

Langholm Moor Demonstration Project

Seven Year Review – December 2014

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The Langholm Moor Demonstration Project Seven Year Review – December 2014

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The Langholm Moor Demonstration Project

Seven Year Review – December 2014

I Executive summary

- 1.1. This document reviews the first seven years (2008 to 2014) of the Langholm Moor Demonstration Project (LMDP – the project). It is a 10-year project designed to show whether and how it is possible to manage the moor in such a way as to produce a combination of good habitat, a population of breeding hen harriers in line with its SPA status, and economically viable driven red grouse shooting. It is thereby a demonstration of how to resolve the conflicts between moorland management for raptors and red grouse. It is the only demonstration of this kind in the UK.
- 1.2. Langholm was the principal moor in the Joint Raptor Study (JRS) in the 1990s, which quantified the impact that raptors could have on red grouse and showed that predation by hen harrier populations may reach levels sufficient to render red grouse shooting unviable. Therefore, when shooting became unviable in 1997, the gamekeepers were laid off¹ and habitat and predator management virtually ceased until the keeping restarted as part of the new LMDP in spring 2008. During that period of little or no keeping, crow and fox numbers increased, breeding hen harrier numbers dropped back to pre-JRS levels, grouse numbers further declined, breeding wader populations declined to very low numbers, and the status of both the SSSI² and SPA³ was found to be unfavourable. The loss of grouse shooting also had a significant negative impact on the local economy. To many observers this represented a 'lose-lose' situation in terms of nature conservation, culture, employment and economic activity.
- 1.3. The LMDP is designed to work towards a potential 'win-win' situation where breeding raptors coexist with commercial driven grouse shooting. The project is relevant to other moors; the central question is: **can moors with low grouse numbers achieve an economically viable state in Scotland with the available policy and management tools?**
- 1.4. The project area covers 11,960 hectares (29,553 acres). It includes the Langholm Moor SSSI/SPA, the areas previously managed as grouse beats, and surrounding buffer areas where legal predator control is undertaken to support the management of the grouse beats.
- 1.5. The core objective is **“to establish Langholm Moor as a driven grouse moor [and] to meet the nature conservation objectives for the SPA and SSSI”**. The project has four deliverables:
 1. Demonstration of how to resolve conflicts between moorland management for raptors and red grouse;
 2. The hen harrier population would be maintained as a viable component of the SPA;
 3. The heather moorland habitat would be extended and improved beyond its state in 2002;
 4. The number of red grouse harvested (shot) would be sufficient to ensure the moor reaches a financially viable state.

¹ Redeployed to other parts of the Buccleuch Estate.

² Site of Special Scientific Interest

³ Special Protection Area

- 1.6. Progress is guided by six evaluation criteria:
1. Heather moorland habitat
 2. Red grouse numbers
 3. Hen harriers and other raptors (birds of prey)
 4. Other wildlife – passerines, waders and voles
 5. Compatible management for raptors and red grouse – predators and predation
 6. Stakeholder engagement and influence
- 1.7. We have used a standard ‘traffic light’ system to provide a clear visual on progress and the end of project projection (see section 5).
- 1.7.1. Habitat improvements and raptor populations are both rated **green**. The number of nesting hen harriers in 2014 exceeded the Project target. The moor also supports high numbers of buzzards, alongside goshawks, peregrines, merlin and short eared owls. The targets of expanding the area of heather and improving heather condition have both been met.
- 1.7.2. Red grouse recovery is classified **red**; despite seven years of keeping, grouse numbers have not recovered sufficiently to allow driven shooting (the target is 1,000 brace shot in one year). It is important to remember that grouse numbers are recovering from a low base. The end of project projection is **red/amber** in anticipation of a need to trial further adaptive management options (in addition to the existing successful diversionary feeding of harrier nests) to benefit both raptor conservation and grouse management and achieve the target for grouse shot.
- 1.7.3. Waders and passerines are rated **amber**. The population targets have not been met for waders, but have been for meadow pipits (in 2014). It is difficult to predict whether the wader targets will be met by the end of the project given the decline in wader numbers nationally during the period of the project, but it is hoped they will respond to habitat improvements.
- 1.7.4. We have not yet achieved the desired compatibility between red grouse and raptors. The quality of keeping and legal predator control is good, as is grouse health, but grouse mortality all year round is high and 78% of adult grouse found dead can be attributed to raptor predation. The evidence does not allow us to distinguish between raptor species. It has not yet proved possible to restore Langholm to a productive grouse moor with the available policy and management tools. This criterion is rated **amber** at the moment, with an end of project projection of **red/amber**, again in anticipation of a need to trial further adaptive management options.
- 1.7.5. Stakeholder engagement is **green** and has led to a better understanding of moorland management; how a viable game shooting enterprise underpins this moorland management; an increased acknowledgement that birds of prey are an important component of a functioning moorland ecosystem; and an improved understanding of practicable and acceptable options to resolving current management concerns.
- 1.8. The diversionary feeding of hen harriers proved to be a cost-effective, practical and viable technique for reducing predation of grouse whilst there were a maximum of three harrier nests (the first six years.)

- I.9. We are not confident that the target of 1,000 brace shot can be achieved within the project timescale given current management measures. We have reasonable confidence that grouse recovery is not being restricted by habitat, but may be restricted by raptor predation of adult grouse and low grouse productivity post laying; we cannot yet determine the cause of the latter with confidence but it seems likely it is also associated with raptor predation rather than disease, inadequate food supply, weather conditions or other mortality.
- I.10. Two large-scale outbreaks of heather beetle in 2009 and 2010 have prompted the keeping team to develop novel restoration and reseedling techniques, which could be of significant help to other moors in Scotland.
- I.11. The annual investment in keeping is £225,000. The keepers' moorland management has allowed it to meet its habitat targets and the SPA objectives, but we now need to consider new adaptive management measures to realise an economic reward in terms of grouse shooting. Until that return on investment is delivered, LMDP is not providing an example of an economic model that other marginal/recovering moors can follow.
- I.12. The project potentially has another three years to run. The key challenge remaining is to achieve grouse recovery. We will be preparing an 'options/next steps' paper for publication in early 2015.

2 Purpose of this Review

- 2.1. This document reviews the first seven years of the Langholm Moor Demonstration Project (LMDP – the project). It is a 10-year project with a review every three years to clarify progress, consider whether and how the project should continue, and to aid communications. The first review is on the project website: www.langholmproject.com
- 2.2. This review is slightly out of sync as year six ended on 31 October 2013, and this report is being finalised in September 2014. We have included all available year seven data to make the review as up to date as possible.
- 2.3. The review has been approved by the project's directors; the evidence within it has been reviewed by the project's scientists and advisors.
- 2.4. There is much published literature on the hen harrier/red grouse conflict. Whilst this review tries to give enough explanation to make it a readily understandable document, it does not attempt to cover all aspects of the subject. A list of suggested further reading is attached in Appendix 5.

3 Project background

- 3.1. Langholm Moor is a well-known grouse moor with a long history of driven red grouse shooting (the historic grouse bags are given in Appendix 1). Over the last 24 years, it has had a central role in trying to resolve the conservation conflict between grouse moor management and raptor conservation (see box below). Langholm was the principal moor in the Joint Raptor Study⁴ (JRS) in the 1990s, which quantified the impact that raptors could have on red grouse and showed that predation by hen harrier populations may reach levels sufficient to render red grouse shooting unviable



*Project staff on Langholm Moor
(Photo credit: Rob Yorke)*

The conflict

In the winter, UK breeding hen harriers are dispersed across Great Britain, Ireland and Continental Europe⁵, and in the spring they move back to breed in heather habitats within the uplands. Hen harriers are generalist hunters and eat a wide variety of small birds and mammals. Harriers appear to readily settle on moorland in the spring, when and where there are many voles and pipits. However, when harriers are feeding their own chicks, red grouse are simultaneously hatching broods in the vicinity – and the grouse can then become an important prey for harriers.

Red grouse are managed as a wild quarry species, gamekeepers seeking to improve productivity and reduce losses of grouse in order to produce a sustainably harvestable surplus in time for the start of the shooting season on 12 August each year. The impact of predators on breeding adult grouse and their chicks is, particularly when grouse densities are low, felt to be unsustainable by sporting interests and this leads to illegal killing of hen harriers. This is having significant impact on the UK hen harrier population and international conservation obligations.

⁴ A collaborative research venture, undertaken jointly by the Game Conservancy Trust (now the GWCT) and the Institute of Terrestrial Ecology (now the Centre for Ecology and Hydrology), but funded and guided by a consortium of interest groups that included the RSPB, Scottish Natural Heritage and Buccleuch Estates.

⁵ Some female harriers do remain in the uplands.

- 3.2. Since October 2007 the moor has hosted the *LMDP*, designed to show whether and how it is possible to manage the moor in such a way as to produce a combination of good habitat, a population of breeding hen harriers in line with its SPA status, and economically viable driven⁶ red grouse shooting, and thereby a *demonstration of how to resolve the conflicts between moorland management for raptors and red grouse*. It is the only demonstration of this kind in the UK.
- 3.3. After driven red grouse shooting at Langholm became unviable at the end of the JRS, the gamekeepers were laid off⁷ and habitat and predator management virtually ceased until the keeping restarted as part of the new *LMDP* in spring 2008. During that period of little or no keeping, crow and fox numbers increased, breeding hen harrier numbers dropped back to pre-JRS levels, grouse numbers further declined, breeding wader populations declined to very low numbers and the status of both the SSSI and SPA was found to be unfavourable. It is not disputed that the loss of grouse shooting also had a significant negative impact on the local economy, though no formal study has been done.
- 3.4. The JRS was conclusive and ground breaking; it opened eyes to a genuine conservation conflict that had to be addressed. To many observers the events in (3.3) represented a 'lose-lose' situation in terms of nature conservation, culture, employment and economic activity. The Langholm Moor Demonstration Project (*LMDP*) was designed to work towards a potential 'win-win' situation where breeding raptors could coexist with commercial driven grouse shooting. The project has considerable relevance to other moors as it aims to answer the question:

Can moors with low grouse numbers achieve an economically viable state in Scotland with the available policy and management tools?⁸

- 3.5. The *LMDP* is a partnership comprising Buccleuch Estates, Scottish Natural Heritage (SNH), the Game & Wildlife Conservation Trust (GWCT), RSPB and Natural England (NE).

"I visited the Langholm Moor Demonstration Project last year and was very impressed with partnership working and the shared determination to succeed in finding a sustainable approach to managing for red grouse while supporting a healthy population of raptors. Great work has been done on restoring the habitat, with heather returning to good condition, the hen harrier population has responded well to the sympathetic management, and diversionary feeding has helped reduce predation on grouse. There is more to be done to get Langholm as a viable working moor again, as is the objective of the landowner, but I am confident we have a team of people with the science and practical know-how to achieve that while sustaining a healthy population of hen harriers and other species"



Paul Wheelhouse, Minister for Environment & Climate Change,
Scottish Government. September 2014.

⁶ Langholm Moor is a driven grouse moor and the project targets assume driven grouse shooting. In the context of this Review any reference to grouse shooting is to driven grouse shooting, not walked up.

⁷ Redeployed to other parts of the Buccleuch Estate.

⁸ Source: Susan Davies, Director, SNH.

4 Project description and objectives

4.1. Location and land area. Langholm Moor is situated between Langholm and Newcastleton within Dumfries & Galloway and the Scottish Borders. The project area covers 11,960 hectares (29,553 acres; Figure 1). It includes the Langholm Moor SSSI/SPA⁹, the areas previously managed as grouse beats, and surrounding buffer areas where legal predator control is undertaken to support the management of the grouse beats. The SPA has hen harrier as the main qualifying feature (further details are given on the project website), and the SSSI designation is for the site's range of upland habitats (including heather moorland, blanket bog, dwarf shrub heath and breeding birds).

