Post-burn bracken *Pteridium aquilinum* control to manage habitat for the heath fritillary butterfly *Mellicta athalia* on Exmoor, Somerset, England

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SUMMARY

During experimental trials, it was discovered that 'bracken bashing' (mechanical damage) to control *Pteridium aquilinum* on an annual basis is not a suitable form of habitat management for the nationally vulnerable heath fritillary *Mellicta athalia.* It was in fact found to be detrimental to promotion of growth of desired vegetation, with lower cow-wheat *Melampyrum pratense* (the larval food plant of heath fritillary) and bilberry *Vaccinium myrtillus* cover than that considered necessary for the habitat to be in suitable condition for the butterfly. Consequently, bracken bashing was halted after 2005, but monitoring of these plots continued. Mechanical damage is a viable option for heath fritillary habitat management in the future but on a less frequent basis. Spraying plots with Asulox in 2002 (commonly used in bracken control) appeared beneficial. Bracken spraying produced favourable ground cover of bilberry and cow-wheat by opening up the previously dense bracken canopy, with bracken itself persisting at lower densities which afforded favourable micro-climate conditions for growth of these plants and shelter for butterflies. Past evidence suggests that livestock grazing is an effective and also a more sustainable management option in the longer term for control of both bracken and invasive woody species, and it is envisaged that other characteristic heathland flora and fauna will also benefit. Livestock have been introduced onto Halse Combe; grazing will be combined with rotational burning and post-burn bracken control (including spraying and mechanical damage) to maintain suitable habitat for heath fritillary in the future.

BACKGROUND

In Britain, the heath fritillary butterfly *Mellicta athalia* is now found in only five counties in southern England: Cornwall, Devon and Somerset in the southwest of the country, and Kent and Essex in the southeast (Asher *et al*. 2001). It has recently been introduced to a woodland locality in Greater London (George 2006). Due to its nationally vulnerable status (Shirt 1987) and severe and rapid decline in the twentieth century, the heath fritillary is a UK Biodiversity Action Plan Priority Species and is fully protected under Schedule 5 of the 1981 Wildlife and Countryside Act (DoE 1994). In 1980 it was known from just 31 colonies in Kent and areas of south-west England.

However, after 1981, new colonies were found in Exmoor (Somerset) but the number of these colonies subsequently declined by nearly 50% over just 10 years, from 29 colonies in 1989 to 15 in 1999/2000 (Stewart *et al*. 2001); the extant colonies experienced severe declines in range and population sizes. Factors implicated in these declines were a lack of appropriate management, including a reduction in grazing that led to a loss of early successional stages of heathland vegetation and a decline in common cow-wheat *Melampyrum pratense*, the primary larval foodplant. On its Exmoor sites, the heath fritillary occupies early successional heath dominated by heather *Calluna vulgaris*, bilberry *Vaccinium myrtillus* and bracken *Pteridium aquilinum.* Common cow-wheat tends to be absent where heathland vegetation is tall and

dense. Favoured breeding areas are sheltered heathland valleys (known locally as combes) from 200-400 m a.s.l. with a high proportion of bilberry and common cow-wheat.

In an attempt to reinstate suitable conditions various management options were considered. Grazing and burning are commonly used in the management and restoration of heathland but burning results in a large input of potash to the soil, causing vigorous growth of bracken, a species frequently invasive on British heaths. This would result in unfavourable conditions for common cow-wheat and therefore heath fritillary, and also unfavourable conditions for other plants and invertebrates characteristic of open heathland. A 5-year experiment was therefore undertaken to test for the most successful method in controlling bracken growth after burning (McCracken *et al*. 2005) including post-burning herbicide application and 'bracken bashing' (mechanical damage) control techniques.

Subsequent to the first three years of this work, we discovered that mechanical damage on an annual basis is not a suitable form of habitat management for heath fritillary and was in fact detrimental to the site where it was trialled, with lower cow-wheat and bilberry cover than control plots and hardly any bracken, low densities of which are required for the foodplant to be in suitable condition for the larva. Consequently, the experiment was halted and bashing was not carried out during 2005-2007. This present study reports on management and outcomes during these years.

