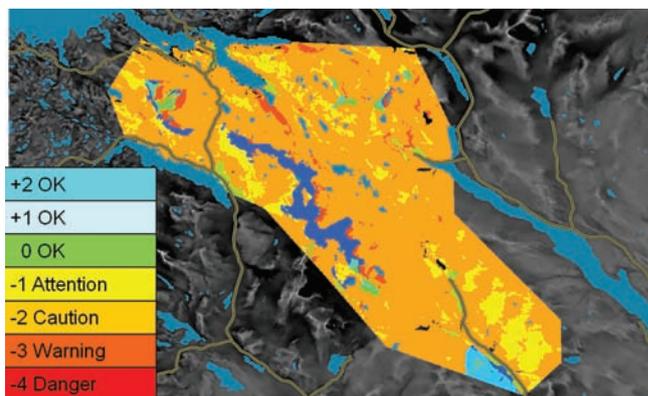


Fig. 2: ‘Impact warning’ map for deer distribution

## Conclusions

- If sustainable management is to be developed that can incorporate changes in climate and land-use policy, we need an adaptive framework that integrates locally specific knowledge with ecological data across the landscape over which the resource occurs. This should enable neighbouring landowners to discuss alternative management actions in the context of an agreed knowledge base helping to diminish conflicting interpretations and foster collaboration.
- Policy development that is inclusive of local managers from the outset is more likely to lead to local collaboration. This project has demonstrated the importance of engaging local practitioners and developing new participatory approaches to build trust and understanding in addressing conflicts over natural resource management.

Further reading:

1. Austin, Z., et al. (2010). *Wildlife Research*, 37(8), 647-657.
2. Irvine, R.J., et al. (2009). *Journal of Applied Ecology*, 46, 344-352.

Contact: Justin Irvine: (j.irvine@macaulay.ac.uk)

[http://www.relu.ac.uk/news/policy\\_and\\_practice\\_notes/Irvine\\_18/Irvine.pdf](http://www.relu.ac.uk/news/policy_and_practice_notes/Irvine_18/Irvine.pdf)

<http://www.macaulay.ac.uk/relu/>



# The economic impacts of sport shooting in the highlands of Scotland



*Nils Bonnéfeld*

## Background

**S**port shooting, hereafter referred to as shooting and used to include all forms of shooting of game species, provides employment for 16,300 full time equivalent (FTE) posts and is estimated to be worth £240 million annually to the Scottish economy. Comparatively little, however, is known about the capture and distribution of economic benefits at local and regional scales. In Scotland, the right to kill game resides with the land owner, although the right can be gifted or sold to third parties. How the right to shoot on private land is managed varies with the game species, and estate and owner motivation; there is therefore a diversity of management structures and practices which are likely to have an effect on the economic impact of shooting. The aims of this study are to construct

a typology which captures the diversity of organisational structures which provide access to shooting opportunities in the Highlands and Islands of Scotland, and to describe the local and regional economic impacts of these “styles” of estate management in terms of employment and whole supply chain effects.

## Approach

Semi-structured interviews were conducted with 24 stakeholders involved with the management of 33 estates in the Highlands and Islands region. Interview questions aimed to establish: the type of ownership, size of estate, type of shooting, the relative importance of shooting compared to other estate activities, and the commercialisation of the sport (e.g. how much shooting was let),

and whether shooting was managed “in-hand”, through a sporting agent, or syndicated. We also asked questions designed to establish the local and regional economic impacts of the sport in terms of employment and the purchasing of goods and services.

## Results

Shooting providers in the Highlands and Islands can be assigned to three main “styles” (Table 1): (i) “highly commercialised sporting estates” are privately owned estates where shooting is the primary management objective and most of the shooting is let, (ii) “non-commercial estates” may be owned privately, by an NGO or the government, no sport is let, either because it is retained for the enjoyment of the owner or because the primary objective is biodiversity management and the shooting takes the form of a deer cull, and (iii) estates with “let shooting as a non-primary activity” are estates owned privately, by an NGO or in community ownership, where either farming or biodiversity conservation is the primary management objective, and all shooting is commercially let.

Regardless of the management “style”, the majority of shooting guests come from outside of the Highlands and Islands region and typically stay in estate-owned accommodation, which can be attributed to a desire on the part of estates to partially offset game management and provision costs. There is very little variation in terms of

the sourcing of goods and services between the three “styles”, with most goods and services being purchased locally where possible. The main difference between management “styles” is the level of employment: Highly commercialised estates generally employ more staff (mean=20.5 FTE) than non-commercial (mean=1.5 FTE) and sport non-primary (mean=2 FTE) estates.

## Conclusions

This study reveals a spectrum of “styles” of sporting estate management which range from the occasionally profitable, to the marginally commercial, to the unambiguously loss-making. But behind these commercial and non-commercial activities lies a web of complex and beneficial economic interactions with the regional economies in which these estates are based. The evidence suggests that the greater the intensity of sporting management the greater the beneficial local economic impact.