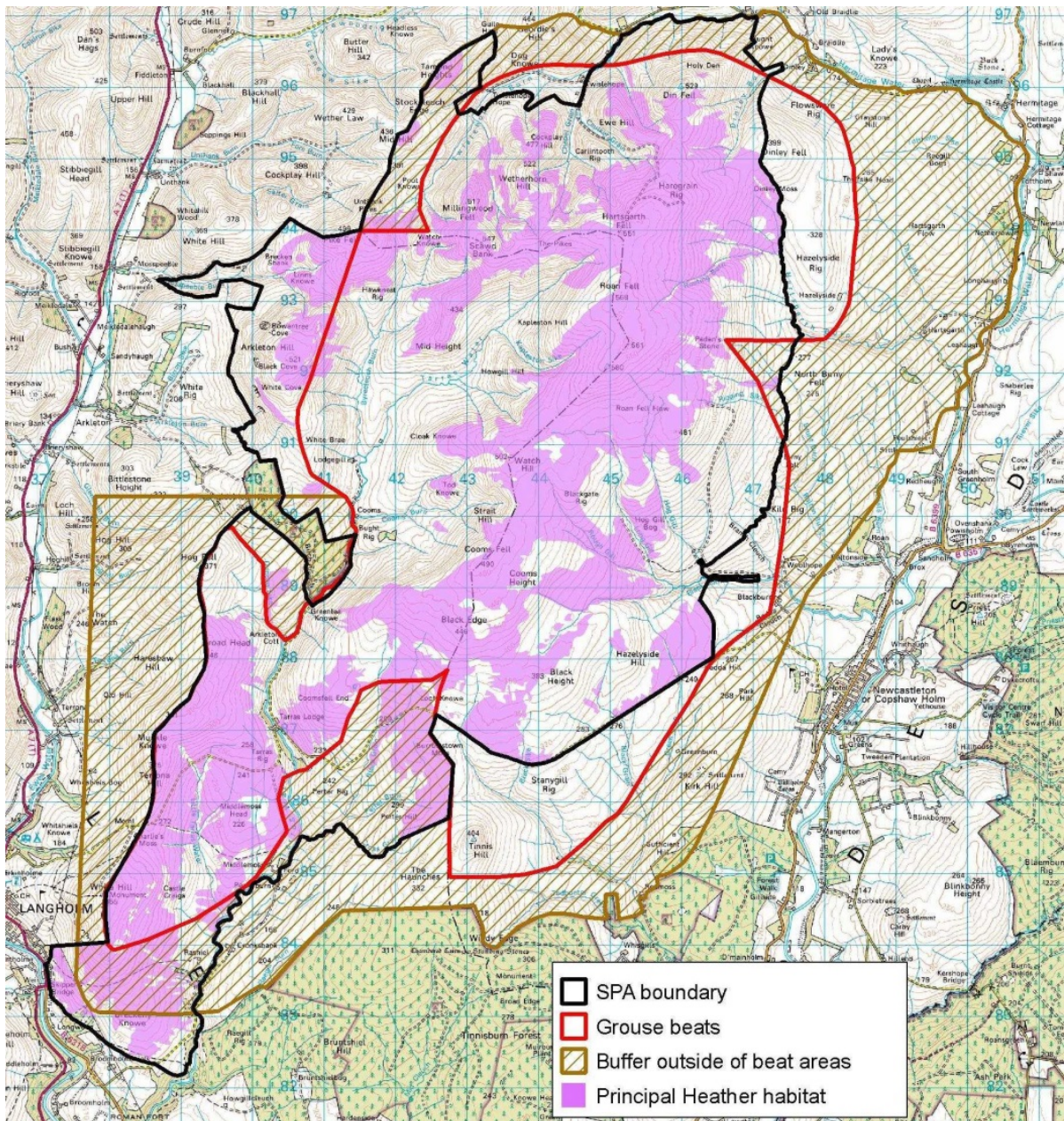


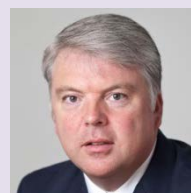
Figure 1. The Langholm Moor project area (brown line), showing heather areas and SPA.

⁹ Site of Special Scientific Interest / Special Protection Area

- 4.2. **Core objective.** This is “to establish Langholm Moor as a driven grouse moor [and] to meet the nature conservation objectives for the SPA and SSSI”.
- 4.3. **Deliverables.** To achieve the objective above, the project set out to deliver four specific elements:
1. Demonstration of how to resolve conflicts between moorland management for raptors and red grouse.
 2. The hen harrier population would be maintained as a viable component of the SPA.
 3. The heather moorland habitat would be extended and improved beyond its state in 2002.
 4. The number of red grouse harvested (shot) would be sufficient to ensure the moor reaches a financially viable state.

Current chairman of the Project Board, Mark Oddy, explains:

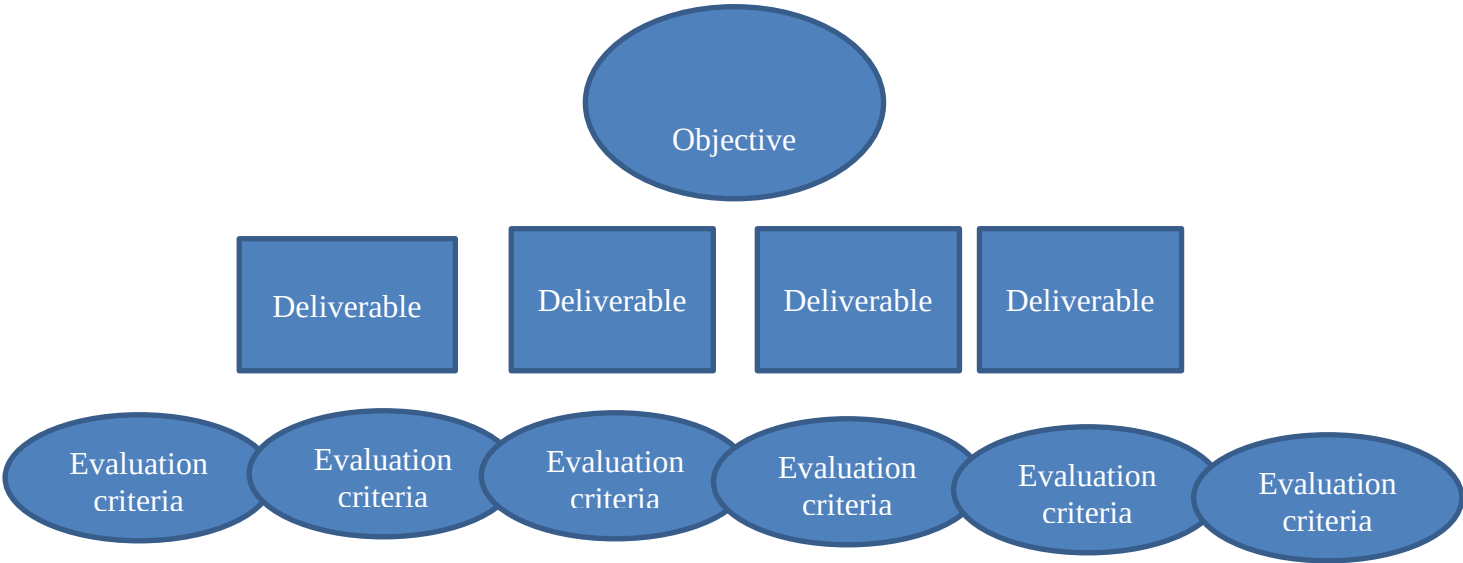
‘The aim is to demonstrate whether it is possible to ‘recover’ a driven grouse moor (within the current legal framework) and then run it as one. The economic driver of shooting supports the employment of at least five keepers whose work delivers the nature conservation objectives for the SPA and SSSI though not necessarily making a financial surplus. The shooting target was set at 1,000 brace (or 2,000 birds), as a way of demonstrating that then the moor would be ‘on track’ to reach financial viability’.



Mark Oddy is the Buccleuch Estate representative on the Project Board

- 4.4. **Evaluation criteria.** Progress in achieving these elements is reviewed every three years, guided by six (it was originally five – see 4.5) evaluation criteria. Section 5 gives a detailed review against each of these criteria; key points are then brought together in a discussion in section 6.
1. Heather moorland habitat
 2. Red grouse numbers
 3. Hen harriers and other raptors (birds of prey)
 4. Other wildlife – passerines, waders and voles
 5. Compatible management for raptors and red grouse – predators and predation
 6. Stakeholder engagement and influence
- 4.5. As a demonstration project, stakeholder engagement, good communication and influencing policy and practice is important. Although that was not included in the original evaluation criteria, with hindsight that was a mistake and it is reported on in this review.
- 4.6. **Governance and operational structure.** This is set out on the project’s website, as is the programme of scientific monitoring.

4.7. It is important to note that the LMDP is a ‘scientifically monitored demonstration project’; it is not an experiment.¹⁰



¹⁰ To date there has been no experimental control of variables within the project. Setting up the project as an experiment with treatment, control and replication would have delayed the search for practical solutions to meeting the objectives and would have increased costs beyond the point where the project was feasible.

5 Status report

This section gives a tabular assessment of the evaluation criteria set for the project, progress at the seven-year point against the targets, and a forward projection to the end of the project. We have illustrated using the standard ‘traffic light’ system to provide a clear visual on progress and the end of project projection. The status is defined as:

‘Green’ = on target/project target already met

‘Amber’ = not on target but management intervention expected to bring it back on track

‘Red’ = not on target and unlikely to be influenced directly by project actions before the end of the project.

Evaluation criteria	Progress at end of seven years		End of project projection	
	Status	Notes	Status	Notes
Habitat improvement (section 7, page 14)	Green	The targets of expanding the area of heather and improving heather condition have both been met.	Green	It is anticipated that habitat will continue to improve.
Red grouse (section 8, page 16)	Red	After seven years, grouse numbers have not recovered sufficiently for shooting. It is important to remember that grouse numbers are recovering from a low base.	Red/ Amber (with adaptive management options)	It is anticipated that there will be a need to trial further adaptive management options (in addition to the existing successful diversionary feeding of harrier nests) to benefit both raptor conservation and grouse management and achieve the target for grouse shot.
Raptors (section 9, page 22)	Green	Number of nesting hen harriers in 2014 exceeded target.	Green	All raptors are expected to remain in good conservation status.
Other wildlife – waders & passerines (section 10, page 27)	Amber	The population targets have not been met for waders, but meadow pipits reached the target in 2014.	Amber	It is hoped wader numbers will respond as a result of the improved habitat and continuing predator control.
Compatibility between management for raptor & red grouse interests (section 11, page 30)	Amber	We have not yet found the win-win solution for both raptors and red grouse. The quality of keeping and legal predator control is good, as is grouse health, but grouse mortality all year round is high and deaths of 78% of adult grouse have been attributed to raptor predation. We cannot distinguish raptor species from evidence. It has not yet proved possible to restore Langholm to a productive grouse moor with the available policy and management tools.	Red/ Amber (with adaptive management options)	The project will need to trial further adaptive management options (in addition to the existing successful diversionary feeding of harrier nests) to benefit both raptor conservation and grouse management.
Stakeholder engagement and influence (section 12, page 36)	Green	35 on-site visits. 20 off-site events. 9 other activities. Reached at least 1,350 people.	Green	Aiming for improved understanding of practicable and acceptable options to resolving current management concerns.

6 Review of progress at the end of year 7

Sections 7 to 12 summarise progress against the project's five evaluation criteria; for each there is an 'agreed position statement' on progress given in the text box at the beginning of each section¹¹. Environmental and management information, and key data and the supporting data relevant to the evaluation, are summarised in the 'agreed position statement'. More detail is provided in the notes that follow each text box.

7 Habitat improvement

General aim:

- To increase the extent, and improve the condition, of heather moorland (dry heath and blanket bog) at Langholm beyond the baseline of that recorded in 2002.

Specific targets:

- To increase heather cover by 20% beyond the 2002 baseline of 1,240ha of dry heath by the tenth year, i.e. effectively restore and enhance up to 250ha of moorland currently made up of areas of white ground and degraded heather within the four grouse beats on Langholm Moor.
- To attain an improvement in the condition assessment of the moor in accordance with SNH's *Site Condition Monitoring* principles.



Heath spotted orchid (Rob Yorke)

Progress (agreed Position Statement):

- Analysis of aerial photographs between 1988 and 2009 showed a significant decline in extent¹² of areas with heather cover (see 7.1 below).
- We have already reached our target of increasing the extent of heather moorland.
- We have improved the condition¹³ of heather moorland (dry heath and blanket bog) at Langholm beyond the baseline of that recorded in 2002.
- Heather decline¹⁴ in the red grouse block counts has generally been halted and was partially reversed between 2007 and 2013.
- There were large-scale heather beetle attacks in 2009 and 2010. A small outbreak of heather beetle in July 2014 needs monitoring and provides an opportunity to assess options to minimise the extent of outbreaks and maximise heather recovery (including on areas already recovering).
- Reductions in grazing on around 6,600ha of the moor through sheep reductions and away wintering have taken place since 2011, and this has helped heather recovery.
- Since 2009, heather reseedling work has been undertaken on around 300ha, involving herbicide treatment, burn/cut, and reseed with a moorland seed mix, which has resulted in heather regeneration.
- Bracken control has been carried out in 2009 and 2011 on around 600ha.
- Considerable progress has been made to break up degenerate and mature heather by cutting and burning.

¹¹ This has been reviewed and agreed by project staff, the Scientific Contact Group (SCG), the Scientific and Technical Advisory Group (STAG) and, finally, the Project Board.

¹² By heather extent we mean heather cover.

¹³ By heather condition we mean a condition favourable for red grouse, i.e. a mosaic of young, nutritious heather and older heather, providing cover and nesting habitat.

¹⁴ By heather decline we mean the reduction in heather cover.

7.1. Change in distribution of heather cover over time. Analysis of aerial photographs between 1948, 1988 and 2009 showed a significant decline in extent of areas with heather cover (though it is noted that the loss was greater outside the project area where grouse shooting has ceased). Heather-dominated cover (>50% heather) decreased from 31km² (1988) to 10km² (see Figure 2). Areas with >30% heather cover declined from 55km² (1988) to 22km². There was a 68% decrease in heather cover between 1988 and 2009 (outside the project boundary the decline was 83%).

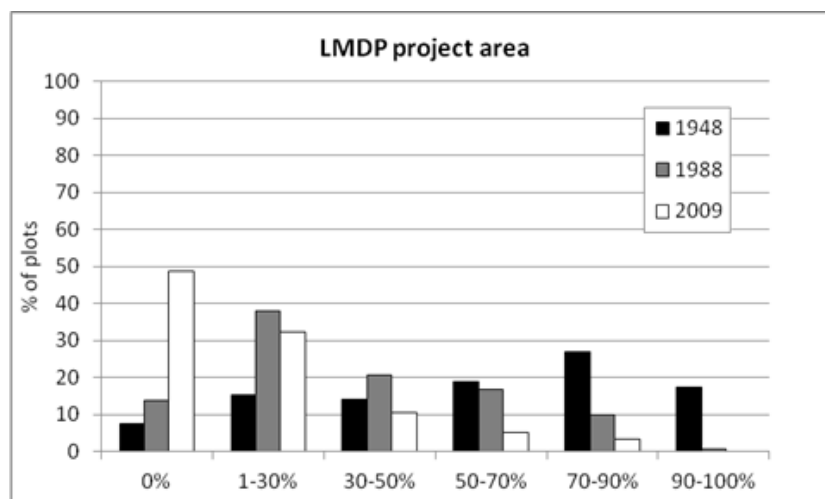


Figure 2. Change in the distribution of heather cover between 1948, 1988 and 2009 on the LMDP area (N=459 25ha plots, 11,475ha). The same areas were evaluated during JRS.