ACTION

Study area: In 1993 Halse Combe on Exmoor (National Grid ref: SS 892455) Somerset, south west England), held the largest population of heath fritillary on Exmoor (estimated at c. 11,600 adults) but by 2001 they became extirpated from this site due to a lack of appropriate management (including a decline in livestock grazing, resulting in the invasion of scrub and dense stands of bracken) which reduced the quality of habitat for the butterfly. Halse Combe was therefore selected to test methods of habitat restoration and management. This site is owned by the National Trust, who were partners with Butterfly Conservation in the heathland restoration trials.

Management: The former heath fritillary flight area at Halse Combe (covering approximately 10 ha) was burnt in March 2002. Following this the site was divided into 18 plots, each 40 x 20 m, with treatments assigned to plots as follows:

Control - six plots were left untreated after the initial burn.

Herbicide treatment - six plots were treated with Asulox (application rate 9.6 l/ha) a selective herbicide commonly used in the control of bracken, applied using a knapsack sprayer in May 2002. These plots were not treated again.

Mechanical treatment (‘bracken bashing’) - six plots were cleared of invading scrub by hand in 2003, a year after the initial prescribed burn across the site. Following this 'bracken bashing' then took place on an annual basis in May 2002-2005 inclusive. This entailed driving an Aebi (a specialist vehicle for steep and difficult terrain), quad bike and/or tipper or tractor and swipe (where possible) over the bracken stands. In areas inaccessible to vehicles, bracken was cut by hand. The concept behind bracken bashing is that it weakens growth through reduced nutrient input into the underground rhizomes by breaking and weakening the stems.

No management was carried out on the site in 2006 and 2007. Annual bashing was ceased subsequent to monitoring in 2005 (see Consequences) to avoid the treatment having a negative effect on desired vegetation and hence the heath fritillary population.

Butterfly monitoring: Monitoring of the heath fritillary adults via timed counts, was conducted as close as possible to the peak flight period throughout the site. Larvae and eggs were not monitored. Estimated peak population sizes are calculated using these results. Adult density (number of adults per hour x flight area (ha)) is multiplied by a correction for peak flight period, which is estimated from transect data also collected on site. The relative adult density is then used in the equation ($y = 0.499x - 2.396$) where y is the relative adult number and x is the estimated population size (Warren 1985).

Vegetation monitoring: Thirty 1m² quadrats were laid at random throughout each plot. Vegetation composition and structure was recorded within each quadrat during the heath fritillary peak flight period from 2003-2007, to

assess bracken density and vigour, cow-wheat density, bilberry cover and cover of other vegetation including gorse *Ulex* spp., bramble *Rubus fruticosus* and foxglove *Digitalis purpurea*. Foxglove is occasionally used as a larval foodplant on heathland, particularly by post-diapause larvae and may be more likely used when cow-wheat is at low densities (Warren 1987).

CONSEQUENCES

Treatment effects: Figures 1 and 2 show two plots, the first treated with Asulox in May 2002, and the second receiving the bracken bashing treatment up to 2005. Plots sprayed with Asulox developed into and remained the most favourable for heath fritillary throughout the experiment with the greatest densities of cow-wheat (Fig. 3) and bilberry and lower levels of bracken (Fig. 4). Although cow-wheat appeared adversely affected by spraying in 2003, it increased to a peak in 2005 at approximately 1.5 spikes per m² on average, more than three times that in bashed and control plots in all years. Bilberry increased steadily on sprayed plots from 9% cover in 2004 to 21% in 2006. Bracken density peaked in sprayed plots in 2005 at 15 stems per m² but declined to 5 stems per m² in 2007. Bracken cover remained fairly stable in sprayed plots (ranging from 8-19% from 2004 to 2007) and was consistently lower than in control (14-60%) or bashed plots (24% in 2006 and 9% in 2007) following the cessation of this treatment in 2005.

