Institution:
UNIVERSITY OF LIVERPOOL

Unit of Assessment:
UOA5 – Biological Sciences

Title of case study:
Evidence-based Weed Control and Land Restoration for Bracken, an Intractable Invasive Species

1. Summary of the impact

Pesticides need to be used safely and effectively, but their use needs to be evidence-based. Work at the University of Liverpool (UoL) has led the field in undertaking research on weed management in the UK uplands and guiding the practices of government bodies and others for over 30 years.

Work on bracken in particular has provided (a) policy guidance backed by statutory regulation on aerial spraying, applied to large areas of the UK throughout the assessment period; (b) policy guidance on bracken control and restoration of vegetation used widely in the UK under instruction from statutory bodies; (c) advice to the Bracken Control Group, allowing Emergency Authorisation from the EU of asulam (the only effective herbicide, but otherwise now banned); and (d) knowledge exchange through 'demonstration days'.

2. Underpinning research

Bracken is a pernicious invasive weed with serious negative impacts in some habitats, which can damage other vegetation, change livestock grazing patterns and out-compete other flora. Bracken control is important to the management of British upland and lowland areas.

There has been active research at the University of Liverpool on the long-term impacts of management of bracken, one of the world's most pernicious weeds, throughout the period 1993-2007, notably by Professor R. Marrs, Dr M. Le Duc and Honorary Professor R. Pakeman under a series of contracts funded by the Department of Food and Rural Affairs (DEFRA) and some experiments are ongoing. This was complemented by work on aerial spray drift funded by MAFF/Nature Conservancy Council that concluded in 1996.

Bracken grows extensively in inaccessible upland areas where the only way to control it is via a selective herbicide applied by helicopter. In the UK, the herbicide used is almost always asulam [10, in section 5]. In the 1980s the Nature Conservancy Council expressed concern over the potential impacts of asulam drift impinging on native ferns growing in the wider countryside, and specifically in protected areas (Sites of Special Scientific Interest/National Nature Reserves). Within a wider program of spray drift impacts, work at Liverpool developed a simple bioassay approach for detecting damage caused by asulam drift under field conditions and developed a buffer zone concept that has been implemented by statutory agencies in providing advice to aerial contractors. Initial research (160m zone suggested) was done using the then current standard technology (helicopter application with booms had raindrop and T-jet nozzles to produce a downward and sideways spray). A series of extended checks was published in 1996 [1]. This early work had an immediate impact in that the herbicide manufacturer repeated the study using just raindrop nozzles, demonstrating that the buffer zone distance could be reduced to 50m with these [7, in section 5].

In 1993, two DEFRA contracts were won competitively by the UoL team to develop techniques for integrated bracken management and moorland restoration, with both a literature review and experiment/survey/modelling phase. This work established a series of replicated experiments across Great Britain and a nationwide survey of sites treated using asulam spraying from the air, and it carried out a series of modelling studies to assess effects of climate change and to verify management models. The contract was extended three times to include assessments of treatment effects on below-ground performance, knowledge exchange, and the inclusion of new control techniques. Central to this work was the development of quantitative approaches to analyzing complex data, but then distilling it down into technical advice notes (exemplified by the selection of publications [2-6]). More importantly, long-term data have been amassed (11 years for all experiments and approaching 20 years for some) where bracken-control impacts on both the bracken and the underlying vegetation have been assessed.

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

1. **Marrs RH** and Frost AJ. 1996. Techniques to reduce the impact of asulam drift from helicopter sprayers on native vegetation. Journal of Environmental Management, 46, 373-393. **DOI:**10.1006/jema.1996.0028 Impact Factor: 3.057

2. **Pakeman RJ**, **Le Duc MG** and **Marrs RH**. 1998. An assessment of aerially applied asulam as a method of bracken control. Journal of Environmental Management, 53, 255-262. **DOI:**10.1006/jema.1998.0207 Impact Factor: 3.057

3. Cox ES, **Marrs RH**, **Pakeman RJ** and **Le Duc MG**. 2007. A multi-site assessment of the effectiveness of Pteridium aquilinum control in Great Britain. Applied Vegetation Science, 10, 429-440. **DOI**: 10.1111/j.1654-109X.2007.tb00442.x Impact Factor: 2.263

