Bracken *Pteridium aquilinum* control on small conservation sites, Miserden, UK

Ian Grange*
Royal Agricultural College, Cirencester, GL7 6JS, UK

SUMMARY

The objective of this work was to test the effectiveness of reducing bracken density by cutting once or twice a year, or by hand-pulling, compared with a control. The experimental site had already been managed by annually cutting bracken for about 10 years. One year after the management treatments were applied to the plots, both the cut treatments had significantly shorter fronds than the control, but no difference was seen with the pulling treatment. Frond densities and frond coverage were not significantly different from the control, with each showing high variability between plots.

BACKGROUND

Traditional management of bracken (*Pteridium aquilinum*), primarily through harvesting it for bedding and thatch (Rymer 1976), has acted as a control on its spread for centuries past. As such usage has declined in more recent decades, land coverage by bracken has expanded (Paterson *et al*. 1997a). This expansion is also thought to be exacerbated by the effects of climate change in some areas (Pakeman and Marrs 1996). Bracken stands are usually considered to be floristically poor, unless linked to protection of vernal ground flora of old woodland sites (Pakeman and Marrs 1992). Bracken encroachment of existing habitats is therefore generally considered to be detrimental to biodiversity.

Bracken has been recognised as problematic by a number of land based sectors including agriculture, forestry, recreation, shooting, catchment water quality, and conservation, as outlined by Paterson *et al*. (1997b). Whilst focus is placed on the conservation sector in this paper, there is clearly much crossover between sectors such that common approaches to control that can be adopted. Attempts at controlling bracken date back decades (e.g. Gordon 1916; Conway and Stephens 1954), with recent methods tending toward chemical control, primarily through the use of asulam (Pakeman *et al*. 2000). Whilst this has often been demonstrated to be effective (e.g. Stewart *et al*. 2007; Snow and Marrs 1997), recent restrictions on usage have raised questions about its continued availability (Hunt, 2012). Furthermore, whilst asulam is generally considered to be a selective herbicide, other plants of conservation value are also classed as susceptible (Britt *et al*. 2003).

Other approaches used to control the spread and density of bracken have included various cutting regimes, focussed on the number of cuts and the timings of these (e.g. Digby 1993, in Stewart *et al*. 2005), as well as other techniques, less well explored experimentally, such as hand-pulling and rolling, which includes bruising and crimping of the plant stems (Stewart *et al*. 2005).

This paper considers management methods that were deemed most appropriate for use by small groups of voluntary conservation workers on small sites with potential access issues.

ACTION

Site description and management: The experimental site for bracken control was established in June 2011 near Miserden, Gloucestershire (SO 948 084) on the Cotswold plateau scarp which gently slopes in a westward direction away from the Cotswold escarpment to the east and with an elevation of about 150 m a.s.l. Mean annual rainfall is about 759 mm and mean maximum and minimum temperatures of 14°C and 6°C, respectively. The site has a gentle west facing slope, consisting of unimproved limestone grassland overlying a lime-rich loamy and clayey soils with impeded drainage (NSRI, 2012), belonging to the Evesham 1 Soil Association (Findlay *et al*. 1984).

The management regime of the site consists of very light conservation grazing with Dexter cattle at stocking rates of between 0.05 to 0.08 /ha, between August to November and February to April. Limited head of cattle and problems with poor fencing have restricted any increase in stocking density for the site. There has been an annual cut of bracken at the site for about 10 years (Dorothy Banks, Cotswold Voluntary Wardens, pers. comm. 14 Dec 2012). Cutting has been carried out using a brush cutter, a small hand operated sickle bar mower and by hand, using brushing hooks. In recent years, the cut materials have been raked and piled around the edges of the site in an effort to limit nutrient return to the soil and reduce soil fertility.

Experimental design: The experimental site was on a relatively flat area, with the three management treatments and a control randomly located. The three treatments were: bracken cut once per year (mid-June), bracken cut twice per year (mid-June and early August), bracken pulled once a year (mid-June) and control (no management). All cut and pulled plant material was removed from the experimental plots.

Each of these treatments were replicated three times giving a total number of 12 experimental plots, each 5 m × 5 m. Analysis of variance was used to test if there were any significant difference between each of the treatments, with the least significant difference identifying where any differences between mean values were using Genstat (2012).