## Acknowledgements

*This work forms part of the project “North Hunt: Sustainable hunting tourism in Northern Europe” and was funded by the Northern Periphery Programme and RERAD. We are particularly grateful to all those who took part in the study.*

Contact: Scott Newey ([s.newey@macaulay.ac.uk](mailto:s.newey@macaulay.ac.uk))



<http://www.north-hunt.org>

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in Europe's Northern  
Periphery for a sustainable  
and prosperous future

	Highly commercialised	Non-commercial	Sport non-primary
Relative importance of sport	Primary or very important	Typically primary, or used for biodiversity management	Not the primary management objective
Amount of let shooting	Most with some retained by the owner	None	All, with the possible exception of hind/doe culls
Type of shooting done	All types	Predominantly deer-stalking	All types
Size (acres)	Typically larger than 10,000, with some larger than 50,000	Typically between 10,000 and 25,000	Varies, from less than 5,000 to close to 50,000
Use of sporting agents	Some	None	Not common
Shooting rights let to tenants or syndicates	Some, particularly on larger estates	None	Rare
Ownership	Private	Private, NGO and government	Private, NGO and government

Table 1: Typology of sport shooting providers in the Highlands and Islands of Scotland

# Culling hares to boost grouse numbers



Scott Newey

## Background

Louping ill virus (LIV) is transmitted by ticks and kills a high proportion of infected red grouse. Mountain hares can carry ticks and can also transmit the virus to other ticks non-viraemically, i.e. through the skin between ticks feeding close together, rather than via the blood system. Therefore, controlling LIV is considered to be important for the continued financial viability of estates managed for grouse shooting. Thus, in some places, grouse managers consider culling mountain hares in order to control ticks and louping ill, in the hope of boosting numbers of red grouse and evidence from a postal survey of land managers shows that a higher proportion of hares are now being killed as part of tick control strategies than for sport. The consequences of

culling on mountain hare conservation status and the upland ecosystem are unknown.

## Mountain Hares

Mountain hares are a UK Biodiversity Action Plan species, and listed in Annex V of the EC Habitats Directive (1992), as a species 'of community interest whose taking in the wild and exploitation may be subject to management measures' which requires Member States to ensure the conservation status of mountain hares is maintained and that their populations are managed sustainably. Mountain hares are an important quarry and prey species, and as a numerous and widespread herbivore in the

uplands play an important but unexplored role in shaping upland habitats and predator communities. Mountain hare populations are under threat from habitat loss, fragmentation, and over-exploitation and are thought to have declined the UK.

## The hare-deer-grouse-sheep-tick System

- Mountain hares; are important tick hosts and though they do not show clinical symptoms of LIV they can transmit the virus between co-feeding ticks, and can act as a disease reservoir.
- Red deer; are important tick hosts, but do not show clinical symptoms of LIV and can not transmit the LIV.
- Red grouse; are a tick host and can suffer high mortality from LIV infection and can transmit the LIV.
- Sheep; are an important tick host and can suffer high mortality from LIV infection. Sheep can transmit the LIV. Sheep can be vaccinated against LIV and can be treated with acaracides to kill biting ticks.

## Does reducing mountain hare density improve red grouse numbers by reducing ticks and LIV prevalence?

Evidence to support the use of hare culling to control ticks, LIV and improve red grouse production comes from one study designed to test the hypothesis that mountain hares act as a disease reservoir to LIV and was not designed to test if mountain hare culling can reduce ticks or LIV. Over a number of years, mountain hare density was reduced on one sporting estate in the Central Highlands where LIV seroprevalence in young red grouse was unusually high (80%). The subsequent changes in tick abundance, LIV prevalence, red grouse brood survival and post-breeding red grouse densities were compared to grouse moors where mountain hare density was not manipulated. This study showed that reducing mountain hare density was associated with a decrease in ticks, lower LIV seroprevalence in shot young grouse and increased grouse chick survival.

However, there are some reasons why the

findings of this one study might not be applicable to most other grouse moors in Scotland. The most important point is that red deer (*Cervus elephus*), which occur on most Scottish grouse moors were, unusually, absent from the study site. While deer do not show symptoms of LIV they are important tick hosts and modelling studies predicted that mountain hare culling would not be effective if alternative tick hosts, such as deer, were present. The model predicted that, even if mountain hares were eradicated, ticks and LIV could still persist if red deer were present, even in low densities. The tick population could persist in the deer population and LIV could be maintained the red grouse population.

## Conclusion

Overall, we found no compelling evidence to suggest that culling mountain hares increases red grouse densities, and hence harvest, except under very particular, and unusual, circumstances (i.e. very high LIV prevalence in red grouse and an absence of red deer, meaning that mountain hares are the only alternative tick hosts). Further, as the demographic response of hare populations to culling is unknown, it is impossible to predict to what extent density dependent processes will affect culling efficiency.

There is a lack of conclusive evidence that culling mountain hares improves red grouse numbers, especially in the presence of other tick hosts.

*Further reading:*

Harrison et al. (2010) *Journal of Applied Ecology* 47, 926-930.

<http://www.macaulay.ac.uk/hares>

Contact: Scott Newey ([s.newey@macaulay.ac.uk](mailto:s.newey@macaulay.ac.uk))



Scott Newey

# The impact of climate-wildlife interactions on ticks

can this help inform tick control strategies?