7.2. Habitat management measures undertaken. The habitat management undertaken by the gamekeeper team is the burning, cutting, spraying and reseedling of heather, bracken control and reducing sheep and goat grazing in collaboration with Buccleuch Estates' farming operation. More information is given in Appendix 2.



Heather burning on Langholm Moor

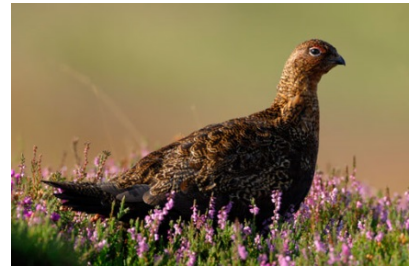
8 Red grouse

General aim:

- The number of red grouse harvested through driven grouse shooting to be sufficient to ensure the moor reaches a financially viable state.

Specific targets:

- A target of 2,000 red grouse (1,000 brace) shot in one year, with sustainable employment of keepers, by the end of the project.
- On a driven red grouse moor, in a typical year for grouse numbers and productivity, it is standard practice to shoot 30% of the grouse on a moor. Therefore a minimum population of around 6,000 birds would be needed in the autumn for a 'bag' of this size. At the beginning of the project this was calculated as a mean density of 150 birds per km² (100ha) in July based on 40km² (4,000ha) of grouse habitat. The aerial photography analysis subsequently revealed that core grouse habitat had reduced to 30km² (3,000ha) and the target density was revised to 200 birds/km². To achieve this July density, a spring density of around 90 birds per km² is needed assuming average productivity.



Red grouse

Progress (agreed Position Statement):

- Numbers (based on distance sampling).
 - Spring numbers increased during the first years of the project and have then levelled off at around 45 birds per km², before increasing to 82 birds per km² in 2014
 - The July counts increased rapidly to 100 grouse per km² in 2009, fell to around 80 grouse per km² until 2012, and increased to 123 grouse per km² in 2013, but did not show a further increase in 2014 with 121 birds per km²
- Productivity.
 - Clutch size. Higher on Langholm Moor than on most other Scottish and English moors.
 - Breeding productivity (measured as chicks per hen). Variable, but lower than on many Scottish and English moors. Most grouse chick losses occur during first three weeks after hatching. Further work on chick survival using radio tags will be undertaken in 2014 in order to quantify different mortality sources (e.g. starvation, predation and weather).
- Mortality.
 - Comparable to many other moors, but the mortality at Langholm Moor does not include shooting¹⁵, as there has been no shooting at Langholm during the project. The mortality rate of radio-tagged adult grouse does not vary between winter and summer.
- Grouse health.
 - Strongylosis¹⁶. Medicated grit to treat strongylosis has been in place since the start of the project. Worm and worm egg counts are below thresholds considered to be a problem for grouse. Worm counts have been undertaken in a total of 16 grouse; 56% had no worms and the rest had a mean of 134/bird. Worm egg counts from 247 samples of grouse caecal material showed that 50% had no eggs and the rest had a mean of 2,796 eggs, the equivalent of 588 worms per grouse. Routine sampling of worm eggs in grouse caecal foil will take place each year, but sample sizes need to be increased. We also recommend that worms are counted from any shot grouse.

¹⁵ Which on northern English moors accounts for 70% of over winter mortality.

¹⁶ Intestinal threadworms (*Trichostrongylus tenuis*) can reduce body condition and significantly reduce breeding productivity. These can be reduced or eliminated by use of medicated grit (a worming compound is 'bound' to the grit).

- Louping ill¹⁷. We believe that virus is absent (blood testing was done at the start of the project). Although shepherding staff routinely look for symptoms of louping ill in sheep, our confidence in the moor being disease-free decreases with increasing time since the date of the original testing. We therefore recommend red grouse are blood-tested as soon as shooting commences, and that sheep (and goats as they are culled) are repeat-tested as soon as possible.
- Ticks. Tick burdens of grouse chicks have been assessed since 2008. From a sample of 361 chicks, 79% had no ticks. Results indicate the number of ticks per grouse chick varied across the moor but that the numbers were below thresholds indicated to cause problems for grouse unless the ticks are carrying louping ill virus.
- Body condition. All grouse caught (to fit radio tags) have been in good body condition. This is supported by the fact that clutch size is higher than on most other Scottish and English moors.
- Winter weather/dispersal.
 - Virtually all radio-tagged red grouse remain on the moor rather than dispersing to other areas, even during cold winter weather.
 - Further work on survival in relation to weather conditions during winter would improve our knowledge of how weather may affect population dynamics of red grouse.
 - The potential of interactions between weather and predation will also be studied.
- Breeding season weather
 - Further work on productivity and adult survival in relation to weather during the breeding season would improve our knowledge of how weather affects population dynamics in red grouse.
 - A full analysis of our current dataset will follow and will include a study of the interaction between weather and predation.

8.1 Red grouse counting. Grouse counts are conducted using pointing dogs¹⁸. The surveyor walks along fixed transects, the pointer works on both sides of the transect line to search for grouse, and all birds pointed and flushed are recorded. Spring pair counts of red grouse are done in March/April to assess numbers likely to breed. Counts on the same areas are undertaken in July to determine breeding success and suggest whether and where there may be enough grouse to harvest. We use two counting methods at Langholm: block counts and distance sampling. See Appendix 3 for an explanation of these.



Counting red grouse using pointer dogs

8.2 Assessing whether shooting can take place. The grouse counts provide an indication on whether the overall grouse density is high enough to allow driven shooting. However, for the final decision the head keeper will also consider practical issues, such as the distribution of birds within the drives. If in doubt, “dummy drives” might be undertaken to see whether a sufficiently high number of birds can be driven over the butts.

¹⁷ Grouse suffer from louping ill, a viral disease spread through sheep tick bites. When infection rates are high, chick losses can be over 80% during the first 2-3 weeks of life. The condition affects sheep and goats in addition to grouse.

¹⁸ Pointers are dogs used for monitoring game birds (and for shooting). They are trained to detect birds and then stand ‘pointing’ at the birds without moving.

8.3 Grouse population modelling. The project science team has also created a model that considers the total number of grouse and a range of bag sizes. This helps inform whether a shootable surplus is likely within the project's lifespan, and whether shooting some grouse will prejudice the project's ability to reach its target of 1,000 brace shot; i.e. will there be a risk that we will 'shoot into (breeding) stock'?

8.4 Other red grouse monitoring. To assess causes for nesting failure, grouse nests have been fitted with thermal loggers (to record whether nest desertion/predation occurred by day or night), dummy eggs (to show teeth and bill marks) and nest cameras. Small radio-tags have been fitted both to young grouse (26 chicks tagged in 2013) and adults (170 tagged 2008-13) to monitor fate and dispersal.



A red grouse chick

8.5 Grouse population. Spring grouse numbers increased in 2009 and 2010, then remained relatively static at around 45 birds per km² in 2011, 2012 and 2013, before increasing to 82 birds per km² in 2014 (based on distance sampling – see Figure 3a and 3c). Breeding success in 2011 and 2012 was below average, improved in 2013, but then below average again in 2014 – reflected in the July counts – also in Figure 3a.

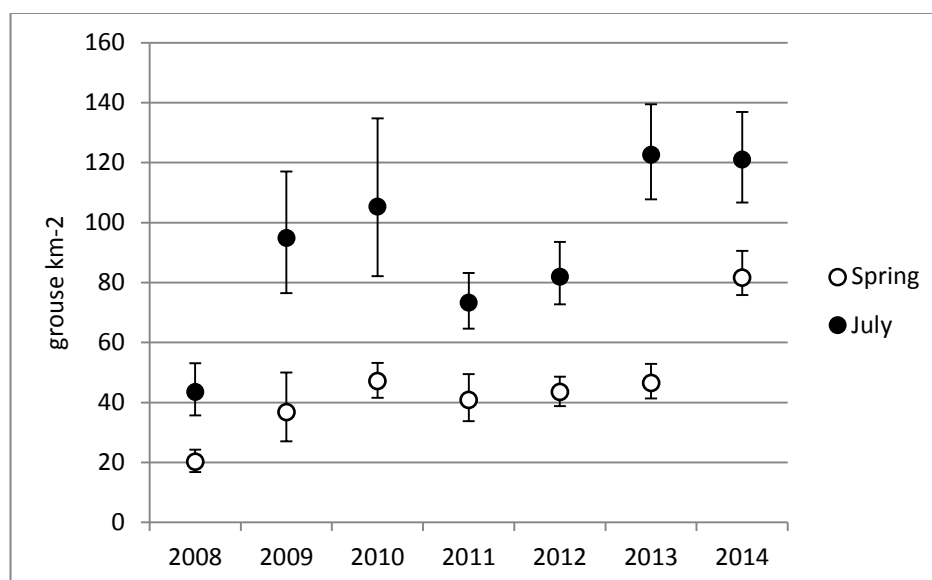


Figure 3a. Mean densities of red grouse at Langholm in spring and July derived from distance sampling. Error bars represent 95% CI.

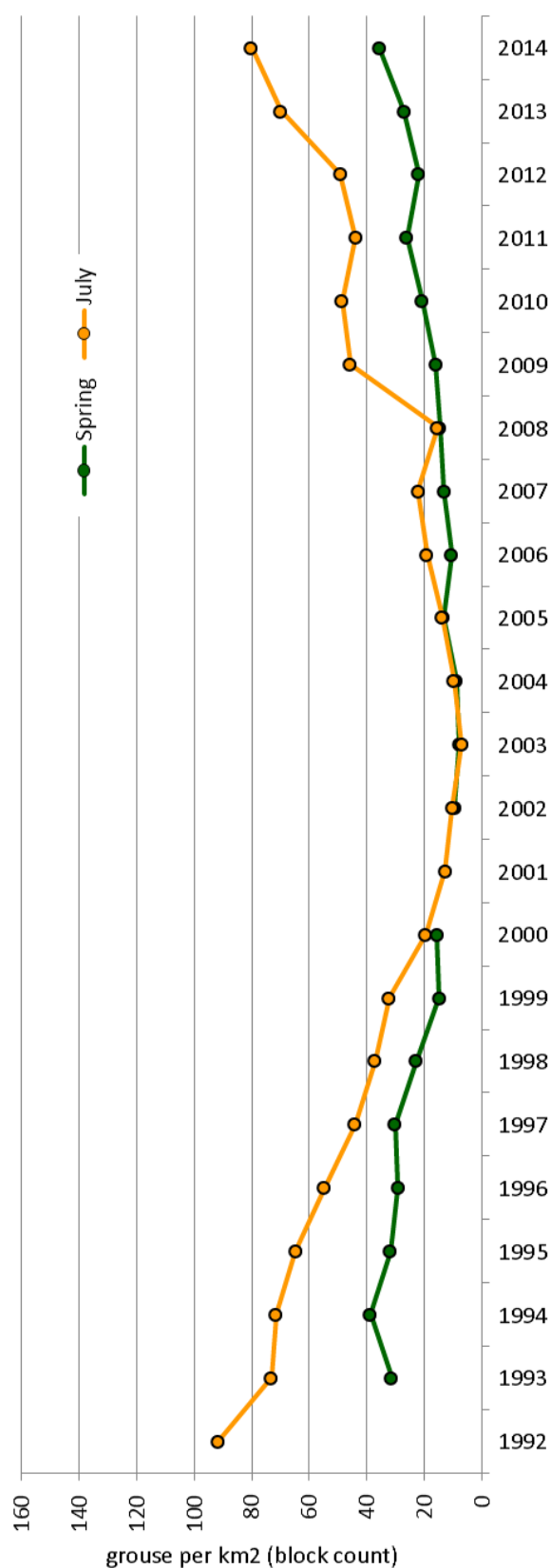


Figure 3b. Mean densities of red grouse at Langholm in spring and July derived from block counts.

