Institution: University of Liverpool

Unit of Assessment: 7. Earth System and Environmental Sciences

Title of case study: Deriving evidence-based land management practices for heathland and moorland conservation

1. Summary of the impact (indicative maximum 100 words)

A major requirement for national conservation strategies within the EU is to ensure that priority habitats for conservation within their domain are in "favourable" condition (i.e. compliance with Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora). In order to achieve this there is an increasing need to provide sound evidence-based advice. This is especially needed in cultural landscapes (grassland, heaths and moors) which were created and maintained by human activity. Marrs' group has led the field in providing evidence-based advice on management of both lowland heaths/upland moors for over 30 years using results from (a) regional-scale, structured-surveys, (b) extensive, long-term, manipulative-experiments and (c) ecosystem modelling. Outcomes have helped frame policy and guide good-practice by conservation practitioners, especially in the area of prescribed burning of moorlands.

2. Underpinning research (indicative maximum 500 words)

Marrs has provided evidence-led advice on two major areas of heath/moor conservation, these are: (1) Development of novel practices in lowland heath restoration/management, and (2) the development of methods for the use of prescribed burning on upland moors.

(a) Development of novel practices in lowland heath restoration (1993-2002)

It is well known that the areas of lowland heath have declined over the latter part of the 20th century and there are several regional-programs to redress this balance. One of these was headed up by the Royal Society for the Protection of Birds (RSPB) at their Minsmere reserve where two lowland heaths were separated by two major blocks of former heathland that had been converted to arable use. Heathland tend to occur on infertile soils and the arable soils had been very heavily fertilized and limed leaving a residual fertility issue. The RSPB policy was to restore the arable fields to lowland-heathland. Using field surveys of the arable soils Marrs' group established that (a) the main problems were soil pH, Ca and P, and (b) there was no layer-stratification that would allow topsoil stripping as a method for reducing fertility. Thereafter a series of field-based experiments produced techniques for acidifying the soils (essentially titrating with elemental S) and seed-additions to restore the arable areas to either *Calluna*-dominated lowland heath or grass heath (**REF.3.1-3.3)**. The RSPB took this research and scaled it up in an implementation phase.

(b) Development of methods for the use of prescribed burning on upland moors (2005-2012)

In 2012 the IUCN "Commission on peatlands" reviewed the status of peatlands in the UK and one of the areas of concern was the impact of prescribed burning. UK moorlands provide a range of ecosystem services including carbon sequestration in peat, water provision, agricultural and sheep outputs and recreation. Prescribed burning is applied under a code of good practice and is mainly implemented for grouse management, but there is increasing evidence it may need to be used in the future for wildfire control if climate warms. Based on earlier work testing both prescribed burning, cutting, herbicide use and re-seeding on *Molinia Caerulea* (Yorkshire Fog) infested ground Marrs was asked by a land manager to start work on prescribed burning and offered his estate for study. This work has expanded into a NERC/DEFRA- funded project under the Biodiversa program (FIREMAN) that encompasses field studies and modelling; the latter being applied to historic, contemporary and future burning scenarios. Here, Marrs' group has produced information on change in (i) species composition in the post-fire burning cycle and (ii) the biomass (fuel load). Moreover, matrix modelling studies has provided predictions of the optimal prescribed burning rotation length to minimize carbon losses from the above-ground vegetation. His group has also re-visited a long-term experiment (Marrs was involved in monitoring in the 1980s) and produced a long-term assessment of impacts of prescribed burning on (a) the vegetation including supposed "fire-sensitive" species and (b) the restoration potential after wildfire. A major feature of the FIREMAN project has been the provision of a Knowledge Exchange (KE) component that is embedded within this research.

In total this project has involved Marrs as PI (FIREMAN, contemporary research), four postdoctoral assistants, five PhD students and one MRes student.

3. References to the research (indicative maximum of six references)

(a) Development of novel practices in lowland heath restoration (1993-2002)

1. **Marrs, R.H.,** Snow, C.S.R., Owen, K.M. & Evans, C.E. 1998. Heathland and acid grassland creation on arable soils at Minsmere: identification of potential problems and a test of cropping to impoverish soils. *Biol. Conserv.,* **85**, 69-82. DOI: **10.1016/S0006-3207(97)00139-0**
2. Owen, K.M., **Marrs, R.H.,** Snow, C.S.R. & Evans, C. 1999. Soil acidification - the use of sulphur and acidic litters to acidify arable soils for the recreation of heathland and acidic grassland at Minsmere, UK. *Biol. Conserv.*, **87**, 105-122. DOI: **10.1016/S0006-3207(98)00027-5**