Lucy Gilbert

## Background

**T**ick numbers are increasing in the Scottish uplands with implications for increased risk of tick-borne diseases. For example, Lyme disease reports in humans are increasing dramatically, and louping ill virus, which kills red grouse and sheep, is a serious issue in the uplands. These increases may be due in part to climate change and/or increased hosts. Of particular concern to some land managers is that the grouse shooting industry may become unsustainable due to ticks and louping ill virus. In the hope of mitigating these problems, attempts are being made in some areas to reduce ticks. Tick control methods include: culling mountain hares, which transmit louping ill virus; culling or fencing out deer, which are the primary tick host; or adding flocks of sheep



frequently treated with acaricide to kill ticks. We are interested in whether ticks are being affected by climate change or by hosts, and how will this information help tick control policies to be targeted in an optimum way?

## Aims

We aimed to answer the questions:

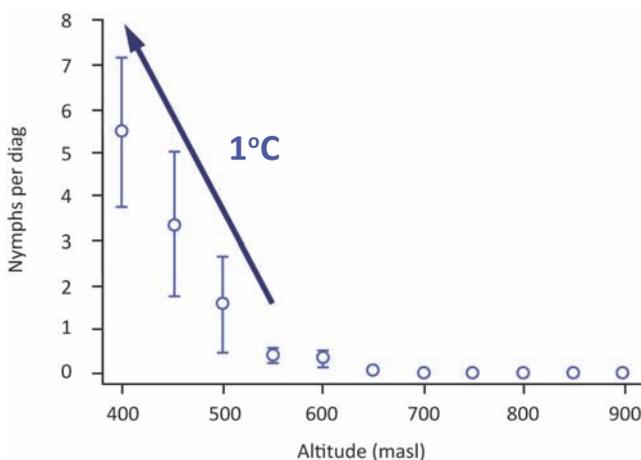
1. *How is climate change affecting ticks in upland Scotland?*
2. *How do hosts and climate interact to determine tick numbers?*
3. *Can this information help to inform policy on how and where to best implement tick control methods?*

## Approach

Climate changes with altitude and, importantly, so do the vegetation and hosts associated with that climate. We therefore used altitudinal gradients as a surrogate for climate change. We surveyed ticks by dragging blankets and hosts by counting dung over nine altitudinal gradients in the Cairngorms, between 400-900m above sea level.

## Results

- Tick abundance dramatically declined with increasing altitude (Fig. 1).

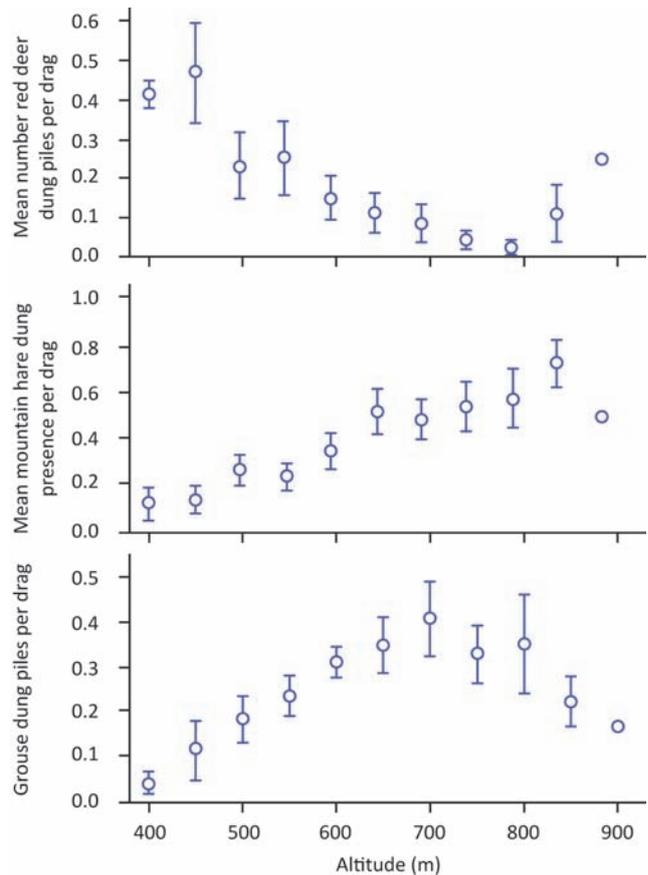


**Fig. 1: Ticks increase dramatically between 550-400m, equivalent to a climate change of 1°C. Deer numbers also play a role in this increase in ticks**

- Hosts also changed with altitude (Fig. 2): deer were more abundant at low altitudes (warm climate), mountain hare numbers increased with altitude (cold climate) and grouse were most abundant at intermediate altitudes (550-800m). Note that above 750m ptarmigan replace or augment red grouse; dung counts could not distinguish between these species.
- Statistical models showed that tick numbers increased with increasing deer numbers and at the same time increased with decreasing altitude. Because key components of altitude, such as vegetation and hosts, were taken account of in the model, we could conclude that the statistical effect of “altitude” was primarily a climate effect.

## Conclusions

Tick numbers increase as altitude drops from 550 to 400m, equivalent to the climate warming



**Fig. 2: The abundance of red deer, mountain hares, and grouse vary with altitude (and therefore climate)**

by just 1°C. However, UKCP09 predicted that summer temperatures will increase by an average of 2.8°C in Scotland by 2080. We can therefore predict that tick numbers will generally increase with climate change in upland Scotland, and will also spread further uphill.