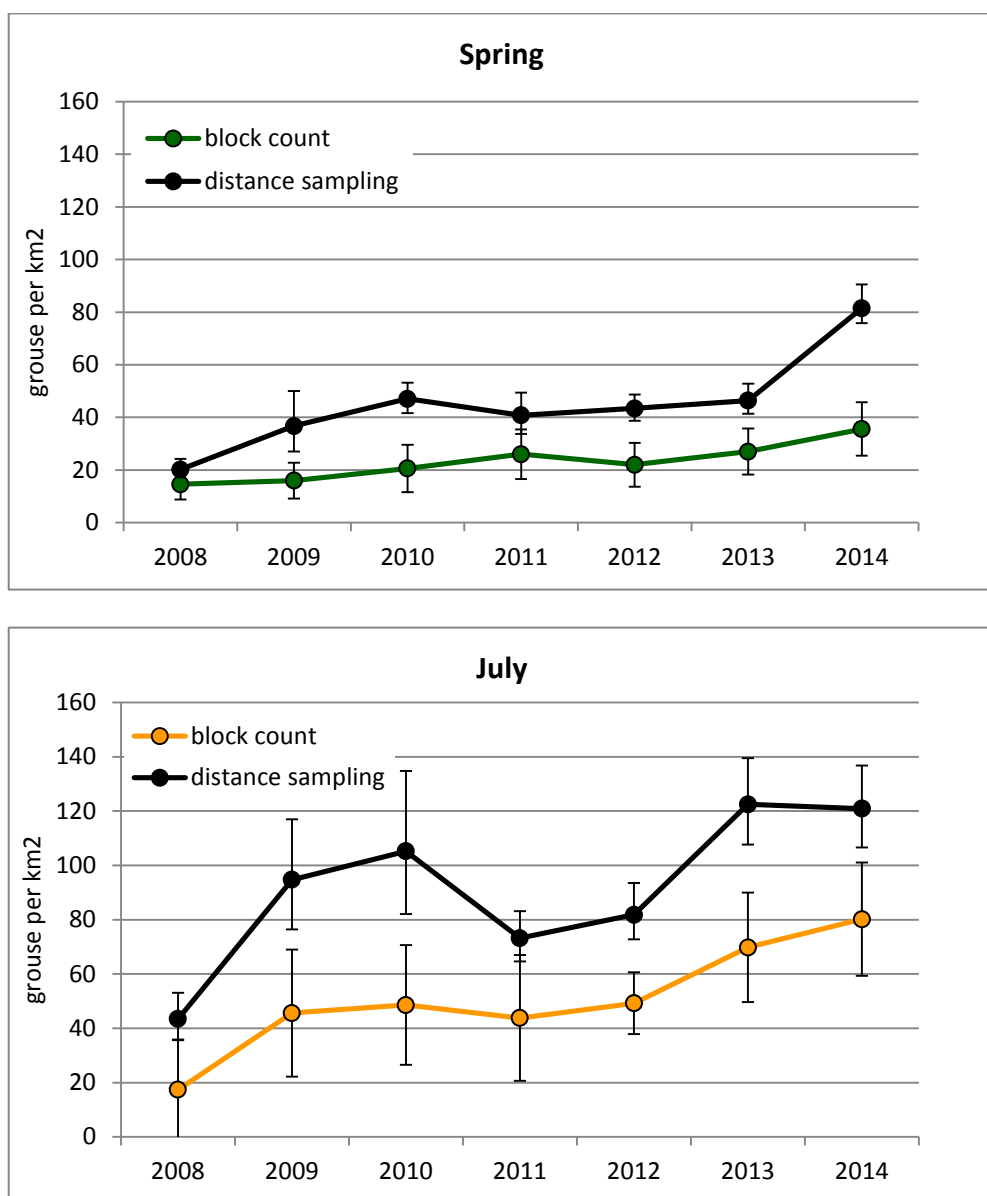


Figure 3c. Relationship between block counts and distance sampling – spring and July grouse counts ($\pm$ 95% CLs)

8.6. **Comparison of red grouse performance with other moors.** Table I compares red grouse performance at Langholm Moor with a sample of 25 English and 22 other Scottish moors¹⁹ between 2009 and 2012. It is important to note that the winter mortality at Langholm is without any mortality from shooting, whereas the English and Scottish comparison figures are with shooting. Our best estimate of the underlying mortality (i.e. without shooting) on the Scottish and English comparison moors is 17%.

¹⁹ There may be management differences between moors.

	LMDP	English moors (25)	Scottish moors (22)
Clutch size*	9.3	9.2 (0.3)	8.7 (0.1)
Nesting success ^{20*}	0.70	0.88 (0.06)	0.85 (0.02)
Brood size	4.1	5.7 (0.2)6	4.3 (0.2)
% hens with broods	0.75	0.91 (0.02)	0.79 (0.02)
Productivity ²¹	3.2	5.1 (0.2)	3.4 (0.2)
Density (spring) Block counts	22	95	49
Density (July) Block counts	39	281	104
Breeding “mortality”	23%	19% (2)	16% (3)
Winter “mortality”	42% without shooting	57% (2) with shooting	42% (3) with shooting

Table 1. Estimates of red grouse performance at Langholm during the LMDP (mean of four annual measures, 2009-2012) in the absence of shooting and the mean from 25 driven grouse moors in northern England and 22 moors in Scotland (data provided by GWCT). Standard errors are given in parentheses.

*Values for clutch size and nesting success are based on data from 4 English moors and 12 Scottish moors.

8.7 Income from grouse shooting. The project aim is for the revenue generated by shooting to approach the cost of managing the moor after ten years. The Project Plan originally valued shooting at approximately £47 per grouse (£94 per brace), so a 2,000 bird bag (1,000 brace) was expected to generate an income of £94,000. By year six (2013), driven grouse were valued at £140 per brace, potentially yielding £140,000. The cost of keeping (moorland management) in year six was £227,000²²; the cumulative cost of keeping (since the project started) is £1.26m. These costs include cottage rent for keeping staff but exclude any capital improvements made during the project (fencing, roads, etc).



Driven grouse shooting

8.8 As yet, no income has been generated through grouse shooting. In 2013 count numbers suggested that grouse numbers were at the lower margin for shooting. The keepers were concerned that there were still too few grouse to drive so a ‘test’ or ‘dummy’ drive was undertaken; on the strength of that shooting did not take place. The decision not to shoot was made again in 2014, for the same reasons as in 2013.

²⁰ Nesting success is proportion of nests which successfully hatch young.

²¹ Productivity is number of chicks per hen in July.

²² This figure comes from the project management accounts and includes the depreciation of working assets (machinery), but not fixed assets.

9 Raptors / Birds of prey

General aim:

- The project plan seeks compatibility between management for raptor and red grouse interests, and a viable population of hen harriers in line with site designation under the EC Birds Directive.

Specific target:

- To ensure the integrity of the Langholm SPA²³ status is maintained and to endeavour to meet a target of at least 1% of the UK population of female hen harriers (seven breeding females).



*Female hen harrier
(Rob Yorke)*

Progress (agreed Position Statement):

- The number of hen harriers breeding on the moor has remained low (1-3 breeding females) during the first six years of the project compared to the period of the Joint Raptor Study in the mid-1990s²⁴. However, the breeding success of those birds that have nested on the moor has been high (see Figure 4). Additional birds have been observed on the moor each spring but they have not settled. Some hen harriers that hatched at Langholm Moor have been fitted with wing or satellite tags and we have found that the return and report rate of these birds is low.
- In 2014, 12 female hen harriers nested at Langholm and from 10 nests reared 47 young, thereby meeting the project target. This last significant increase in harrier breeding numbers was during the JRS (see Figure 4). It is noted that this sudden peak coincides with the highest vole population in the area. Two of the 2014 nesting females were satellite tagged as chicks in 2013 and overwintered on Langholm and nearby moors. The natal area of other untagged females on the moor could not be identified.
- The diversionary feeding of hen harriers has proven to be a cost-effective, practical and viable technique for reducing predation of grouse during the period when harriers have chicks at or around the nest. No grouse were observed being brought to harrier nests during nest watches in 2008-2012. Further analyses of nest camera footage from 2010-2014 are underway. This statement comes with the caveats that in the first six years of the project, only a maximum of three nests have been fed per season, nests have been close to access tracks used by the keepers, and grouse numbers have been relatively low.
- Buzzards. In each year 2011-2013, there were 12 active buzzard nests on the moor, and between 7 and 11 nests were monitored within a 2km buffer zone around the moor (it is likely that some additional nests were not found). In 2014, nine buzzard nests were confirmed on the project area and an additional five nests within the buffer zone, however, search effort was reduced in that year. The number of buzzards recorded during vantage point (VP) watches varies between years and seasons, but in summer the number of buzzards recorded is three times higher than during JRS. During the winter, the number of buzzards recorded at VP watches is marginally higher than during the JRS. Analyses of prey items brought to nests recorded by nest cameras and of prey remains and pellets from in and around nests suggest that buzzards are opportunistic foragers, mainly eating voles, lagomorphs and pheasants. Over three breeding seasons (2011-2013), only 1.0% of prey items identified through nest camera footage and 4.8% of prey remains from in and around nests were red grouse.

²³ The rapid increase in hen harrier numbers during the Joint Raptor Study led to Langholm Moor being designated as an SPA for hen harriers in 2001 at the level of 13 breeding females.

²⁴ The UK population trend between 2004 and 2010 has been a significant decline of -18% (Hayhow et al. 2013).

- Data collected so far thus clearly shows that breeding buzzards provision very few grouse to their chicks. Further work is underway to study how (captive) buzzards digest grouse and other prey items to clarify how representative pellet remains are of their actual diet. In addition, radio-tagging of sub-adult and adult buzzards in order to identify roost sites where pellets could be collected is taking place to inform the amount of grouse the buzzards consume during the winter.
- Peregrines. The number of occupied territories has remained at generally 2-3 sites per year in and within 2km of the project area. Vantage point watches suggest that the summer densities of peregrines on the moor are equivalent to those observed during the JRS, whereas winter densities have declined. More work on the effects of peregrines on red grouse is needed.
- Goshawks. Vantage point watches suggest that the winter abundance of goshawks has declined at Langholm Moor since the JRS. There are no comparable data from JRS for the summer months. More work on the effects of goshawks on red grouse might be needed.

9.1 Harrier monitoring.²⁵ Breeding pairs are recorded by watching for displaying males ('sky dancing') from a series of vantage points. Nests are found by observing nest building and food passes, then monitored to determine hatching and fledging success. Nest cameras and observations from hides close to the nests are used to record the amount and type of food brought to the nests. Harrier pellets are also analysed to show prey remains.

9.2 Diversionary feeding of harriers. Feeding is done in accordance with a protocol developed following the JRS (for more information see www.snh.org.uk/pdfs/species/hen%20harriers.pdf). In the early years diversionary feeding was undertaken by the scientific staff; latterly the gamekeepers have taken over. Until 2009, feeding took place both pre-laying and post-hatching; thereafter post-hatching only.

9.3 Harrier numbers and breeding success. The numbers of breeding females and fledged young since 1992 are given in Figure 4. Productivity during the LMDP has been good, with on average 4.2 fledged young per female. In Scotland as a whole, the percentage of harriers rearing young has declined from 61% in 2004 to just under 43% in 2013. At the LMDP the equivalent figure in the seven years of the project is 83%.

²⁵ All raptor monitoring is done under a Schedule 1 licence.

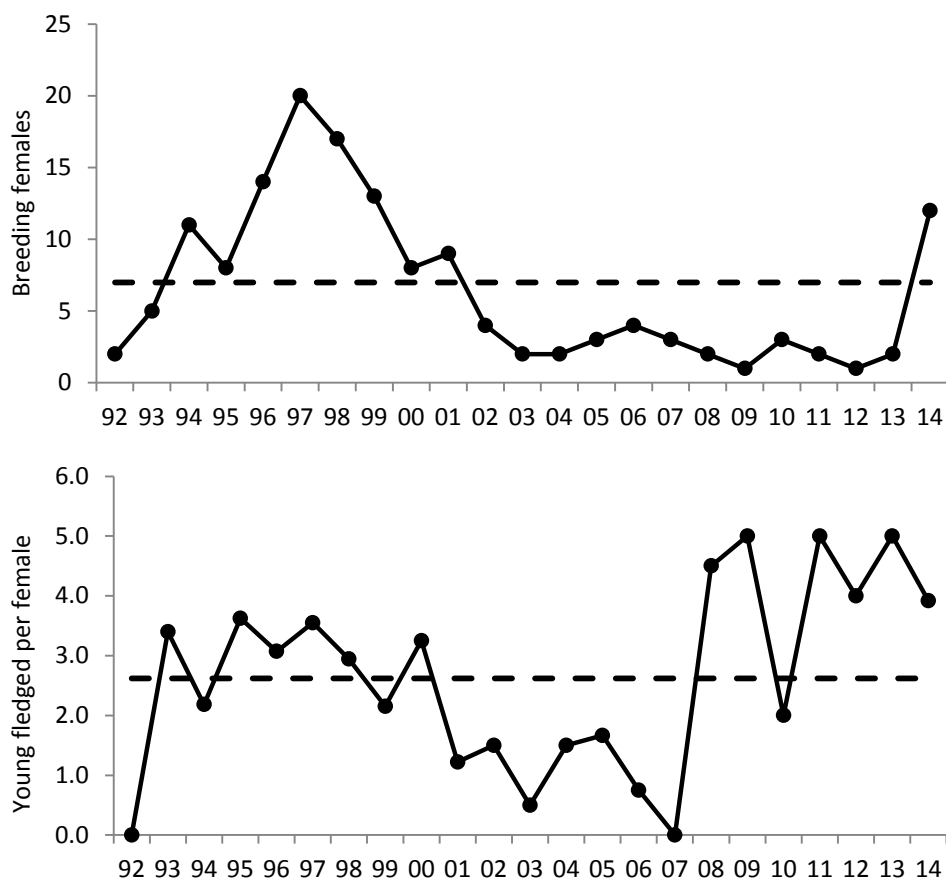


Figure 4. Number of breeding hen harrier females (top) and number of young fledged per female (bottom) from 1992 to 2014. The dashed lines represent the respective target values according to SPA guidelines.

This heightened success (in productivity) appears to be as result of keeping activity, which provides: protection from foxes, good hunting (hen harriers have been observed hunting along the cut edges of the heather and across the recently burnt areas²⁶) and nesting habitat (patches of longer heather have been retained as potential hen harrier nest sites), and an excellent food supply (including diversionary feeding). Breeding success increased markedly when keeping was restored (Figure 5).

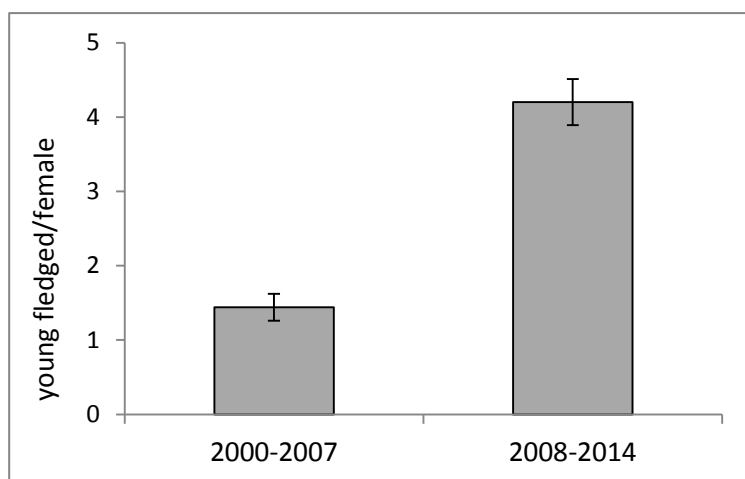


Figure 5. Mean number of hen harrier young fledged per female during the unkept years (2000-2007) and during LMDP (2008-2014) when keeping took place. Values for unkept years as given by Baines & Richardson (2013).