(b) Development of methods for the use of prescribed burning on upland moors (2005-2013)

3. Harris, M.P.K., Allen, K., McAllister, H., Eyre, G., Le Duc, M., **Marrs, R**. (2011) Factors affecting moorland plant communities and component species in relation to prescribed burning in the Peak District, England. *Journal of Applied Ecology*, **48**, 1411–1421. DOI: **10.1111/j.1365-2664.2011.02052.x.**
4. Allen, K A., Harris, M.P.K., **Marrs, R.H.** (2013). Matrix modelling of prescribed burning in *Calluna vulgaris* moorland: intermediate burning rotations minimise carbon loss at increased wildfire frequencies. *Journal of Applied Ecology*, **50**, 614-624, DOI: 10.1111/1365-2664.12075.
5. Lee, H., Alday, J.G., Rose, R.J., O'Reilly, J., **Marrs, R.H.** 2013. Long-term effects of rotational prescribed-burning and low-intensity sheep-grazing on blanket-bog plant communities. *Journal of Applied Ecology***, 50,** 625-635**.** DOI: 10.1111/1365-2664.12078. DOI: **10.1111/1365-2664.12078**
6. Lee, H., Alday, J.G., Rosenburgh, A., Harris, M., McAllister, H., Marrs R.H. (2013). Change in propagule banks during prescribed burning: a tale of two contrasting moorlands. *Biological Conservation*, **165**, 187-197. DOI: http://dx.doi.org/10.1016/j.biocon.2013.05.023

Grants to support this impact: all grants to Marrs as PI or Co-PI.

Years	Sponsor and title	£K
1993-94	UoL studentship	30
1993-97	RSPB:Restoration of lowland heaths	35
1994-98	NERC:Modelling species change in lowland heath	35
1994-98	RSPB:Restoring heath and acid grassland at Minsmere	50
2009-12	Biodiversa (NERC/DEFRA): FIREMAN	650
2001-2005	Government of Iran: PhD studentship on seed bank ecology	50
2007-2012	Private sector: PhD studentship, research on burning in the Peak District	25

4. Details of the impact (indicative maximum 750 words)

A major feature or our heath/moorland research throughout has been the development of an evidence-based framework that guides policy development that is of direct use to land managers.

Development of novel practices in lowland heath restoration at Minsmere, Suffolk (1993-2002)

Marrs' experimental research on both cereal cropping to deplete soil nutrients and specifically on soil acidification, provided the underpinning methods allowing the RSPB to implement acid-grassland and heathland restoration at the landscape-scale on former arable land (1999-present) at their flagship reserve. This restoration linked up existing patches of good quality habitat and

conservation value e.g. recovery of silver-studded blue and Stone curlew populations; this resulted in a significant improvement in the conservation of the landscape, which was reported by RSPB staff in British Wildlife describing the RSPB's restoration program on lowland heathland on the Suffolk coast; six of the 11 cited references were produced by Marrs' group and the soil chemical data quoted in the paper are their results. This improvement in conservation value was further recognized by the award of the Environment Agency's `Pioneering Biodiversity Programme` prize in 2010 the RSPB's Suffolk coast project won. The RSPB have used the overall program as a contribution to meeting the UK Biodiversity Action Plan (BAP) targets. The methods developed, although geared towards this site, are generic and can be applied to any former agricultural land.

(b) Development of methods for the use of prescribed burning on upland moors (2005-2012)

There are several ways that Marrs' group has been involved in influencing policy and practice. In 2006 Marrs was the only practising vegetation scientist to sit on the DEFRA panel which reviewed the policy for "Heather and grass burning in England and Wales". Marrs was included because of his upland vegetation experience and specifically knowledge of long-term burning experiments on Moor House National Nature Reserve. One of the reasons for this review was a concern over the potential for earlier bird nesting as a result of climate change and the potential need for revised burning dates, specifically making the latest date for burning earlier in Spring. This was not substantiated by evidence. However, at the same time the impact of prescribed burning on both biodiversity and ecosystem services were reviewed. The output was a complete revision of the "DEFRA Burning Code", and led to changes in the law affecting heather and grass burning, effective 1 October 2008. Compliance with the Burning Code is required (*inter alia*) for estate owners receiving Higher Level Stewardship grants for land management.

This review work led to the formulation of many of the hypotheses tested in the FIREMAN project and advisory work done since.