Higher tick abundance at lower altitudes was not due to temperature alone, but also due to more deer at lower altitudes.

Tick control strategies will clearly benefit grouse most if they are conducted where both grouse and ticks coincide. However, results from our nine sites suggested that ticks were uncommon above 550m, whereas grouse became more abundant above 550m.

Therefore, tick control strategies may have most benefit where grouse occur below 550m. At these altitudes, there are generally fewer mountain hares, but management policies targeting deer and sheep might potentially help mitigate tick problems. Other issues relating to deer and sheep management would have to be carefully assessed in line with environmental policies.

*Further reading:*

*Gilbert, L. (2010), Oecologia, 162 (1), 217-225.*

*Contact: Lucy Gilbert (l.gilbert@macaulay.ac.uk)*

# Bird diversity and upland management



## Background

**T**he Scottish uplands, comprising large expanses of heather moorland, are highly valued and recognised as an important habitat for birds, many of which have experienced declines over recent years. Thus, this semi-natural heather dominated community maintained by traditional management practices of livestock production and sport shooting is listed as a priority habitat in the UK Biodiversity Action Plan.

## Aims and Rationale

Previous work suggests wader abundance increases in association with grouse moor management. However at the Macaulay Land Use Research Institute we wanted to build on this and were interested in investigating how various upland management practices influenced bird species diversity. This is of current interest

as there is a drive to maintain biodiversity whilst changes in upland management are being experienced. Changes include reductions in upland sheep farming, influenced by changes in agricultural policy, reductions in the number of full time gamekeepers employed on estates and an increase in afforestation. Furthermore, there has been an increase in the proportion of land managed by conservation organisations.

## Approach

To investigate this relationship we conducted bird surveys on 26 sites across Scotland (Fig. 1) ranging from commercial grouse moors where practices such as muirburn and predator control are common practice, to conservation sites where the management choice is often to allow natural regeneration. At each site we also interviewed a land manager who was able to tell us about

the management of the site. The information provided by these gamekeepers, farmers, conservation workers and landowners enabled us to quantify the extent of muirburn, predator control, and grazing by sheep and deer on each estate.

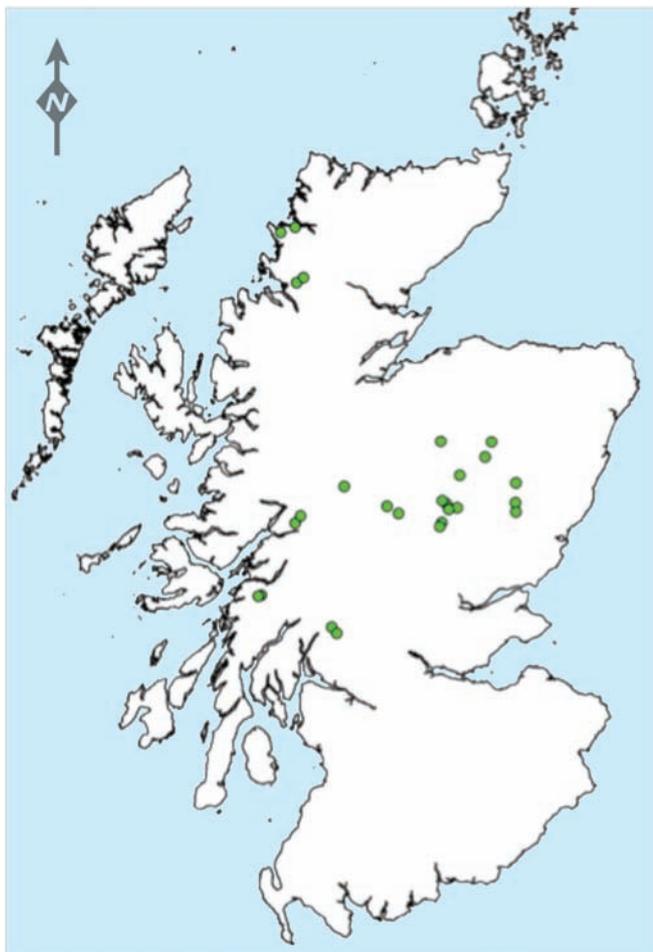


Fig. 1: Location of bird survey sites

## Results and Conclusions

Initial results suggest that management which benefits waders may not necessarily benefit groups such as the passerines. Our key results are listed below:

Key results:

- Higher numbers of waders were found on sites with more muirburn (Fig. 2)
- Curlew and golden plover were most abundant on estates with more predator control
- More passerines (song birds) were recorded on sites where there were more sheep (Fig. 3)

Both the high number of wader species on sites with more heather burning and also the high abundance of curlew and golden plover on estates with more predator control supports

previous work. This suggests that grouse moor management has a positive effect on waders. However, we also found more passerine species where higher numbers of sheep were present. This indicates passerines are sensitive to grazing pressure, possibly suggesting that the heather grass mosaic created by sheep grazing provides suitable habitat for this group of birds. Further analysis is ongoing to tease apart the relationships between the different management practices and bird species diversity.