²⁶ Keeper observations

9.4 Vantage point (VP) raptor watches. These provide a relative abundance estimate of avian predators during summer and winter. The sites are those used during the JRS with three new sites. VP watches last three hours and the entire area is scanned at two-minute intervals with binoculars to detect both presence and behaviour of raptors. The number of raptor sightings per 100 scans is given in Table 2 below.

	Buzzard	Harrier	Peregrine	Goshawk	Kestrel	Merlin	Short eared owl
Winter							
JRS 92/93	5.58	3.06	1.91	0.24	4.95	0.01	0.37
JRS 93/94	8.15	4.77	2.02	0.02	9.68	0.01	0.57
JRS 94/95	1.52	1.00	2.47	0.06	2.37	0	0.40
LMDP 11/12	9.28	0.05	0.42	0.03	2.11	0.17	0.12
LMDP 12/13	3.20	0.01	0.07	0.01	0.59	0.03	0
LMDP 13/14	10.26	1.83	0.39	0.07	2.80	0.21	0.07
Summer							
JRS 94	3.36		0.25		4.38	0.14	2.98
JRS 95	3.49		0.12		2.68	0.15	0.10
JRS 96	2.96		0.22		0.98	0.10	0.98
LMDP 12	9.44	0.25	0.51	0.09	4.12	0.13	0.05
LMDP 13	6.17	2.14	0.26	0.16	1.18	0.24	0.20
LMDP 14	15.65	7.43	0.68	0	0.91	1.44	1.74

Table 2. Sightings of raptors per 100 scans during (A) winter vantage point watches and (B) summer vantage point watches.

9.5 Number of breeding pairs of raptors. Merlin pairs have increased significantly during the project (Table 3). Short-eared owls are present (see Table 2 above), but not systematically monitored. 1-2 pairs of goshawks bred within 2km outside the project boundary in an adjacent forest. Members of the Scottish Raptor Study Group (Dumfries & Galloway, Lothian & Borders) assisted with raptor monitoring and did annual surveys of traditional peregrine eyries to determine numbers and nesting success. Nest visits are minimised in frequency and duration, and essential visits are only carried out under suitable weather conditions.

Species	2008	2009	2010	2011	2012	2013	2014
Hen harrier	2	1	3	2	1	2	12
Peregrine	2	2	2	1	2	2	2
Merlin	1	1	4	5	3	6	6
Buzzard							
Project area only	(10)	(8)	14	12	12	12	(9)
2km buffer zone			1	7	4	11	5
Short-eared owl	(2)	(1)	(?)	(?)	(1)	(3)	(12)

Table 3. Number of raptor breeding pairs present on the project area during 2008-2014. Peregrine nests include one site within close proximity (500m) of the project boundary; for buzzards additional nests found within a 2km buffer zone outside the project boundary are given as well (note that search effort varied between years). Numbers in brackets are likely to be an underestimate as no systematic search for nests was carried out in these years.

9.6 **Buzzard studies.** Specific work on buzzards²⁷ included vantage point watches, systematic carcass searches, fitting Global Positioning System tags to full-grown buzzards, and locating and monitoring various nests, alongside diet analysis. In 2013, 26 buzzard chicks from 13 nests were ringed and fitted with coloured wing tags. In 2014, 17 buzzard chicks from seven nests were ringed and fitted with wing tags.



Inspecting a buzzard's nest

- 9.7 Observations and fixes of tagged buzzards at dusk highlight the location of roost sites, which can subsequently be searched for pellets to analyse for winter diet proportions. Initial results suggest that small mammals formed the largest proportion of prey identified in pellets (67%), with red grouse remains found in 3% of pellets and constituting 1% of identified prey in pellets. More work is currently underway into the biases associated with pellet analysis.
- 9.8 Between 2011 and 2013, vole indices from trapping surveys decreased from 6.7 voles per 100 traps to 0.6 voles per 100 traps. The presence of voles in buzzard diet decreased in line with this from 51% to 19% using camera images and from 9% to 1% using prey remains from buzzard nests. This appears to be compensated by an increase in the frequency of moles and other small mammals; from 25% to 45% using camera images and from 23% to 36% using prey remains.
- 9.9 There also appears to be a slight decrease in the proportion of grouse in the buzzard diet (with significant variation between nests) with decreasing vole abundance: from 13% to 2% using prey remains. This counter-intuitive response might be explained by buzzards responding to declining vole abundance on the moor and moving to hunt more on neighbouring farmland.



Juvenile buzzard in the nest (Rob Yorke)

²⁷ Undertaken as part of a PhD project hosted by Newcastle University.

10 Other wildlife – passerines, waders and voles

General aim:

- Project Plan is for a substantial population of passerines and waders, including the full range of species within the breeding bird assemblage present at the time of SSSI notification.

Specific targets:

The following densities were set, from Breeding Bird Survey (BBS) transects, as targets:

- Lapwing: 0.6 birds/km
- Curlew: 1.9 birds/km
- Golden plover: 0.5 birds/km
- Meadow pipit: 21.9 birds/km



Lapwing

Progress (agreed Position Statement)

- The numbers of wader and upland passerines, based on Breeding Bird Survey data, remained low (see Figure 7) across the moor during the first five years of the project, but in 2013 and 2014 there was an increase of both species groups, with meadow pipits reaching the target density in 2014.

10.1 Monitoring mammals. Vole numbers are estimated annually (using unbaited snap traps) and lagomorph (rabbit/hare) surveys are conducted within the farmland habitats on the project periphery specifically to support research on buzzards (see 9.9 above). Langholm seems to have a three-year vole cycle (see Figure 6 below).

10.2 Breeding waders (lapwing, curlew, and golden plover) and meadow pipit have been monitored in sample 1 km squares on the Langholm Estate since 1992 (see Figure 7). The abundance of all birds has been estimated annually using Breeding Bird Survey (BBS) techniques on 20 plots. Golden plover (0.2 birds/km) and curlew (0.9 birds/km) are now improving, but lapwings remaining low (0.1 birds/km), while meadow pipits have exceeded the target density (24.6 birds/km) (data from BBS late count).



Monitoring mammals

10.3 Upland Predation Experiment context. GWCT's Upland Predation Experiment at Otterburn showed wader numbers increased as a result of similar management to Langholm (burning/cutting of heather and predator management). It is unclear why this has not been reflected at LMDP, although the very low initial numbers and stochastic (random) events may be involved. Monitoring is limited to the Breeding Bird Surveys and resources are not sufficient to investigate wader productivity and mortality further.

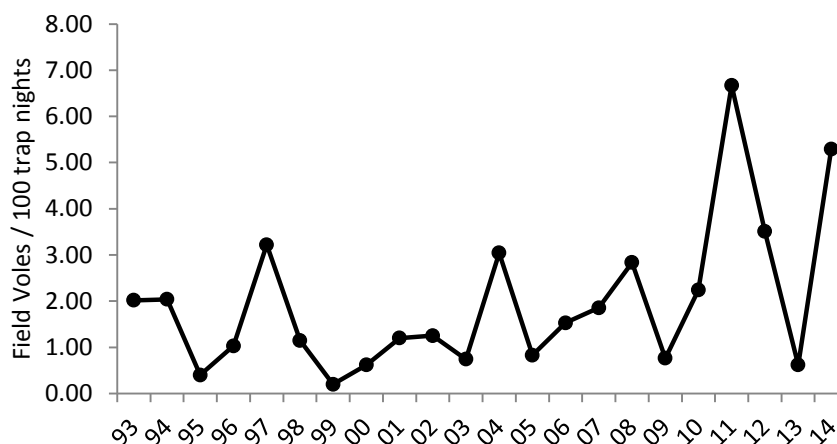


Figure 6. Numbers of voles trapped at Langholm in spring (per 100 trap nights). Note that in 2001 data were collected six weeks later than usual due to foot-and-mouth disease.

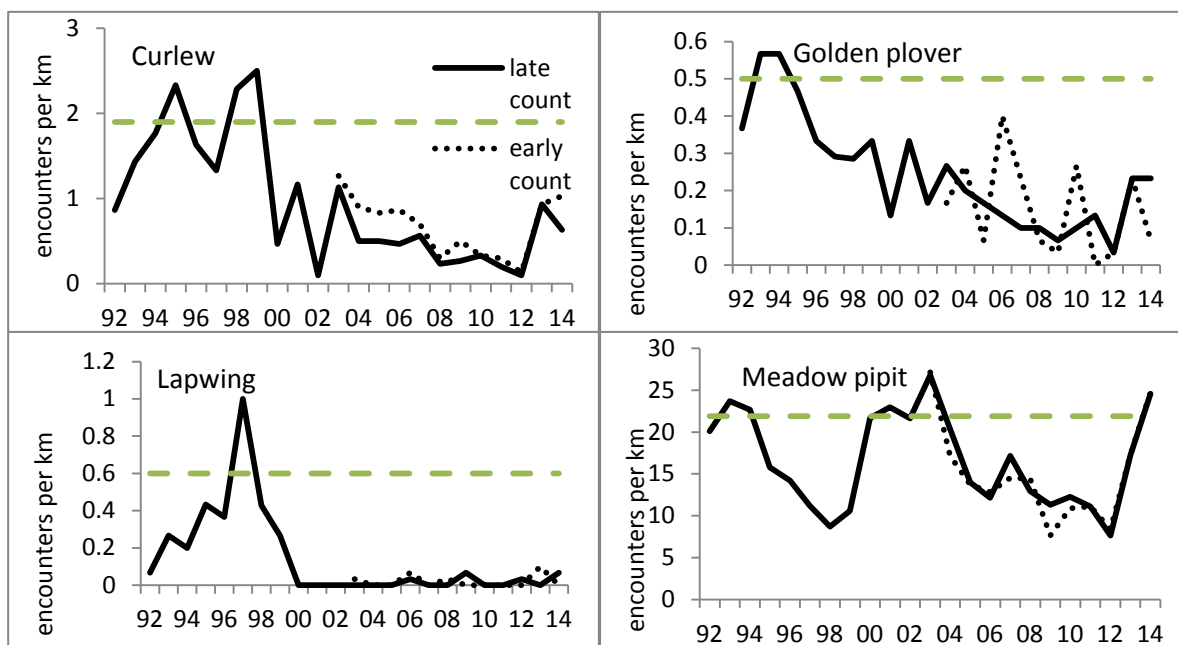


Figure 7. Wader population trends at Langholm. Abundance of lapwing, curlew, golden plover and meadow pipit during the Breeding Bird Surveys 1992-2014 on the same 15 BBS squares monitored since JRS. The dotted line shows the respective target density.

10.4. **Black grouse.** The number of lekking males has increased from 5 to 18 since 2008. See Figure 8.

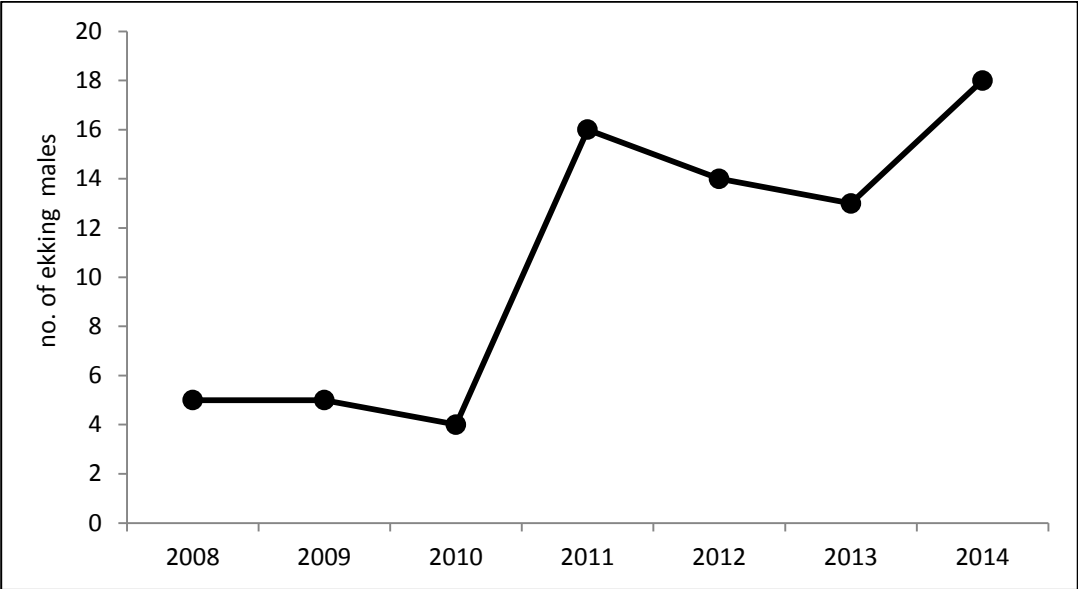


Figure 8. Black grouse males counted on leks in spring 2008-2014

11 Predators and predation/compatibility between management for raptor and red grouse interests

General aim:

- The project seeks to demonstrate compatibility between management for raptor and red grouse interests.
- This will necessarily mean reducing predation pressure on red grouse. The gamekeepers control foxes, corvids (except ravens) and mustelids. The predation pressure of harriers is mitigated by providing diversionary food at harrier nests.