The effects of management treatments on bracken were assessed in three ways, within each of the 5 m × 5 m plots. Frond height: 10 fronds were randomly selected by 'walking a Z' within each plot, selecting fronds closest to set lengths along the Z. Frond density: 5 × 1 m wide strips were marked within each 5 m × 5 m plot and fronds within each strip were systematically counted from one end of the strip to the other Frond surface coverage: digital images were made of each plot by mounting a camera on a pole, setting the timer and lifting to a set distance above each of the plots. Several shots were taken to ensure a quality image. The percentage bracken canopy coverage was estimated by using a transparent grid, scaled to size, which was mounted on the computer monitor

* To whom correspondence should be addressed: ian.grange@rac.ac.uk

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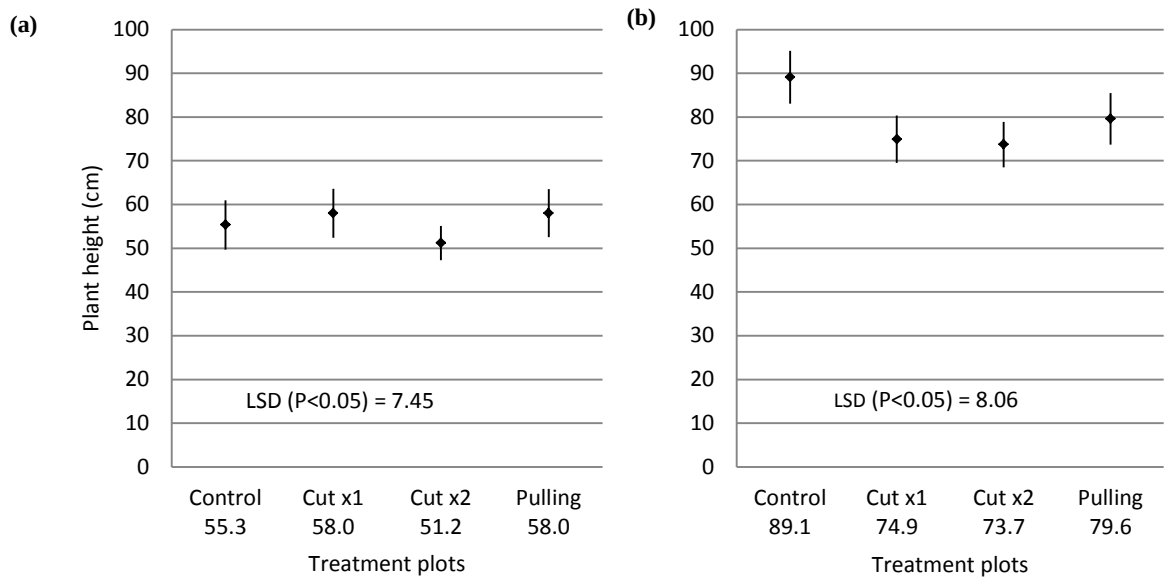

Figure 1. Mean frond height ±95% confidence interval for the bracken control treatments in (a) Year 0, that is, the benchmark measurements before any management treatments were implemented, and (b) Year 1, one year after implementation of the first treatment.