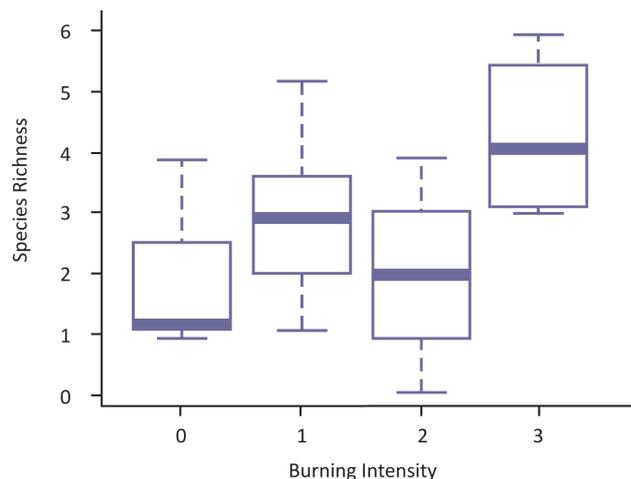


Fig. 2: Wader species richness in relation to burning intensity (y axis spp richness)

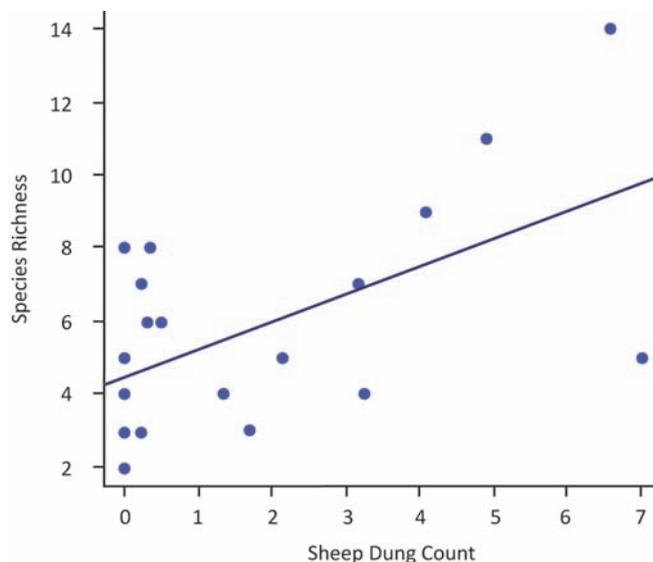


Fig. 3: Passerine species richness in relation to sheep density based on dung counts

Contact: Debbie Fielding ([d.fielding@macaulay.ac.uk](mailto:d.fielding@macaulay.ac.uk))

<http://fp7hunt.net>



# Livestock retreat from the hills

## consequences for deer and plant diversity



Richard Birnie

### Background

**D**ecades of grazing at high levels has raised concerns about habitat condition and the loss of biodiversity, particularly on the dwindling areas of heather moor. However, there have been significant reductions in sheep numbers in recent years particularly in the North and West Highlands. Since there is evidence that sheep have a greater grazing and trampling impact on heather-dominated vegetation communities than other herbivores, these recent reductions in sheep stocks should raise hopes for habitat recovery.

However, there is uncertainty about the potential for recovery. First, red deer densities may increase because of a reduction in competition with sheep. Second, even if deer numbers do

not increase, deer may prefer to graze on the grassy swards vacated by the removal of sheep so that effective impacts remain locally high. Third, even if deer densities are also reduced, heather may not be able to re-colonise large grass patches without additional management intervention. To date research has tended to concentrate on habitat condition and there has been comparatively little assessment of the consequences of changing the ratios and/or densities of deer and sheep on plant diversity in the uplands.

### Approach

We surveyed ten pairs of sites in the Scottish uplands. Each pair consisted of a site where

red deer and sheep were present and a site where sheep had been removed in the recent past. Within pairs, we chose areas of heather-dominated communities with similar altitudes and aspects. At these sites we quantified the effect of sheep removal on deer density, the consequences of deer density for heather utilisation and the relationship between herbivore densities and plant species diversity. The work was carried out in 2007 and repeated in 2009.

## Results

- Deer dung counts (a measure of deer grazing pressure) were higher (Fig. 1a) and heather was shorter when sheep were absent. Furthermore, utilisation of heather increased significantly in relation to increasing deer dung counts (Fig. 1b), the amount of grass present and smooth grass height.
- The number of plant species present (Alpha diversity) increased with the percentage of grass in sites, but was also increased with the amount of sheep dung, a measure of sheep grazing pressure (Fig. 1c). Plant species turnover (a measure of heterogeneity of plant species across the landscape - Beta diversity) was higher when sheep were present (Fig. 1d)

and also greater for sites with taller heather.

- Our results suggest that a mixed grazing regime increases upland plant diversity, compared to deer-only grazing, and may keep deer populations at lower densities, at least in the short-term, potentially reducing heather utilisation.