Progress (agreed Position Statement):

- Adult red grouse predation by raptors. The majority (78%) of radio-tagged grouse found dead during the summer (April-August 2008-2013; N=33) showed signs of raptors killing the grouse. Similarly, a majority (64%) of radio-tagged grouse found dead in the winter (September-March 2008-2013; N=39) showed signs of raptors killing the grouse. Few actual predation events (defined as seeing a predator leave a warm, dead grouse) have been witnessed by either keepers or scientists. Flushed predators have all involved daytime hunting raptors. Further work is being taken forward to investigate the impact of different raptor species.
- Impact of hen harriers. Based on grouse and hen harrier densities observed to date (i.e. to 2013), hen harriers have not constrained red grouse numbers.
- Adult red grouse predation by foxes. Indices of fox abundance suggest a 93% reduction in numbers since the start of the project, mainly due to intensive fox control. Approximately 11% of the radio-tagged grouse that have died in the summer (April-August 2008-2013; N=33) show signs of foxes killing the grouse. In the winter (September-March 2008-2013; N=39), around 10% of the radio-tagged grouse that have died show signs of foxes killing the grouse. Few actual predation events (defined as seeing a predator leave a warm, dead grouse) have been witnessed by either keepers or scientists. None of these events involved foxes, which are mainly nocturnal.
- Red grouse predation by ravens. Ravens have increased in numbers at Langholm Moor from the levels recorded during the Joint Raptor Study. There are usually four or five nests in or within 500m of the study area, and most of them fledge chicks every year. Radio-tracking of fledgling ravens in 2013 noted that birds initially spent most time close to the nest but gradually expanded their foraging range. Of the 21 pellets analysed, only four contained grouse remains, whereas 11 contained small mammals, seven contained goat/sheep remains (probably scavenged) and eight invertebrates.
- Red grouse predation by crows. Carrion crows are controlled on the moor and the Breeding Bird Survey indices show that carrion crow numbers during the breeding season have been reduced (see Figure 11) since the start of the project. Crow control will be continued and this is expected to maintain this situation.
- Red grouse predation by small mustelid (i.e. stoat and weasel). Mustelid numbers seem to be regulated by vole numbers. Stoat indices appear to be lower than on English moors, but as there is no systematic monitoring of mustelid densities on other moors we cannot verify this. Mustelid indices are highest on in-bye ground. Only one adult grouse corpse found indicated that it had been killed by a mustelid, thus the impacts of small mustelids on adult grouse numbers is regarded as insignificant. However, further research needs to address their importance regarding grouse chick predation.

11.1. **Predator management.** The lethal control of foxes, corvids (not ravens) and mustelids is done throughout the year, with the main effort in spring to benefit nesting hen harriers, red grouse and wading birds. Keepers comply with current legislation and various codes of good practice, for instance:

- All keepers have had mandatory snare training and have snare operator numbers.
- The project has crow trap operator numbers issued by the police.
- All crow traps and snares are tagged and inspected daily.
- All non-target species are released from traps and snares.

The project has been recognised as a site of best practice demonstration. In 2010 it was instrumental in briefing MSPs considering the Wildlife & Natural Environment (Scotland) Bill, and sheriffs and procurators fiscal have visited for field briefings on predator management.

11.2. **Records of numbers** of all predators trapped and/or killed are collated monthly by the scientists. In addition, all animals killed have been logged and mapped and carcasses made available for analysis. Gamekeepers keep a daily log of keeping effort (e.g. number of set traps or lamping hours), found grouse carcasses, and raptor observations.

11.3. **Fox management and numbers.** Foxes are managed by snaring, lamping²⁸ and shooting at dens. The reduction in fox numbers is measured by the change in scat (faeces) transects, and supported by the analysis of fox lamping observations by keepers. In 2008 a fox was seen on average every 2.5 hours of lamping; whereas for 2009-2013 the average was 7.7 hours (see Figure 9a). The monitoring of fox scats indicates a 93% reduction in fox activity/abundance since the start of the project (see Figure 9b).

11.4. **Stoat and weasel management and numbers.** The keepers control mustelids using spring traps positioned in tunnels and by opportunistic shooting. Populations are assessed using footprint tracking tunnels set in locations likely to be used by stoats and weasels (see Figure 10).

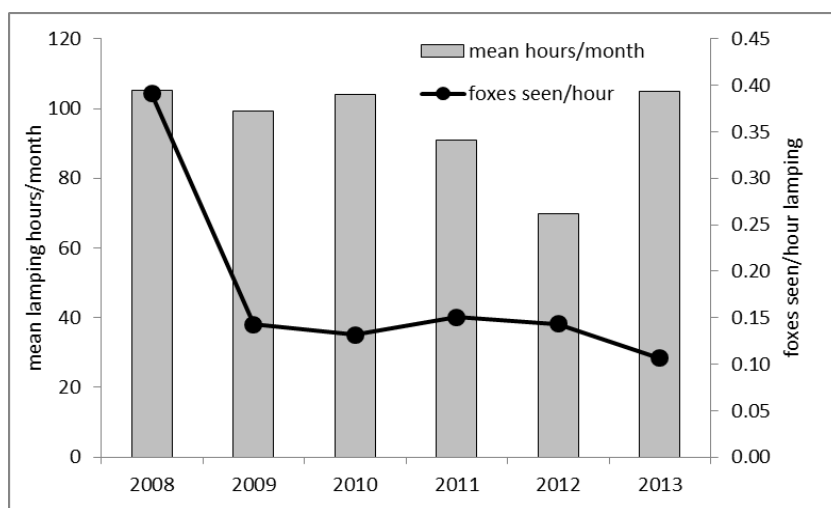


Figure 9a. Lamping effort (mean hours/month) and number of foxes seen per hour lamping 2008-2013.

²⁸ The foxes are detected with a lamp (the light reflects the eyes) at night and shot with a rifle.

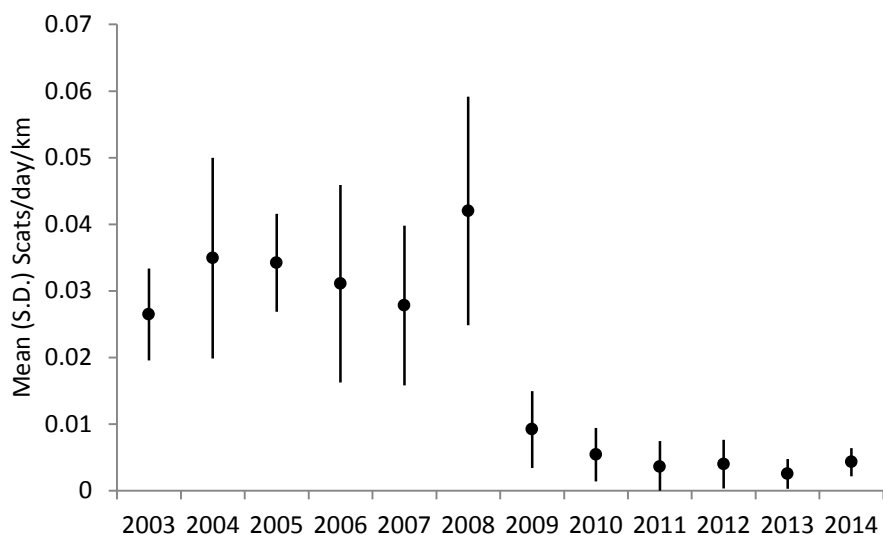


Figure 9b. Average number of fox scats found (per km and day) on transects 2003-2014.

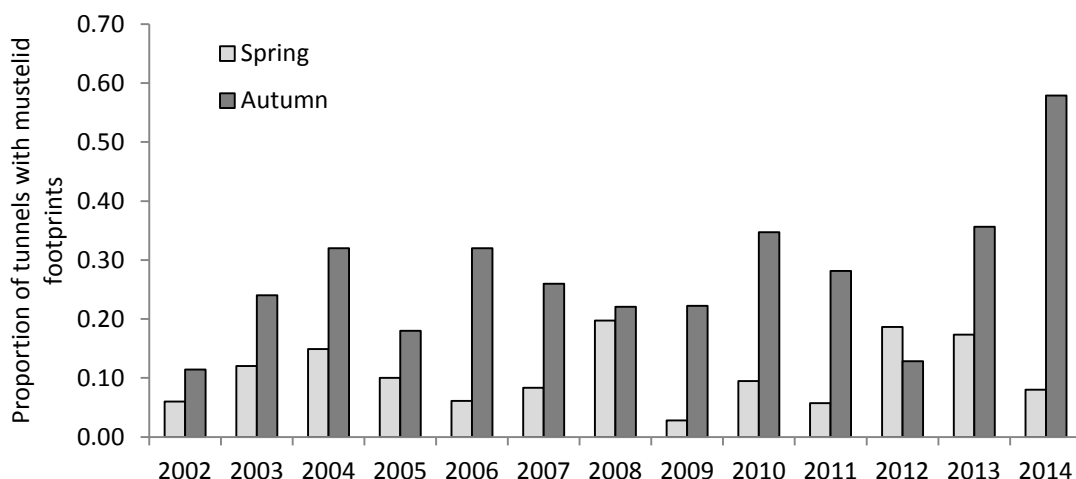


Figure 10. Proportion of tunnels showing mustelid footprints in spring and autumn 2002-2014 (2002-2007 50 tunnels, 2008-2014 N=75 tunnels).

- 11.5. **Carrion crow** control with crow cages, Larsen traps and shooting takes place throughout the year with a focus immediately prior to and during the nesting/brood-rearing period. BBS counts are given in Figure 11; between 2008 and 2014 carrion crows were seen approximately twice as often as ravens on BBS transects (birds seen per km (mean 2008-14): early count CC 4.3, RN 1.9; late count CC 6.0, RN 3.6). Raptor vantage point watches also record ravens and carrion crows.



Multi-catch crow trap

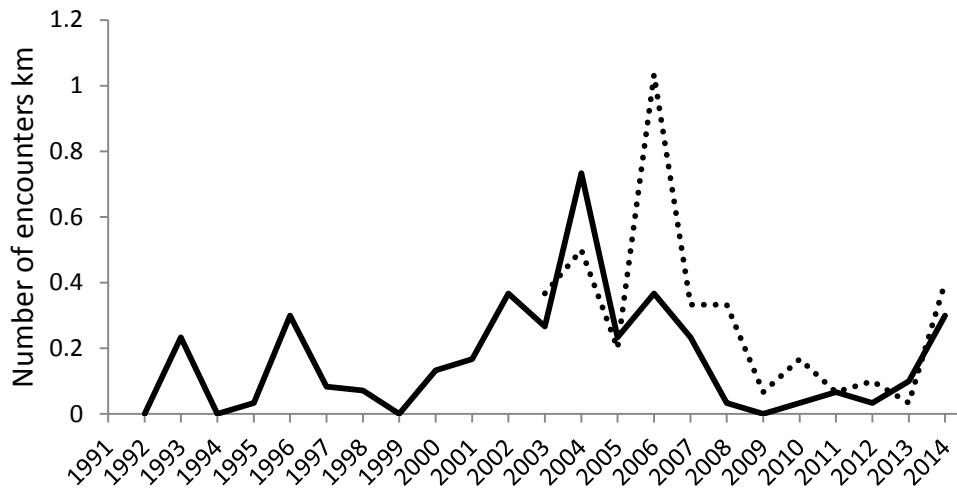
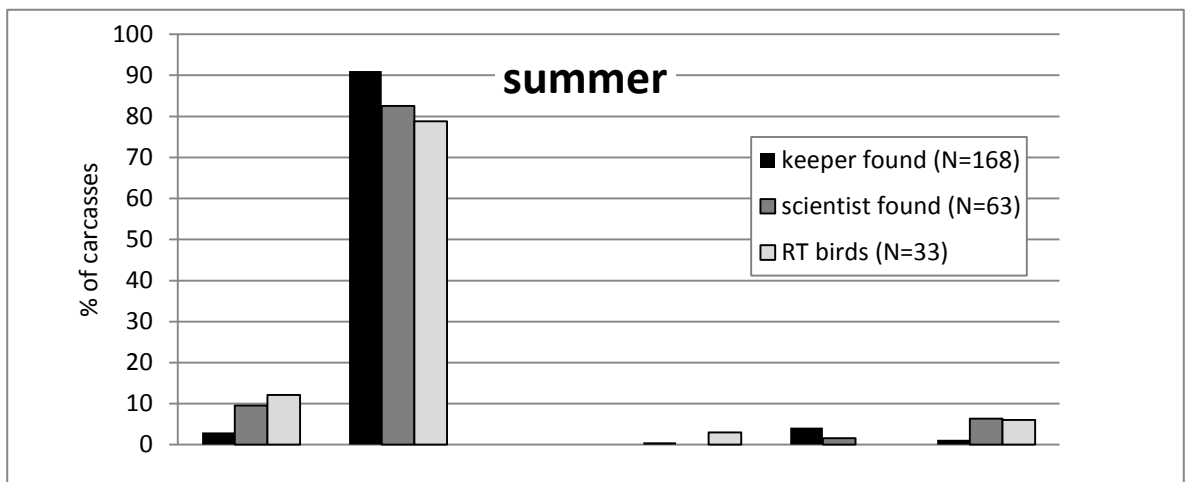


Figure 11. Number of carrion crows encountered during Breeding Bird Surveys (dotted line: early visit, black line: late visit) on the same 15 BBS squares from 1992 to 2014.