4. Stewart GB, Cox ES, **Le Duc MG**, **Pakeman RJ**, Pullin AS and **Marrs RH**. 2008. Control of Pteridium aquilinum: meta-analysis of a multi-site study in the UK. Annals of Botany, 101, 957-970. **DOI:**10.1093/aob/mcn020 Impact Factor: 3.449

5. Alday JG, Cox ES, **Pakeman RJ**, Harris MPK, **Le Duc MG** and **Marrs RH**. 2013. Overcoming resistance and resilience of an invaded community is necessary for effective restoration: a multi-site bracken-control study. Journal of Applied Ecology, 50,156-167. **DOI**: 10.1111/1365-2664.12015 Impact Factor: 4.740

6. Alday JG, Cox ES, **Pakeman RJ**, Harris MPK, **Le Duc MG** and **Marrs RH** 2013. Effectiveness of Calluna-heathland restoration methods after invasive plant control. Ecological Engineering, 54, 218-226. DOI: org/10.1016/j.ecoleng.2013.01.038 Impact Factor: 2.958

Key research grants

Five DEFRA contracts (1993-2007) on bracken control and subsequent re-vegetation (in total = £912k; one DEFRA contract on Demonstration Moors and KE (2001-6, £348k), and two PhD studentships funded by the Government of Iran and the private sector (£75k each). All awarded to the University of Liverpool.

4. Details of the impact

The major impacts of the UoL bracken research throughout the period 2008-2013 have been (a) the provision of clear results that were translated into policy guidance and informed regulation, and (b) Knowledge Exchange via demonstrations days, where training in good practice bracken management is delivered. All the reported impacts derived from UoL work and took place in the period 2008-2013.

Scottish Natural Heritage states that “Professor Marrs is now firmly established in the minds of government environmental policy advisers as one of the most effective researchers in carrying out clear, experiment-based work, which is then readily and highly effectively translated into on-the-ground good practice” [14].

Provision of policy guidance and statutory regulation– aerial spraying

The buffer zone approach to spray drift has been taken up as policy guidance, most notably by the Environment Agency in its 2010 aerial spraying guidelines. More specifically, and directly related to the UoL research, their current (2010) guidelines state that for aerial spraying for bracken control: “We and pesticide manufacturers have agreed on minimum ‘no-spray’ buffer zones around water sources to protect water”. The Aerial spraying distances are 160 metres (conventional nozzles) and 50 m (raindrop nozzles) [7]. Generally, aerial application of pesticides must be carried out to prevent the contamination of water and agreement from the EA is required to spray from the air within 250 m of waterways. In the uplands it is assumed that everywhere is near water. Compliance with the Health & Safety Executive’s regulatory system, which also directly

incorporates the research, is essential [8].

The 160m distance was derived directly from [1], where raindrop and T-jet nozzles were used. The 50m distance came from later research done by the herbicide manufacturers using the Liverpool bioassay technique, and is hence a derived impact [9].

These regulations must be applied for all aspects of asulam use in the UK, and the extent of the impact is thus highly significant. Usage from the air in the UK has been recorded at 5,990, 10,303 and 11,222 ha in 2008, 2009 and 2010 respectively [10].

Further, in England, asulam has been recently been applied to 6,680 ha of SSSI (Sites of Special Scientific Interest) and 7,000 ha of land under Higher Level Stewardship Agreements. Natural England noted that “this [asulam use] was a major contributor to an improvement in SSSI condition”. In Scotland, bracken management has recently been approved under three schemes: 'Bracken Management Programme for Habitat Enhancement' (49,191 ha), ‘Natura 2000 sites’ (35,497 ha) and ‘SSSI/Natura 2000 sites combined’ (58,023ha) [11].

Hence the impact overall is direct, obligatory (covered by legislation) and widespread. Beneficiaries include the environment, regulators and policymakers as well as asulam users and land managers.