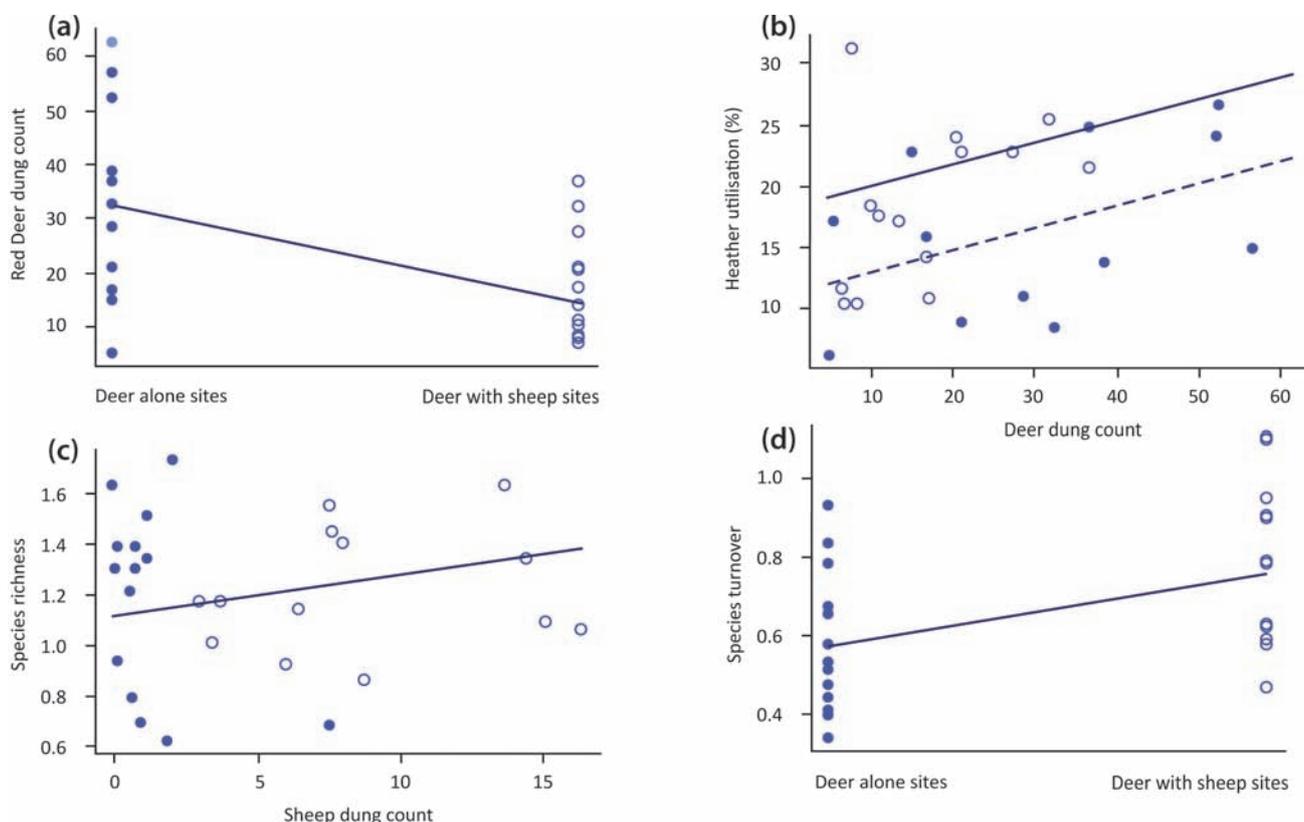
## Conclusions

Upland heath is a UKBAP priority habitat and halting its decline is a policy objective. Understanding the important role different herbivores have on habitat condition and the consequences for biodiversity is essential if we are to find a balance between public and private objectives for the management of the uplands. The work highlights the need for policy instruments that can take into account the response and impacts of the deer population when livestock densities are modified through the Common Agricultural Policy (CAP) policy implementation.

*Further reading:*

*DeGabriel, J.L., et al. Journal of Applied Ecology (in press).*

*Contact: Justin Irvine (j. Irvine@macaulay.ac.uk)*



**Fig.1:** Closed circles indicate observed values for sites with only deer; open circles indicate sites with both deer and sheep  
**Note:** for b) the solid line shows the relationship in 2007 and the dashed line is for 2009

# Unravelling grazing impacts on biodiversity in the uplands



Gina Prior

## Background

Changes are afoot in the management of upland grasslands. In 2003, agricultural subsidies based on livestock numbers were replaced by the Single Farm Payment. This has prompted year on year reductions in sheep and cattle numbers and grazing abandonment in some areas. With 12.3% of Scotland being covered by semi natural acid grassland, such changes could significantly alter our landscape and impact on the biodiversity that uses it.

## Approach

The GRUB (Grazing and Upland Birds) project started in 2002 on the Woodland Trust's largest land holding, the Glen Finglas estate. Since then it has been helping to unravel the cascading

effects through the food web of changed grazing regimes. The experiment consists of four treatments: high intensity sheep grazing, low intensity sheep grazing, low intensity mixed sheep and cattle grazing and ungrazed plots. This is now the only long-term replicated upland grazing experiment of its kind in Britain.

## Results

Some effects of the different grazing regimes became apparent early in the project. For example, breeding Meadow Pipits (the commonest bird at the site) showed higher densities in the less grazed plots. In particular, highest densities were found in the mixed sheep and cattle grazed plots. Other changes have

occurred much more slowly, with vegetation communities showing little change.