- 11.6 **Determining the level of raptor predation on red grouse.** This is one of the main aims of the project. The scientists rely on agreed field signs to determine the cause of mortality. This can reveal if a grouse has been killed by a raptor but not the specific raptor involved.
- 11.7 Figure 12 below shows the cause of death attributable to grouse carcasses found since the start of the project during both summer (April-August) and winter (September-March); carcasses are found by chance (keepers or scientists), by radio-tracking, or on systematic kill searches. Of the 874 grouse carcasses found, 718 were raptor kills. 874 is roughly 10% of the birds that have died (deduced from count data).



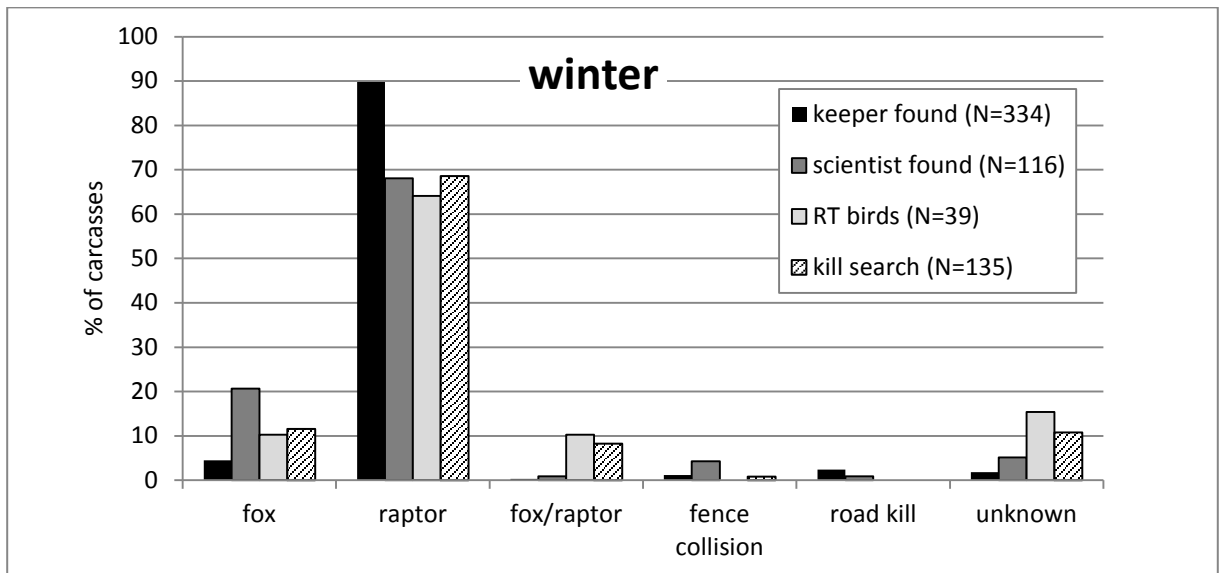


Figure 12. Assumed causes of death for 874 grouse carcasses found during summer (April-August) and winter (September-March)

11.8. Explanation of Figure 12.

- 'Raptor'. Only carcasses with clear field signs as raptor kills are assigned as such.
- The 'fox/raptor' column includes all carcasses showing signs of both mammal and raptor, though it is not clear who scavenged from whom.
- 'Fence collision' includes carcasses showing signs of raptor predation that were found close to a fence.
- 'Road kill' includes carcasses with signs of raptor predation that were found close to a road.
- Only full-grown birds are included. Dead chicks are too small to find by chance and also will mostly be swallowed or carried away whole, leaving no or few remains.
- Fox kills might be underrepresented, as it is easier to find a raptor kill (the mounds or perches where the prey is plucked by the raptor are fairly obvious) than a fox kill, which may be taken underground. (The radio tracking signal can be detected underground in fox dens but the weaker signal may not be picked up.)

11.9 Grouse chick mortality. In 2013, approximately 50% of chicks died within the first three weeks. We do not know which causes for chick mortality are significant, but we found evidence of predation by mustelids and raptors. Corvid predation on grouse nests seems to be quite variable between years. From 2009-2012, 14% of nests of radio-tagged hens (N=64) were found predated by corvids (between 0% and 30% per year). However, from these data we cannot tell whether corvids actually caused the failure or whether they predated the eggs after the clutch was deserted. In 2013-14 we monitored 37 nests more closely with cameras, and corvids did not cause any nesting failure. However, in four nests (11%) corvids took the eggs after the nest was deserted due to the hen being predated.

11.10 Raven predation. Although raven numbers have increased in the vantage point surveys, the numbers of breeding pairs have been stable (see Tables 4 and 5). The only anecdotal evidence of predation by ravens (it is indistinguishable from carrion crow predation) has been keeper observations of them hunting grouse habitat known to be occupied by grouse broods.

Winter raven			Summer raven		
JRS	92/93	0.14	JRS	1994	n/a
	93/94	0.39		1995	
	94/95	0.06		1996	
LMDP	11/12	3.36	LMDP	2012	3.18
	12/13	4.75		2013	7.61
	13/14	4.20		2014	2.27

Table 4. Sightings of ravens per 100 scans during winter and summer vantage point watches.

	2008	2009	2010	2011	2012	2013	2014
Raven	5	5	5	5	4	4	4

Table 5. Number of raven breeding pairs present on or within close proximity (max. 500m) of the project area during 2008-2014.

12 Stakeholder engagement and influence

- 12.1 **Aim.** Moorland is a complex cultural landscape and, from the outset, the project has engaged with the many aspects of society that use moorland to secure support for the project and to:
- Increase awareness of moorland conservation and management
 - Develop an appreciation of the need for solutions to the raptor/red grouse conflict
 - Use stakeholder knowledge to identify key obstacles to resolution
 - Identify options that could help resolve conflict
 - Promote wider use of these conflict resolution tools
- 12.2 **Method.** Key stakeholders for project dialogue were identified as:
- Moorland managers (grouse moor managers, conservation managers), shooting community and estate managers
 - Policy makers (Scotland, England, UK, EU)
 - Local community
 - Scientists and natural history enthusiasts
- 12.3 There was a limited public relations budget and no formal stakeholder engagement process in the Project Plan. A PR group was set up and used a range of approaches to trigger interest and dialogue including:
- On-site group visits
 - Off-site briefings and presentations
 - Member/trade magazine articles
 - TV and radio
 - Word of mouth
 - Website
 - Collaboration with 'Making the most of Moorlands' project
 - Attendance and displays at game fairs, member meetings
- 12.4 Project gamekeepers, scientists and the project manager have done the majority of the engagement work. Non-project staff, including project partner staff, wanting to disseminate information about the project have discussed their approach with the PR group in advance.
- 12.5 A standard PowerPoint presentation, regularly updated, ensures all visitors receive the same key messages:
- Importance of all aspects of legal predator control
 - Diversionary feeding as an option to mitigate impact on grouse from breeding hen harriers
 - The excellent habitat developed by reduced grazing levels (particularly during the winter), heather burning and cutting, aerial bracken control, and active heather reseeded on previously heavily beetleed areas.

12.6 Outcomes.

- 12.6.1 There has been considerable interest with 35 on-site visits, 20 off-site events and nine other activities in the past three years; reaching at least 1,350 people (see Appendix 4).
- 12.6.2 **Moorland managers, shooting community and estate managers.** Much of this interest has been catered for by on-site visits, off-site illustrated presentations by project staff or articles in industry press. Project staff have also attended external events including local game fairs and the Scottish Game Fair to provide a one-to-one informal opportunity to discuss specific aspects of the project. In addition, the gamekeeping team have attended shooting days on other moors to provide informal updates to guns, estate owners and staff, and others; an effective mechanism to disseminate key messages in a credible and personal form.
- 12.6.3 **Policy makers.** The project has hosted a large number of visits from key decision makers: to introduce them to game management in a moorland setting; illustrate the practicalities of potential new legislation; and as part of continuing professional development. Visitors include Scottish Government Environment Ministers Michael Russell, Roseanna Cunningham, Stewart Stevenson and Paul Wheelhouse.
- 12.6.4 **Local community.** An initiative, 'Making the Most of Moorlands', has provided information about the project for the local community in Langholm (www.langholm Moorland.co.uk). The Project Officer, Dr Cat Barlow, has developed extensive links (from nursery groups and local schools to youth groups like the Duke of Edinburgh's Award) and has undertaken a diverse range of events. Over 5,000 local school children have been made aware of the moor, its wildlife and management. She has also helped publicise the movements of tagged hen harriers.
- 12.6.5 **Scientists and natural history enthusiasts.** The project has hosted many informal visits from interested scientists and research workers, covering a wide range of moorland management interests. In addition, off-site presentations made to a range of Scottish natural history groups. Summary details are included in Appendix 4.



Visitors on Langholm Moor

13 Discussion

- 13.1 The LMDP core objective is “to establish Langholm Moor as a driven grouse moor [and] to meet the nature conservation objectives for the SPA and SSSI”.
- 13.2 The project has now been running for seven years. We have met the nature conservation objectives of the SPA (harriers) and SSSI (heather habitat) but we have not yet found the ‘win-win’ solution for both raptors and red grouse on this recovering moor. The quality of keeping and legal predator control is exemplary, grouse health is good, but grouse mortality all year round is high and 78% of adult grouse found dead can be attributed to raptor predation; we cannot distinguish between raptor species from the evidence. It has not yet proved possible to restore Langholm to a productive grouse moor with the available policy and management tools.
- 13.3 The project will need to trial further adaptive management options (in addition to the existing successful diversionary feeding of harrier nests) to benefit both raptor conservation and grouse management.
- 13.4 The number of nesting hen harriers in 2014 exceeded the project target. The moor supports two to three times the number of buzzards in the summer as during the JRS (though a similar number to JRS in winter), alongside goshawks, peregrines, merlin and short-eared owls.
- 13.5 The diversionary feeding of hen harriers proved to be a cost-effective, practical and viable technique for reducing predation of grouse while harrier nests were a maximum of three (the first six years). No grouse were observed being brought to harrier nests during nest watches in years one to five. Year seven, with ten active nests, has been more difficult. Notwithstanding the successes, we have low confidence that diversionary feeding of harriers will be perceived by gamekeepers as offering a complete solution to the conflict on a recovering moor; it did not create an increase in the shootable surplus of grouse at the end of the JRS nor yet during LMDP.
- 13.6 After seven years, grouse numbers are insufficient for driven shooting. We are not confident that the target of 1,000 brace shot can be achieved within the project timescale given current management measures. Population modelling indicates that it will not be possible if grouse productivity remains at the average of the previous seven years, or at the year seven level. We do, however, recognise that although habitat has improved to a point where we do not believe it is limiting grouse numbers, there is a view that the moor remains in a recovery phase and will not achieve its full potential until the full range of management measures takes effect.
- 13.7 The targets of expanding the area of heather and improving heather condition have both been met. Two large-scale heather beetle outbreaks in 2009 and 2010 have prompted the keeping team to develop novel restoration and reseedling techniques, which will hopefully be of significant help to other moors in Scotland. The Heather Trust is following this up.
- 13.8 We have reasonable confidence that grouse recovery is not being restricted by habitat, but may be restricted by raptor predation of adult grouse and low grouse productivity post-laying; we cannot yet determine the cause of the latter with confidence but it seems likely it



is associated with similar predation rather than disease, inadequate food supply, weather conditions or other mortality.

- 13.9 We consider these factors to be less likely to be restricting grouse recovery for a number of reasons. Habitat quality has been assessed against the project target itself, and by comparison to other operational grouse moors in year seven. There appears to be adequate food supply in the winter, as grouse hens produce good clutch sizes relative to other moors, indicating they go into the breeding season in good condition. Disease levels have been low compared to other grouse moors (strongylosis and louping ill), as have tick burdens (on both adults and chicks). Nonetheless, grouse productivity is low compared to other moors in England and Scotland. Chick mortality in the first three weeks of life is high; radio-tracking of chicks has indicated that predation might be a major cause.
- 13.10 The population targets have not been met for waders, but have for meadow pipits (in 2014). It is difficult to predict whether the wader targets will be met by the end of the project given the decline in wader numbers nationally during the period of the project.
- 13.11 The annual investment in keepering is £225,000. The keepers' moorland management has allowed it to meet its habitat targets and the SPA objectives, but we now need to consider new adaptive management measures to realise an economic reward in terms of grouse shooting. Until that return on investment is delivered, LMDP is not providing an example of an economic model that other marginal/recovering moors can follow.
- 13.12 Driven grouse shooting can provide a strong incentive for sustainably financing the environmental management of moorland. Shooting is a **cultural ecosystem service**, harvesting a sustainable wild food (**provisioning ecosystem service**), while enhancing habitat and biodiversity. Increasingly these services must demonstrably support other environmental benefits – supplying clean water and moderating run-off in catchments (**regulating ecosystem service**), carbon and blanket bog management (**supporting ecosystem service**), enhancing landscape enjoyment (subjective) and a 'sense of space/well-being' and maintaining economic activity in the uplands – as these are increasingly important within the current social and climatic conditions.
- 13.13 We wish to introduce a mechanism to assess the success and impact of stakeholder engagement, and hope to develop that over the coming months. In the meantime, an informal assessment considers the work so far has led to:
- A better understanding of moorland management (e.g. predator control for joint game/raptor benefit, heather restoration techniques).
 - A greater acceptance/support for a viable game shooting enterprise to underpin moorland management.
 - An increased acknowledgement that birds of prey are an important component of a functioning moorland ecosystem.
 - An improved understanding of practicable and acceptable options to resolving current problems.
 - In the remaining years of the project, disseminating results through scientific papers and reports will be increasingly important.
 - Good practical engagement between scientists, SRSs and gamekeepers, and the partner organisations.

14 Next steps

The project potentially has another three years to run. The key challenge remaining is to achieve grouse recovery. We will be preparing an 'options / next steps' paper next for publication in early 2015.