Provision of policy guidance and development of good practice – bracken control and restoration of vegetation

The UoL team was asked to distil their ongoing research on bracken control and subsequent vegetation management into a set of guidelines that could be used to inform policy and give advice to farmers and estate managers. They worked closely with what was then the Rural Development Service (RDS), an agency closely allied to DEFRA. The initial draft was based on ongoing research covering both lowlands and uplands (1979-2005) but was “road-tested” by RDS with user-groups. The resultant Technical Advice Note, making explicit reference to the Liverpool team and their work, was published in 2005 and re-issued by Natural England in 2008 [12], and this also forms the basis of the advisory leaflet produced by Scottish Natural Heritage in 2008 [13]. The advice in these notes provides the methodology for land-owners or contractors to control bracken and restore native plant communities; its use would be an inevitable part of cross-compliance in agri-environment scheme funding [14]. Natural England indicate that UoL advice will be used on 6,850 ha of live Higher Level Stewardship and ‘classic scheme’ agreements in 2012 [15].

Advice to the Bracken Control Group – emergency authorisation of asulam

The UoL team used its research results to provide advice to the Bracken Control Group for the formulation of emergency authorisation to use asulam, following an EU ban on the use of this product effective 1st January 2013. As asulam is central to bracken control, and there is no other available product, an emergency derogation was sought, and approved, for use in 2013. A subsequent application has been submitted for 2014. This has maintained the use of asulam in the UK for bracken control. The Director of the Bracken Control Group has expressed his gratitude “for first class advice [that] contributed to the successful application” [16].

Knowledge Exchange via demonstrations

The UoL team has either run or participated in good-practice demonstrations days for practitioners in England, Scotland and Wales and in the Azores (where there is a particularly bad bracken infestation problem resulting in cattle disease). To ensure maximum impact, partnerships were established with the International Bracken Group (IBG), the Heather Trust (HT) and the “Organic Farming in Wales” initiative. These days have involved lectures covering bracken biology and control methods and, when on site, demonstrations of good management practice were presented. At the demonstration days of our own experiments, the attendees could see the results of our ongoing experimental treatments. There have been four such days since 2008 at Builth Wells (2008), Dyffryn Ceiriog near Llangollen (2009), Glenshee, and Candacraig, both (2010), reaching 190 participants [16] including policy-makers, farmers, estate managers and conservation agency staff.

5. Sources to corroborate the impact

Each source listed below provides evidence for the corresponding numbered claim made in section 4 (details of the impact).

7. Environment Agency. 2010. Aerial.spraying.guidlines 2010. http://publications.environment-agency.gov.uk/PDF/GEHO0110BRZO-E-E.pdf

8. Health & Safety Executive (HSE). Application plan for the aerial spraying of pesticides (bracken control with asulam) in England and Wales. http://www.pesticides.gov.uk/Resources/CRD/Migrated-Resources/Documents/A/application_plan_bracken_and_asulam_England_and_Wales_2013v2.doc

9. Robinson, R.C., Parsons, R.G., Barbe, G., Patel, P.T. & Murphy, S. 2000. Drift control and buffer zones for helicopter spraying of bracken (Pteridium aquilinum). Agriculture, Ecosystems and Environment, 79, 215–231. **DOI:**10.1016/S0167-8809(00)00127-4.

   Dr Robinson at the time of this paper worked for BayerCropScience – the then manufacturers of asulam (chemical) or Asulox (product). His assessment method (use of R. acetosa as a bioassay plant) was derived from [1].

10. National statistics 2013. Pesticide Usage Survey 2013. http://www.fera.defra.gov.uk/scienceResearch/scienceCapabilities/landUseSustainability/surveys/documents/arable2010.pdf#.

11. Bracken Control Group (2013). Supporting information. The Heather Trust, Dumfries. http://www.jottercms.com/files/brackencontrol/130809_EA_Application_Supporting_Info.pdf?utm_campaign=130809%20Bracken%20Control&utm_medium=email&utm_source=newsletter&utm_content=Asulam%20Supporting%20Information

12. Natural England (2008). Natural England Technical Information Note TIN048 First edition 16 October 2008 Bracken management and control. http://publications.naturalengland.org.uk/search?q=97003&num=100

13. Scottish Natural Heritage (2008). Bracken control: a guide to best practice. http://www.snh.org.uk/pdfs/publications/SEARS/brackencontrol.pdf

14. Letter: Natural England, confirming impact of work.

15. Letter: Scottish Natural Heritage, confirming impact on bracken control policy and Knowledge Exchange.

16. Letter: Heather Trust, confirming activity on Professor Marrs' advisory role on asulam regulations and impact on KE days.