Changes in the vegetation structure provide a clue to what is causing these trends in Meadow Pipit densities. Whilst the plant species in the plots have not changed markedly, the proportion that each species contributes to the overall vegetation biomass has changed. As one might expect, the vegetation is lower where grazing pressure is higher (Fig. 1). However, the activity of grazers is patchy, especially in the low intensity mixed sheep and cattle grazed plots where the different grazing styles of these two animals are apparent, and this produces a varied sward structure with a mosaic of short and tall vegetation.

Responses to the grazing regimes vary between different insect groups but phytophagous (plant eating) insects such as leafhoppers have shown reduced abundance where grazing pressure is highest. Indeed, some leafhopper species can be several times more abundant in ungrazed plots compared to the other treatments<sup>1</sup> (Fig. 2). The reason pipits are also not most abundant in these areas is that not all food is equally accessible to them. The most common leafhoppers in ungrazed plots are epigeic species. This means that they live at ground level, deep underneath tall, dense vegetation and such insects may simply be too difficult for pipits to get to. Pipits do the next best thing and choose to forage for prey in areas with low grazing intensity that still harbour large insect populations but crucially, also have a more varied structure, allowing the birds to get in among the vegetation<sup>2</sup>.

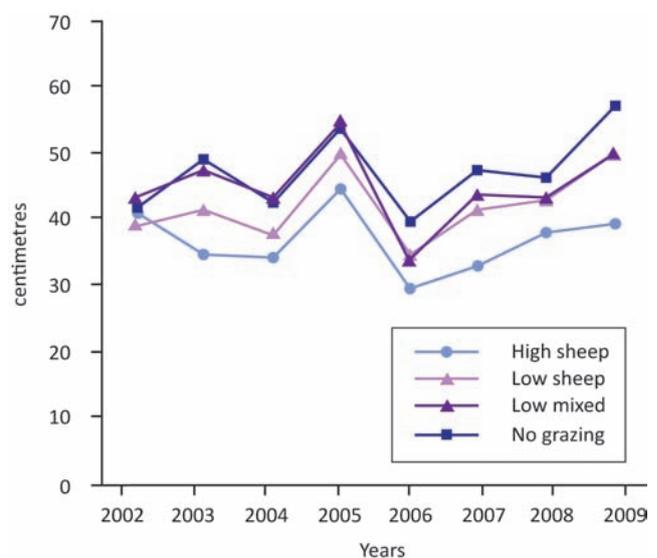
## Conclusions

Meadow Pipits are in a significant long-term decline as a UK breeding bird with a drop in numbers of 20% between 1995 and 2008. Whilst multiple mechanisms are likely to contribute to this, the Glen Finglas experiment is showing that abandonment of sheep grazing in upland Scotland might be having the ironic effect of making their food more abundant but simply less accessible.

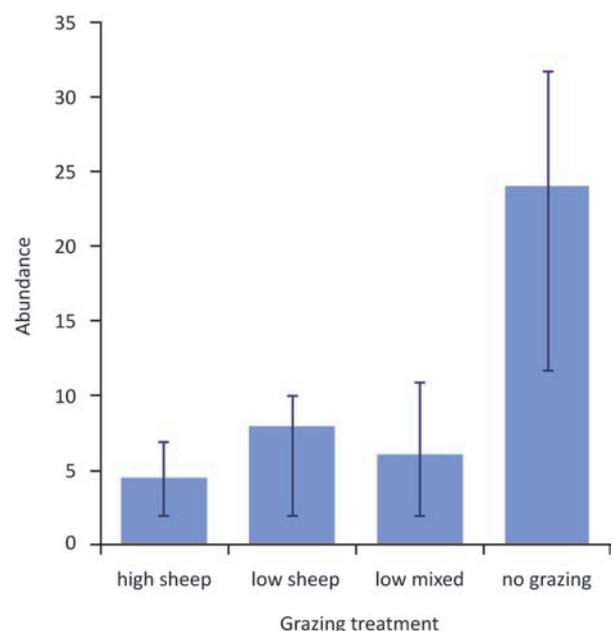
*Further reading:*

1. Littlewood *et al.* *Insect Conservation and Diversity* (in press).
2. Vandenberghe *et al.* (2009) *Basic and Applied Ecology*, 10, 662-670.

Contact: Nick Littlewood ([n.littlewood@macaulay.ac.uk](mailto:n.littlewood@macaulay.ac.uk))



**Fig. 1: Vegetation height in each grazing treatment, 2002-2009 (note 2002 was the baseline year with grazing treatments being implemented from spring 2003)**



**Fig. 2: Mean abundance (with standard error bars) of adult leafhoppers in suction samples from each grazing treatment in summer 2007**



# Deer performance and health in the Scottish uplands



Sharon Flanigan

## Background

With widespread support from many large open-hill sporting estates in Scotland and in collaboration with colleagues from Forest Research, we have over the last three years, begun to collect information on red and roe deer performance and health. The underlying purpose is to be able to understand whether factors such as climate and land-use change (for example as a result of the reduction in sheep stocking rates on the hills) are affecting deer performance and health. While many estates have collected some information routinely for many years, one of the strengths of this project lies in the agreement of all participants to collect information in the same way and to the same standard, which we audit as part of the project.