Figure 1. Photograph of a plot sprayed in May 2002, with favourable ground cover of bilberry, cow-wheat and bracken, June 2007.

Figure 2. Photograph of a 'bracken bashed' experimental plot in the foreground (with many dead bracken fronds) and a sprayed plot behind showing large amounts of gorse, June 2007.

Foxglove density was low across all treatments but consistently highest in sprayed plots, reaching a peak of 2.2 plants per m² in 2005. Density subsequently declined across all treatments to 0.42 per m² in sprayed plots, 0.3 per m² in bashed plots and 0.03 per m² in control plots in 2007.

In 2006 and 2007 European gorse *Ulex europaeus* substantially increased in sprayed plots and across all plots regardless of treatment by 2007 (Fig.5). This suggests that management to control gorse will have to be undertaken on a rotational basis at about 5-year intervals. It was also evident that gorse cover increased most in the herbicide-treated plots, with a marked increase in cover from about 6% in 2005 to 23% in 2006 (3-years after spraying), presumably in response to a reduction in the, previously dense, bracken canopy allowing seeds to geminate and grow; by 2007 gorse cover had increased to an average of 40% in these plots in comparison to 24% in bashed plots and 20% in controls.

Although levels of cow-wheat and bilberry remain high in sprayed plots, they have declined since 2005, a probable consequence of gorse encroachment, which left unchecked is likely to continue.

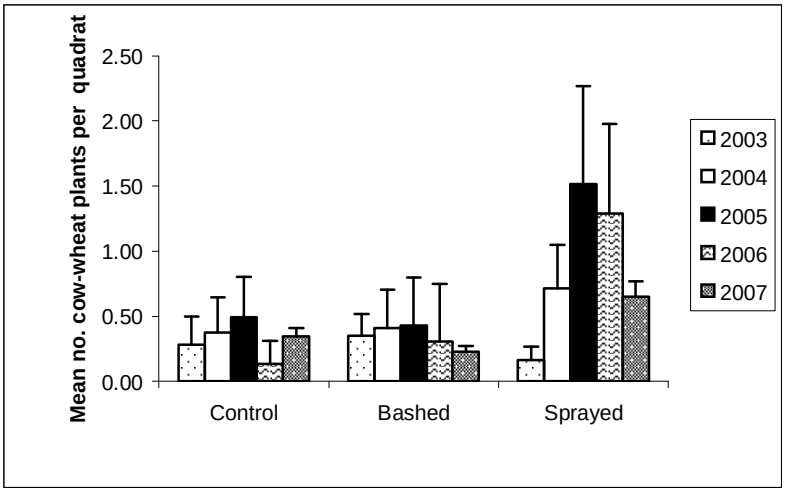

Figure 3. Mean number of cow-wheat plants per 1 m² quadrat in each treatment (with 95% confidence intervals).

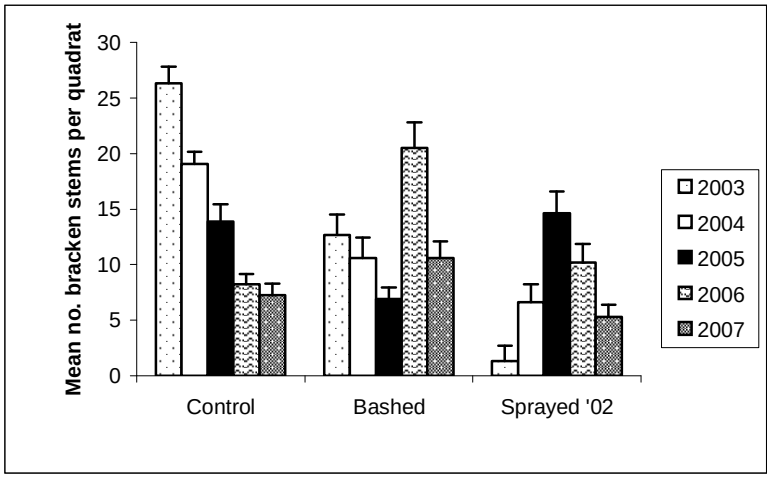

Figure 4. Mean density of bracken stems per 1 m² quadrat in each treatment (with 95% confidence intervals).