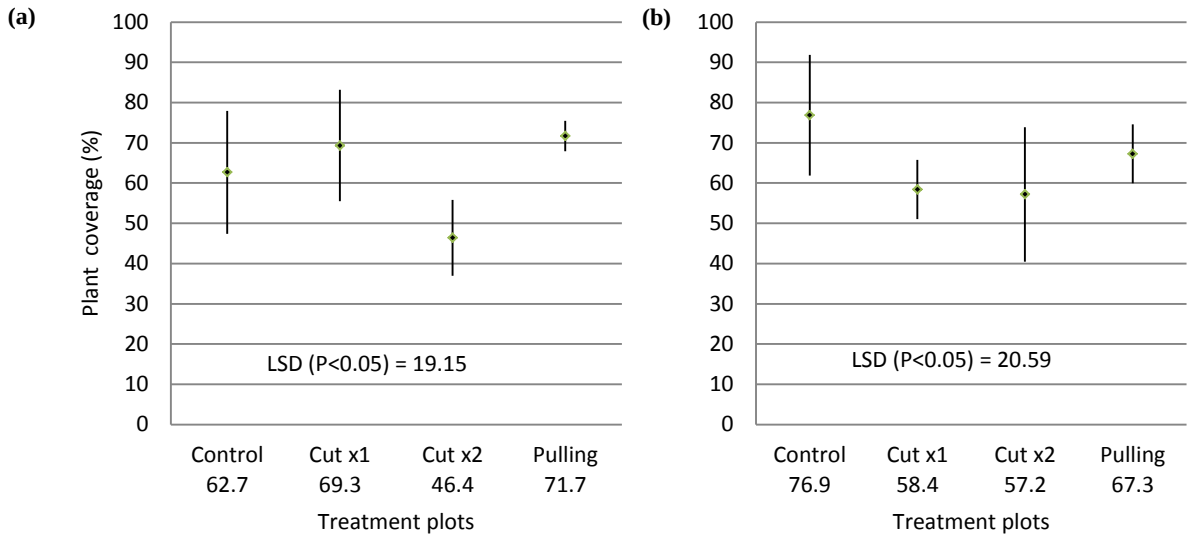

Figure 2. Mean frond coverage ±95% confidence interval for the bracken control treatments in (a) Year 0 (2011), that is, the benchmark measurements before any treatments were implemented, and (b) Year 1 (2012), one year after implementation of the first treatment.

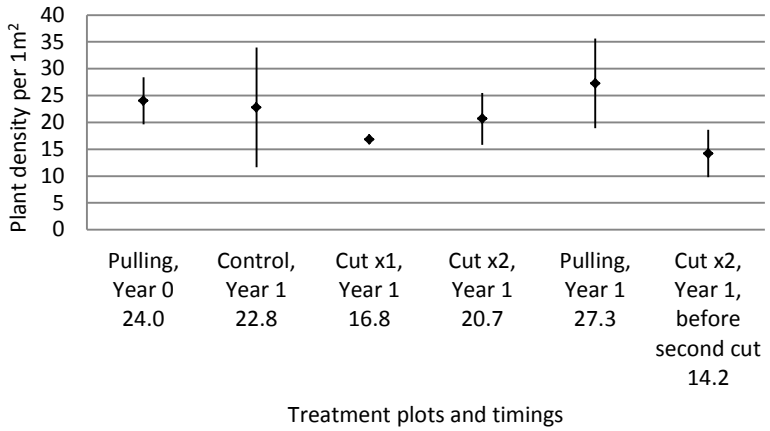

Figure 3. Mean frond density (number of fronds per 5m x 5m) showing the ±95% confidence interval for the bracken control treatments in Year 0 (hand-pulling only) and Year 1, after implementation of the first treatment. Frond density for the Cutting x2 treatment just prior to the second cut in Year 1 is also shown.

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over the screen image. The number of bracken frond 'hits' within each square of the grid were counted and divided by the total grid number to give the percentage cover per plot.

The experimental plots were established in early June 2011 (Year 0) and benchmark measurements (frond height and coverage) were made prior to implementation of treatments. Treatments were then conducted on 7 June 2011, followed by 5 August for the second cut treatment. The plots were then revisited in June 2012 (Year 1) where all measurements were made prior to implementation of the second annual treatment (22 June and 6 August for the second cut treatment).

CONSEQUENCES

There was no significant difference in frond heights between each of the treatment plots in Year 0, that is, prior to implementation of any treatment as shown by ANOVA. This was to be expected as the experimental area had all been subject to the same bracken management of one cut per year, for several years, and demonstrated the relative uniformity of the bracken growth and distribution within the experimental area prior to treatment. However, some significant differences were observed between frond canopy coverage, at the start before any treatments were implemented. Of particular note was a lower coverage in the Cut x2 treatment plots (Figure 2a). This may also be reflected in the lower frond density of the Cut x2 treatment (Figure 3).

In Year 1 (2012), after the management treatments had been implemented in Year 0 (2011), frond heights were significantly lower in all treatments compared to the control (Figure 1b). This was particularly pronounced for both the cutting treatments. Whilst the same trend was followed in the frond canopy coverage assessment (Figure 2b), no significant differences were noted between treatments and the control. Frond density per $1m^2$ showed no significant differences either when measured in Year 1 (2012), except for there being a significantly lower value for the Cut x2 treatment (Figure 3).