## Approach

To date we have around 5,000 individual records in our database. Information includes deer carcass weight and length, estimated age, weight of kidney fat and the indicative signs of some important diseases such as liver fluke. With this developing resource, we have begun to conduct some analyses that have enabled us to feed back preliminary findings to the participating estates and we can already see differences emerging between estates and the two culling seasons we have studied so far. Since the estates cover the length and breadth of Scotland we hope to understand better the influence of underlying factors such as habitat quality, management and weather.

## Results

To give a flavour of potential outputs, we can generate plots of carcass weight against each estate in an easily-visualised format (Fig. 1). In relation to observations of liver fluke, we can show that there is an association between annual rainfall and the observation of lesions (Fig. 2). Another aspect of the project is to try to develop an accurate field guide to ageing deer, based on their tooth presence and the wear of molars. While this is of fundamental interest to any estate, in order for us to use the information to understand climate change and management in the long term, it is critical to have an accurate age for each carcass. In a previous report (Up-land), we explained how this was done in our laboratory but we do need a precise and reliable method that can be easily used by stalkers in the game larders.

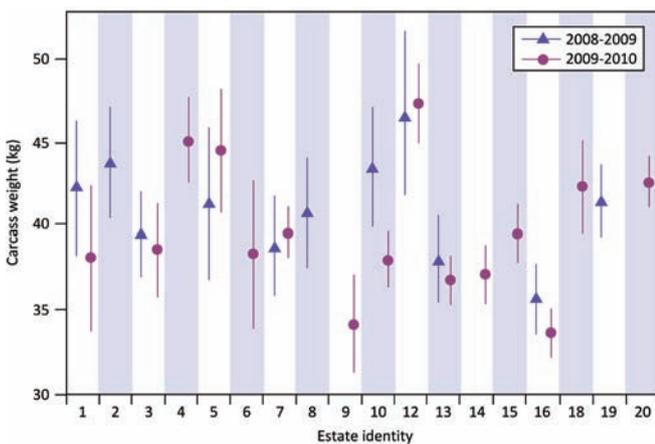


Fig. 1: Range of hind carcass weights for individual estates in 2008-2009 and 2009-2010.

## Conclusions

We recognise that the real value of this project will accrue as reliable records accumulate across many years and we wish to acknowledge the commitment and effort of participating estates to making this possible. This will allow us to develop statistical models to investigate the relationship between environmental and management factors using our range of indicators in order to track changes within and between deer populations over time. This will contribute to the evidence base for supporting Scotland's Wild Deer: A National Approach.

Contact: Pete Goddard ([p.goddard@macaulay.ac.uk](mailto:p.goddard@macaulay.ac.uk))

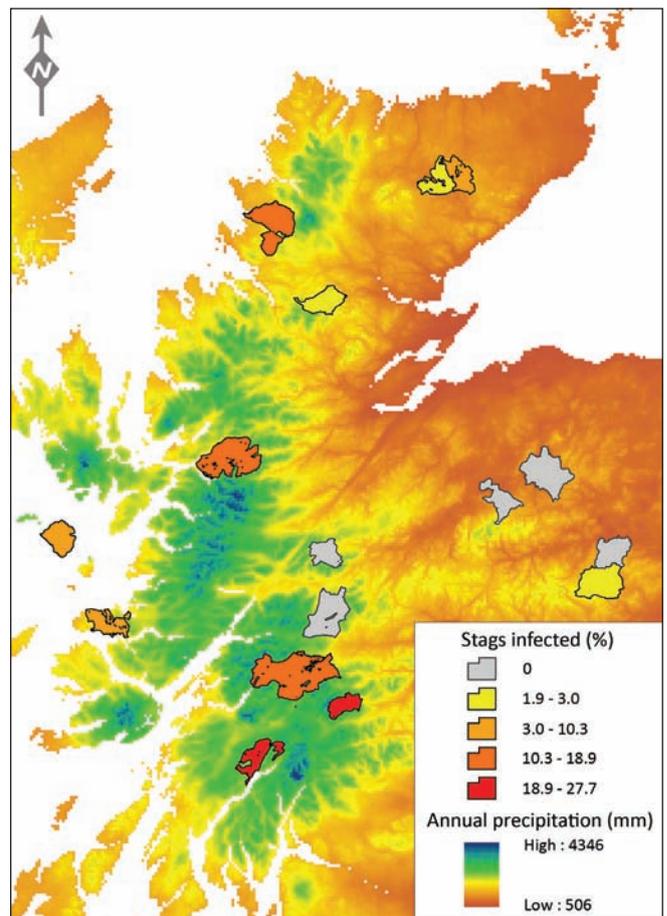


Fig. 2: Prevalence of liver fluke in red deer stags, culled in sixteen estates, in relation to annual precipitation (averaged 1971 – 2000). Stags were culled between May 2009 and February 2010

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This booklet summarises some of the key findings concerning sustainable upland management that have arisen from the Scottish Government Rural and Environment Research and Analysis Directorate's research programme "Environment – Land Use and Rural Stewardship".

The research programme involved researchers from:

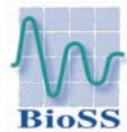
Biomathematics and Statistics Scotland

Macaulay Land Use Research Institute

Moredun Research Institute

Scottish Agricultural College

Additional funding on the strength of this programme was secured from RCUK and the EU which has added value to the research.



Further information can be found at  
<http://www.programme3.net/>

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