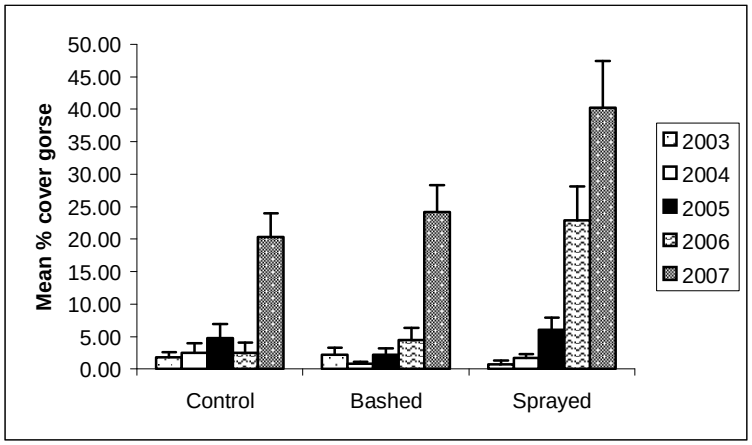

Figure 5. Mean percent cover of gorse per 1 m² quadrat in each treatment (with 95% confidence intervals).

Bracken bashing: Subsequent to 2005, annual bracken bashing was not considered an appropriate form of habitat management for heath fritillary as it was observed that vegetation structure and composition was not recovering sufficiently following treatment. For example, in 2005 bracken cover had declined to less than 2% (some bracken is beneficial to heath fritillary) and vegetation height (other than bracken) was at its lowest recorded level throughout the entire study period in bashed plots in 2005 at 5.4 cm on average. Annual bashing was therefore ceased after 2005 to avoid the treatment having a detrimental effect on the heath fritillary population. No management was carried out all on previously bashed plots in 2006 and 2007.

Vegetation structure and composition was similar on bashed and control plots, particularly in 2006 and 2007. Cow-wheat density remained stable but low at less than 0.5 spikes per m² in control and bashed plots in all years (Fig. 3). Apart from coverage of bilberry in bashed plots in 2003, which was the highest across all treatments in that year (12%), control and bashed plots had significantly less bilberry than sprayed plots in all years at under 7% per m². Bracken density and cover (60% in 2004 and 33% in 2005) was highest in control plots initially but density (Fig. 4), height and cover increased dramatically in bashed plots in 2006 and 2007 following the cessation of treatment. Cover was similar across treatments in 2006 and 2007 but marginally lowest in sprayed plots (30% control, 18% sprayed in 2006 and 14% control, 8% sprayed in 2007). It is thought that extensive bracken litter left *in situ* acted as a mulch and suppressed cow-wheat and bilberry growth in some areas, in addition to the bashing procedure which physically damaged the non-target species on an annual basis.

Maintenance of food plants and bilberry: Cover of cow-wheat and bilberry will vary naturally with successional processes on heathland unless management intervenes in this process. Habitat is no longer suitable for heath fritillary when cow-wheat becomes too shaded for ovipositing (Warren 1985). High and dense bracken stands and other scrubby vegetation will shade out cow-wheat and bilberry over time, limiting the growth of these species and making oviposition difficult for the butterfly. At Halse Combe cow-wheat was absent from plots with bracken densities greater than 40 stems per m² and at heights of over 110 cm tall (McCracken *et al*. 2005). These heights were reached in control plots in all years since 2004, and in 1% of sprayed quadrats in 2006 and 10% in 2007 suggesting that under the current management practices, bracken control will be necessary on approximately a five yearly rotational basis at Halse Combe.