In 2012, Marrs has provided expert witness testimony on prescribed burning (based on 30-years research-experience on moorlands and especially work associated with the FIREMAN project) at a landmark Public Inquiry (PI) run by DEFRA. The PI tested some aspects of the need for prescribed burning and hence examined some of the guidance within the Burning Code (see above). The PI was to hear an appeal against a "Notice of modification of consent (NoMoCo)" where Natural England (statutory conservation body) was attempting to change the burning rotation interval (along with several other practices) on an upland estate in the Pennines. Indeed, the preferred stated case of Natural England was to ban burning all together (the subject of a second NoMoCo). After evidence was presented, but before closing speeches, a settlement was reached where Natural England agreed conditions that were agreeable to the estate owner with sensible burning rotations allowed. This allowed the estate owner to manage for commercial grouse production whilst maintaining a more sustainable upland landscape which included a wildfire resilience strategy. Mr David Elvin QC stated *"Marrs' evidence came from rigorously analysed long-term studies … I found his scientific analysis, objectivity and rigour particularly welcome ….. The conclusion [of the PI] was to a significant extent the result of evidence we presented, a significant part of which was that of Professor Marrs.*"

Marrs' has continued to translate his long-term research on heathland/moorland management to end-users through Knowledge Exchange. Apart from helping to revise the Burning Code, he helped establish a series of Demonstration Moors and through this implemented "Good-practice-management training days"; here up-to-the-minute research has been translated to end-users (farmers, estate owners, land agents, gamekeepers and conservation agency staff). Some of this has been done in partnership with the Heather Trust and the International Bracken Group. Between 2008-2012, five training days have been run reaching over 400 end-users. Simon Thorp (Director, Heather Trust) stated that "*His research work based on a combination of surveys, modelling and both current and past experiments, where he has an obvious "hands-on" approach endears him to practitioners. On our burning KE days, it is obvious to the visiting practitioners that he knows what he is talking about, because he shows them that he can do the job himself, action as well as words*."

5. Sources to corroborate the impact (indicative maximum of 10 references)

(a) Development of novel practices in lowland heath restoration (1993-2002)

1. Ausden, M., Allison, M., Bradley, P., Coates, M., Kemp M., Phillips, N. 2010. Increasing the resilience of our lowland dry heaths and acid grasslands. *British Wildlife*, December, pp. 101-109 provides evidence that the experimental research undertaken by Marrs' group led to a significant improvement in the conservation of the landscape http://www.britishwildlife.com/viewbackissue.asp?issueid=73.

2. The RSPB's Heathland Warden at Minsmere Reserve has provided a statement to confirm that the Suffolk coast including Minsmere project won the inaugural EA `pioneering biodiversity programme` due to the improvement in conservation value and as a result of the experimental research undertaken by Marrs' group.

(b) Development of methods for the use of prescribed burning on upland moors (2007-2012)

3. The complete revision of the Anon (2007), *The Heather and Grass Burning Code,* Defra, London, was directly informed by the evidence of Marrs' research on prescribed burning on biodiversity and ecosystem services http://www.naturalengland.org.uk/Images/heathergrassburningcode_tcm6-7795.pdf.
4. The changes in the law affecting heather and grass burning, Anon (2008), *Heather and Grass Burning,* Natural England, Leeds, was directly informed by Marrs' research on prescribed burning on biodiversity and ecosystem services http://www.naturalengland.org.uk/ourwork/regulation/burning/default.aspx
5. Anon (2013). *Higher Level Stewardship: Environmental Stewardship Handbook, Fourth Edition* – January 2013 (NE350) (see Option directory),Natural England, Leeds, provides evidence that the research on prescribed burning on biodiversity and ecosystem services has directly informed compliance manuals for estate owners http://publications.naturalengland.org.uk/publication/2827091.
6. Marrs, R.H. 2011. Public Inquiry (PI) evidence: (a) Witness statement; (b) Rebuttal PoE, (c) Appendices, corroborates that Marrs' long-term research provided evidence to support the outcome of the inquiry. Confirmation of this impact can be provided by the Lead Barrister for the PI.
7. Natural England's statement regarding successful conclusion of the Public Inquiry was directly informed by Marrs' scientific analysis based on the long-term research on moorlands he had undertaken http://www.naturalengland.org.uk/home_page_-_latest_news/walshawmoor2.aspx.
8. The Director of the Moorland Association has provided a statement of support to confirm the impact associated with the Public Inquiry.
9. The Director of Boundary Mill (and estate owner) has provided a statement of support to confirm the impact associated with the Public Inquiry.
10. The Director of the Heather Trust has provided a statement to confirm the impact generated from Marrs' research via good practice management training days for practitioners including farmers, estate owners, land agents, gamekeepers and conservation agency staff.