Acknowledgements and thanks

The directors of the LMDP would like to thank the gamekeepers and scientists whose hard work and commitment over the last six to seven years has made this project possible. Secondly, the directors would like to warmly thank the chairman and members of the Scientific and Technical Advisory Group who have all given their time and expertise for no reward. Thanks are also due to many members of staff in all the partner organisations who have provided support and backup to the LMDP, Dr Cat Barlow, the Raptor Study Groups and other volunteers who have helped with monitoring.



Some of the project team. From L to R: Sonja Ludwig (project scientist), Simon Lester (head gamekeeper), Mark Oddy (project director, Buccleuch), Duncan Orr-Ewing (project director, RSPB), Graeme Dalby (project manager), Susan Davies (project director, SNH), Teresa Dent (project director, GWCT).

Historical grouse bags

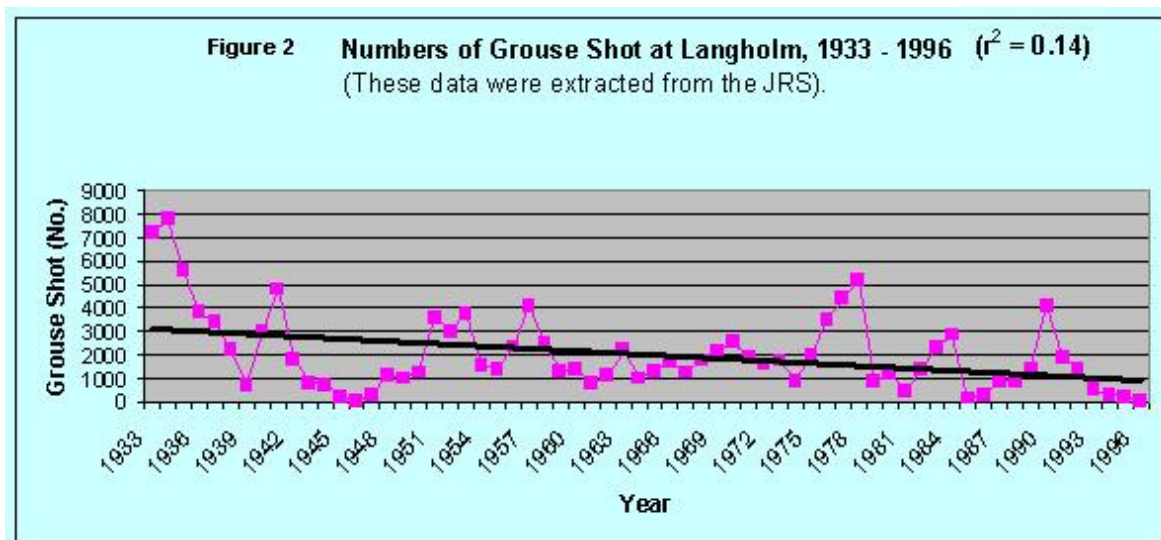


Figure 13. Numbers of grouse shot at Langholm Moor 1933 to 1996.

Heather restoration and management

1. Heather burning and cutting. Burning is undertaken in compliance with Scottish Government's Muirburn Code²⁹. Cutting and burning is used to trigger the growth of vigorous young heather, create a small-scale mosaic of different age and height heather across the moor. Habitat managed in this way is used for nesting and feeding by passerines and waders – older, taller heather is preferred by raptors for nesting. This more mature heather is also used by red grouse for nesting and feeding during periods of snow-cover while young, short, nutritious heather is used as a food and insect-rich areas for brood rearing. There is an average 15-year burning rotation for dry heather habitats, increasing to a 20-25 year rotation for some blanket bog (on which burning is permitted).
2. Heather cutting (flailing) can be done where suitable vehicles can drive on the moor without causing damage or getting stuck; it is less weather dependent than burning, allows large blocks of heather to be quickly broken-up, and is used to create firebreaks round areas due to be burnt.
3. Heather beetle outbreaks. These have affected large areas of heather across most of the southern sections of the moor (close to 10km² was affected to some degree); affected heather was often largely defoliated. Reducing grazing in combination with high-intervention heather restoration has allowed excellent regeneration.
4. Blanket bog management. There are 1,490 hectares of blanket bog, with much of the heather cover in a degraded state. Management has been undertaken to stimulate heather recovery while maintaining the integrity of the bog mosses (to maximise carbon storage and water quality). Careful burning of bog areas with 'cool burns' (mature heather is burnt off without any damage to lower level vegetation – *Sphagnum* mosses – or peat) has taken place to assist with heather regeneration.
5. Raptor nest sites. In areas historically used by breeding hen harriers, the keepers liaise with scientific staff over location and timing of heather burning and/or cutting; patches of mature heather are left unburned/uncut for ground-nesting raptors.
6. Bracken control. Bracken has become a significant problem across Scotland in the past 30 years. Dense bracken growth suppresses plants under it, resulting in loss of heather habitat. Bracken beds themselves have relatively few wildlife benefits but can contribute to overall biodiversity in the landscape and are used by whinchats, a declining migrant breeding bird. Bracken control by aerial spraying has been used to recover 600ha of heather in accordance with best practice (e.g. areas adjacent to watercourses are not sprayed except by hand).



²⁹ <http://www.scotland.gov.uk/Resource/Doc/219276/0058846.pdf>

7. Agri-environment funding and appropriate consents were secured by Langholm Farms to compensate for the loss of income from reduced stock numbers, to contribute to the capital cost of stock fencing (to allow managed grazing on the SSSI habitat) and heather restoration.
8. Heather restoration. This has been undertaken by excluding stock (removing grazing pressure allows remaining heather to regenerate), heather cutting and burning, or heather reseeded (where there are too few heather plants left to regenerate).
9. Heather restoration by reseeded
 - 9.1. The areas selected for reseeded were those that had recently lost heather, and concentrated on areas that suffered heather beetle attacks in 2009 and 2010. Areas of wet flushes, with high *Eriophorum* and *Sphagnum* cover, were avoided as they have inherent botanical and invertebrate interest and travel on such areas with machinery is problematic. Selected areas were scattered both to increase the extent of the treatment and to create a more diverse habitat mosaic
 - 9.2. Treatment involved initially spraying with 360g/l glyphosate-based chemical at a rate of 4 litres/ha, and a dilution rate of 100 litres of water per hectare. The herbicide was sprayed using a four-wheel-drive tractor equipped with twin wheels throughout and sprayed through a mounted, 6m sprayer. Tractor speed was regulated to ensure correct and even coverage of the area being treated. The initial spraying was undertaken during July when there was active growth, bird nesting was completed and travelling conditions were drier.
 - 9.3. Ideally, sprayed areas are then burned once the growth had died back and whilst surrounding ground remains green and vigorous (ideally August or September); this considerably assists fire control. In the early years of the project, this timing was not possible, but latterly, the option for an out-of-season heather burning licence from SNH permitted it. However, despite having a licence for three years, only half a day of burning was achieved due to ongoing poor weather conditions. As only a limited extent was burnt, all remaining areas were cut. Cutting was achieved using a four-wheel-drive tractor equipped with twin wheels throughout and a rear-mounted flail. In order to reduce the number of machinery passes (both to reduce ground impacts and reduce costs), an air-seeder was mounted on the flail to enable heather/moorland seed mix to be distributed and incorporated within the mulch.
 - 9.4. As heather regenerating from seed is particularly vulnerable to grazing, sheep were removed throughout the year on treated areas (note, many of the areas had already had sheep removed following the extensive heather beetle outbreaks of 2009 and 2010).
 - 9.5. Most of the areas subject to this active heather restoration showed good recovery of heather. They also however, showed strong recovery of potentially dominant grasses, including *Molinia* and wavy hair grass. As these could compromise the achievement of good cover of dwarf shrubs, all areas were over-sprayed with a specific grass specific herbicide. The product (a 200g/l formulation of cycloxydim) was sprayed at a rate of 2.25l/hectare at a dilution of 100 litres/hectare. Spraying was carried out during late June and early July 2013, again using a four-wheel-drive tractor equipped with twin wheels throughout and sprayed through a mounted, 6m sprayer. Tractor speed was regulated to ensure correct and even coverage of the area being treated.

10. Heather restoration by grazing management

- 10.1. The Project Plan identified a number of specific areas where restoration of heather was considered a priority. These are listed in Table 6.
- 10.2. Overgrazing has caused most of the heather cover decline. To allow heather recovery, sheep numbers have been reduced overall, with the greatest reduction over winter when grazing does more damage. Sheep numbers have reduced by 1,060 ewes (all year) and a further 1,455 sheep are away wintered (before the project, numbers were 3,995 ewes and 955 hogs). The feral goat population has also been reduced to around 100 individuals.
- 10.3. In addition, there is increased shepherding on 4,127 hectares to keep sheep off vulnerable areas and spread grazing pressure. Supplementary feed is now only available at agreed locations.
- 10.4. Sheep were removed from the areas affected by heather beetle in 2010, with the reductions in grazing (as part of the Langholm Farms Ltd SRDP agreement) taking place in autumn/winter 2011.

Area	Action Taken to Date
A	Sheep stock reduced by 500, all sheep off during winter, no cattle, additional shepherding
B	Sheep removed for bulk of year from 50% of area, active heather reseeded on 50% of area, no cattle, additional shepherding when animals on area
C	Sheep stock reduced by 500, all sheep off during winter, no cattle, additional shepherding when animals on area
D	Sheep stock reduced by 500, all sheep off during winter, no cattle, additional shepherding when animals on area
E	Sheep removed for bulk of year from 50% of area, active heather reseeded, no cattle, additional shepherding when animals on area
F	Livestock on area unchanged (low density), goat numbers much reduced, additional shepherding when animals on area
G	Livestock on area unchanged (low density), goat numbers much reduced, additional shepherding when animals on area
H	Livestock on area unchanged (low density), goat numbers much reduced, additional shepherding when animals on area
M	Sheep removed for bulk of year, no cattle, additional shepherding when animals on area
N	Sheep stock reduced by 500, all sheep off during winter, no cattle, additional shepherding
P	All sheep removed, no cattle, active heather reseeded

Table 6. Action taken to date on grazed areas identified in Project Plan for heather restoration.

Grouse counting methods

1. Block counts. Block counts are a traditional method of counting grouse, which involves working the dog along several parallel transects within a 0.5km² block. Historically it was assumed that this method would produce an absolute count. However, newer techniques such as distance sampling have shown that this is not the case. At Langholm, block counts are conducted within ten traditional areas, which have been counted using this method since JRS.
2. Distance sampling. Distance sampling is a newer technique to estimate population density, which can account for the area actually searched by the dog, and thus correct for differences between individual dogs and observers, as well as differences in detectability depending on weather conditions, the timing of counts, etc. By recording the perpendicular distance of the dog on each grouse point to the transect line, it is possible to calculate the “effective strip width” searched by the dog and estimate the probability of finding grouse in relation to distance from the transect line. Distance sampling is conducted on 68km of line transects distributed evenly across the core grouse habitat at Langholm.
3. Comparison of count methods. Block counts are simple but tend to underestimate grouse numbers. As this technique was used during the JRS it has been continued to maintain long-term trends (distance sampling was developed as a method after JRS). Distance sampling allows an estimate to be made of the number of grouse present but not detected, thus producing population estimates that are more likely to be correct.

Stakeholder engagement and influence – list of events

Date	Event	No people engaged
Aug 2014	2 publications (land management)	Unknown
July	5 on-site visits (land management) 1 3-day off-site event (land management, policy, general)	25 >100
June	1 publication (land management)	Unknown
May	1 on-site visit (land management) Scottish Parliament debate mention (policy) Television package broadcast (natural history, general)	4 Unknown Unknown
April	1 on-site visit (policy) 1 publication (natural history, public)	3 Unknown
Feb	1 on-site visit (land management, student)	12
Jan	1 on-site visit (land management, FCS)	1
Nov 2013	2 off-site meetings (land management)	>50
Oct	3 on-site visits (land management, policy) 2 publications (natural history, land management)	7 Unknown
Sep	3 on-site visits (land management, policy)	10
Aug	1 2-day off-site visit	Unknown
July	3 on-site visits (Policy, natural history, land management) 1 3-day off-site event (land management, policy, general)	10 >100
June	1 off-site event (land management, policy, general)	Approx 50
May	2 on-site visits (land management, natural history)	88
March	1 off-site event (land management)	70+
Jan	1 on-site visit (education, land management)	12
Nov 2012	2 off-site events (land management, natural history) 1 on-site visit (land management, policy)	155 4
Oct	1 on-site visit (land management, policy)	45
Sept	1 on-site visit (land management, policy) 1 off-site events (land management, natural history)	5 35
Aug	1 2-day off-site visit	Unknown
July	1 3-day off-site event (land management, policy, general)	>100
June	1 2-day off-site visit (land management, policy, general) 1 on-site visit (policy)	100+ 3
May	5 on-site visits (Policy, natural history, land management)	73
April	1 off-site event (policy, land management) 3 on-site visits (Policy, natural history, land management)	98 14
March	1 publication (natural history) 2 off-site events (policy, land management) 1 on-site visit (policy)	Unknown 130 6
Feb	3 off-site events (land management)	42
Jan	1 on-site visit	1
	Est min of	1359 (inc 31/8/14)

A detailed diary of visits and events prior to January 2012 was not maintained.

Student Presentations
Autumn 2013, Kirsten Hazelwood 5 min presentation of MSc project presentation to British Ecological Society PhD presentations.
Autumn 2013, Ayla Paul Poster paper presentation of MSc project presentation to British Ecological Society PhD presentations.
Spring 2014, Richard Francksen Poster presentation of PhD research to British Ornithologists' Union Conference. Awarded Best Poster Presentation.

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