Leaf litter associated with dense bracken stands also prevents heath fritillary foodplants and bilberry from thriving (McCracken *et al*. 2005). However, low-density bracken stands are an important component of heath fritillary habitat as larvae appear to prefer to feed on plants in these lightly shaded stands as opposed to isolated plants, or those on open slopes (Fox 1997). Habitat management for heath fritillary therefore needs to be sensitive and flexible to these requirements.

Heath fritillary recolonisation: Heath fritillaries recolonised the study site in 2004 and by 2005 it supported a large fritillary population with an estimated peak of about 967 individuals. The population appears to have subsequently stabilised, with timed counts producing similar peak population estimates in 2006 and 2007 (Table 1). However, heath fritillary populations fluctuate naturally, so although this is below the peak 1993 estimate of over 11,000 individuals, yearly variations in population size are to be expected; for example, in 1984-86 the population was approximately 2,000 adults, it peaked again in 1988 to around 8,500, declined to virtually none in 1991 and then peaked again in 1993 at 11,600.

Conclusions and discussion: We have learned through these experimental trials that spraying with herbicide (Asulox) appears the best technique for post-burn bracken control and that annual mechanical damage (bracken bashing) is not a viable option for maintaining heath fritillary habitat. Annual bashing resulted in the suppression of vegetation in general (not restricted to just bracken) and the habitat becoming less suitable for heath fritillary. Mechanical damage on a longer rotation is probably beneficial and will be investigated. However, it is evident that grazing is also needed to maintain suitable habitat in the long-term, to control invasion of woody species, e.g. gorse and bramble, as well as bracken. Although difficult to quantify and not included in this experiment, appropriate grazing pressure can reduce bracken dominance and improve habitat conditions for

Table 1. Number of heath fritillaries observed during timed counts and estimated population sizes at Halse Combe from 2004 to 2007.

Flight area (ha)	Survey date	Number of fritillaries observed	Search time (min)	Estimated maximum population size
3	08/06/2007	11	5	798
6	08/06/2006	31	30	750
10	08/06/2005	16	20	967
10	09/06/2004	3	60	65

heath fritillary (McCracken *et al*. 2005). Grazing is also considered a more sustainable method of management. The National Trust has recently secured a herd of North Devon cattle for grazing on Halse Combe and management for the heath fritillary will be extended across the whole site.

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REFERENCES

Asher J., Warren M., Fox R., Harding P., Jeffcoate G. & Jeffcoate S. (2001) *The Millennium atlas of butterflies in Britain and Ireland*. Oxford University Press, Oxford, UK.

Department of the Environment (1994) *Biodiversity, the UK Action Plan*. HMSO, London, UK.

Fox B. (1997) *The heath fritillary on Exmoor*. Unpublished report for the National Trust, UK.

George A.M. (2006) The Heath Fritillary Project. *Journal of the Ruislip & District Nat. Hist. Soc*. **32**, 50-57.

McCracken M., Bulman C., Camp P. & Bourn N. (2005) *Heath fritillary habitat management: A three-year experimental study at Halse Combe, Exmoor*. Butterfly Conservation, Wareham, Dorset, UK. Report no. S05-44 (a summary of this report can be viewed at: http://www.conservationevidence.com/ViewEntry.asp?ID=225).

Shirt D.B. (1987) *British Red Data Books 2. Insects*. Nature Conservancy Council, Peterborough, UK.

Stewart K.S., Bourn N., Warren M. & Brereton T. (2001) *The heath fritillary (*Mellicta athalia*) on Exmoor: changing status 1980-2000 and conservation recommendations*. Butterfly Conservation, Wareham, Dorset, UK.

Warren M. (1985) *The ecology and conservation of the heath fritillary* (Mellicta athalia). Unpublished report: Nature Conservancy Council, Peterborough, UK.

Warren M. (1987) The ecology and conservation of the heath fritillary butterfly, *Mellicta athalia*.

I. Host selection and phenology. *Journal of Applied Ecology* **24**, 467-482.