DISCUSSION

It was thought that any differences between management treatments would not necessarily be very pronounced after such a short management period of 1 year. It was therefore pleasing to see that the two cutting treatments did reduce bracken growth, with significant decreases in frond heights and reductions in canopy cover, compared to the control. Longer term management, over at least three years, is recommended to increase efficiency of management (Pakeman *et al*. 2005). It is therefore the intention to continue implementation of these treatments at this site for at least another two years to gain a better impression of control over time.

Bracken frond height and density appeared to be more reliable at indicating differences between management treatments. It was noted that the frond canopy cover assessment method had wider variability as indicated by large confidence intervals (Figure 2). Whilst the canopy coverage assessment approach could be a quick and useful surrogate assessment method, linked in closely to the function of the bracken canopy in shading the understorey, future emphasis will be placed on the more quantitative assessments of frond height and density, with possible inclusion of weighing the cut biomass (Stewart *et al*. 2005).

Hand-pulling as a bracken control method has received little attention, particularly from the experimental perspective. Anecdotal evidence suggests that this is an effective means of controlling bracken, albeit a laborious one (Julian Bendle, pers. comm. 9th October 2012). The removal of part of the rhizome and its stored carbohydrate may weaken plant vigour. In practice, this approach was deemed to be both laborious, as well as being unpopular amongst the voluntary work force when compared to the cutting methods. Removal was also a lot slower, estimated to be about 2 minutes per 1 m^2 or 50 minutes per 25 m^2. This represented quite intensive work, although this was eased slightly by first bending the bracken frond to break its join to the underground horizontal rhizome, before hand-pulling and to use gloves with rubber grips to prevent slippage over the stem. It was also considered easier to work in an upslope direction.

Use of rolling and/ or crushing was discounted at the outset at this site for three main reasons: the lack of readily available and suitable machinery (e.g. ATV) for moving equipment around the site; the additional training required for such operations, coupled with costs; and, the difficult terrain of the experimental site with associated safety issues, this also being a reflection of other typical sites on which conservation management occurs.

The trampling effects of cattle have also been reported on as a means of bracken control (Stewart *et al*. 2005). The hoof action breaking the soil surface and penetrating sub-surface levels are thought to cause damage to the bracken rhizome, thus reducing its vigour. In addition, soil and surface litter disturbance, resulting in greater exposure of rhizomes to winter frosts would be a further means of control (Pakeman and Marrs, 1996). Much depends on cattle numbers and condition of the soil, specifically moisture content. A careful balance has therefore to be achieved between stocking rates and timing. This is not currently thought to be an effective means of controlling bracken at the experimental site as there are too few cattle to have a site based impact. Other related factors, potentially influencing bracken spread and density, are soil characteristics including soil fertility, texture, pH and depth, and could be worth further investigation.

Aside from on-going annual management, other factors likely to have influences on the spread and density of bracken include climate. The experiment was set up in a relatively dry year (2011 had only 600 mm rainfall), where growth and density were less than for 2012 when there was considerably more rainfall (1039 mm). Temperature, specifically frost dates are a major factor controlling bracken (Pakeman and Marrs, 1996), with predicted warmer wetter winters (Murphy *et al*. 2009) reducing frost dates, and potentially encouraging further spread. The proceeding winter of 2010-11 had 43 frost dates compared with 32 frost dates for 2011-12 (Royal Agricultural College meteorological station). Further work would be required to determine any relationships between climate condition and bracken growth performance.

The current work examines some of the gaps in the knowledge as regards bracken control (Stewart *et al*. 2005), but focusses on management methods considered most appropriate for use by voluntary conservation workers on small sites with potential access issues. Clearly, the conclusions that can be drawn from this work, given that it has only been in place for one year, are limited. However, early indications demonstrate that cutting once a year, but particularly twice a year, does

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appear able to reduce bracken density and vigour, as indicated by reduced frond height. This was encouraging at this early stage, since cutting has been the preferred method used on the site to date, and been shown to be practicable and convenient.

Hand-pulling has been shown to be useful in reducing frond height compared to the control, but less effective than the cutting regimes. If hand-pulling was shown to be an effective, longer term method of control, then the additional investment in time and resources in conducting this would be useful. However, the early indications from this work suggest that there is little advantage over the cutting regimes.

However, despite management being a major factor in controlling bracken, the combined effects of other factors, such as climate, conservation grazing, soil characteristics and others, are likely to strongly influence bracken spread and density. It is recommended that such factors also be considered in this work in the future, using other environmental indicators of change, such as under storey floral characteristics, in addition to those measurements made on bracken.

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