Moor Water

Non-herbicide Bracken Control Trial Report:
Jaggers Clough

2025

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Contents

1. Summary

- Bracken (*Pteridium aquilinum*) is able to rapidly colonise and dominate large areas, outcompeting other species.
- Until 2024, chemical control of bracken through the use of the herbicide Asulam was one option available to land managers.
- Many previous studies have taken place investigating the efficacy on non-herbicide means of controlling bracken through repeatedly cutting and bruising the plant.
- An additional trial was set up in the Peak District to test the efficacy of non-herbicide control by cutting and mulching bracken fronds once a year in late summer on an annual basis.
- After two years of treatment no change in bracken canopy cover was found.
- After two years of treatment, bracken frond height was reduced in all trial plots.
- After two years of treatment, bracken litter cover was reduced in all trial plots.
- After two years of treatment, cover of non-bracken ground flora increased in two of three trial plots.

2. Introduction

Bracken (*Pteridium aquilinum*) is a large perennial fern growing up to ~180 cm tall, with an extensive underground rhizome system. Although it is native to the UK, it can form dense stands, rapidly colonise new areas and is able outcompete many other plant species.

Bracken has multiple adaptations to enable this success, including the production of a thick litter layer and a dense canopy – shading out other species. It is also allelopathic – producing toxic compounds to directly reduce growth of nearby plants of other species and to deter herbivores (Cutress, 2022). It is common across much of the UK including the Peak District National Park, and covers many areas such as well drained slopes that were previously wooded but were subsequently converted to pasture. It has been proposed that such environmental changes have increased the area of suitable habitat available for bracken to colonise and dominate (Milligan et al, 2016).

Bracken domination has proven to be difficult to reduce, in part because of the above adaptations and especially the rhizome system, which allows the plant to spread underground and also to retain large accumulations of energy and nutrients, allowing it to recover from damage to the above-ground fronds. The plant can also regenerate from small fragments of rhizome, making it difficult to eradicate.

Until 2012 in the EU (and subsequently until 2024 in England under Emergency Use Authorisations), chemical treatment through the use of Asulam was one of the methods of control available to land managers. Asulam (marketed as Asulox) is a pteridophyte and rumex selective carbamate herbicide (University of Hertfordshire, 2024). However, in 2024 Emergency Use Authorisation was withdrawn due to advice from the UK Expert Committee on Pesticides (ECP) – citing concerns that the active ingredient is an endocrine disruptor, posing a potential risk to human, animal and environmental health (ECP, 2023).

The use of physical bracken control methods such as repeated cutting or crushing/bruising of the fronds has previously been the subject of several studies (e.g. Lowday and Mars 1992;

Milligan *et al*. 2016) seeking to quantify the efficacy of non-chemical approaches to reducing bracken dominance. Physical control methods aim to reduce the ability of the plant to store carbohydrates and nutrients in their rhizomes, thereby gradually reducing their size and dominance as they regrow in following years. Milligan's 2016 study in the Peak District showed that when applied over a number of years, multiple cuts carried out in a growing season reduced bracken dominance more rapidly and effectively than a single cut.

In this monitoring programme, further evidence was gathered on the efficacy of cutting as an alternative to control by herbicide, with a focus on evidencing a cutting regime that is likely to be more cost effective and practical for many land managers than the multiple cuts described above. This involved carrying out a single cut annually in August, after bird breeding season, with the aim that this regime is more sustainable in the long term. A post-bird-breeding season cut was also chosen as it may assist land managers to gain Natural England consent where a site is within a SSSI.

In addition, several other treatment combinations were trialled in adjacent plots, including crushing/bruising, the removal of the cut mulch and the adjustment of soil chemistry.

This treatment and monitoring program was designed to be relatively simple, to help ensure the financial sustainability of the trial. Long-term monitoring is anticipated to be important for observing changes, based on the result from previous studies.

2.1. Location

Jaggers Clough in the Peak District National Park is a steep-sided valley to the east of Edale in the High Peak, Derbyshire. Other areas within the clough have previously undergone non-chemical bracken control by landowners, the National Trust. This consisted of an annual 'crushing/ bruising' treatment within the last decade carried out by dragging a heavy object behind a vehicle.

Good results appeared to have been achieved in the areas repeatedly treated in this way (National Trust, 2022). Bracken density was reportedly reduced and many other herb and shrub/tree species have colonised, increasing the floral diversity of the area and opening up additional grazing area. However, due to the steepness of the upper slopes, this treatment could not be applied to the entire valley. Any reduction in bracken dominance achieved through this work in the treated areas was not quantified.

Several areas were impractical to treat with the methods described above, due to the steepness of the slope; and these have remained very dense with ~100% bracken cover. These untreated areas were the focus of this trial, using a small and relatively light self-driven flail which can access these steep areas.

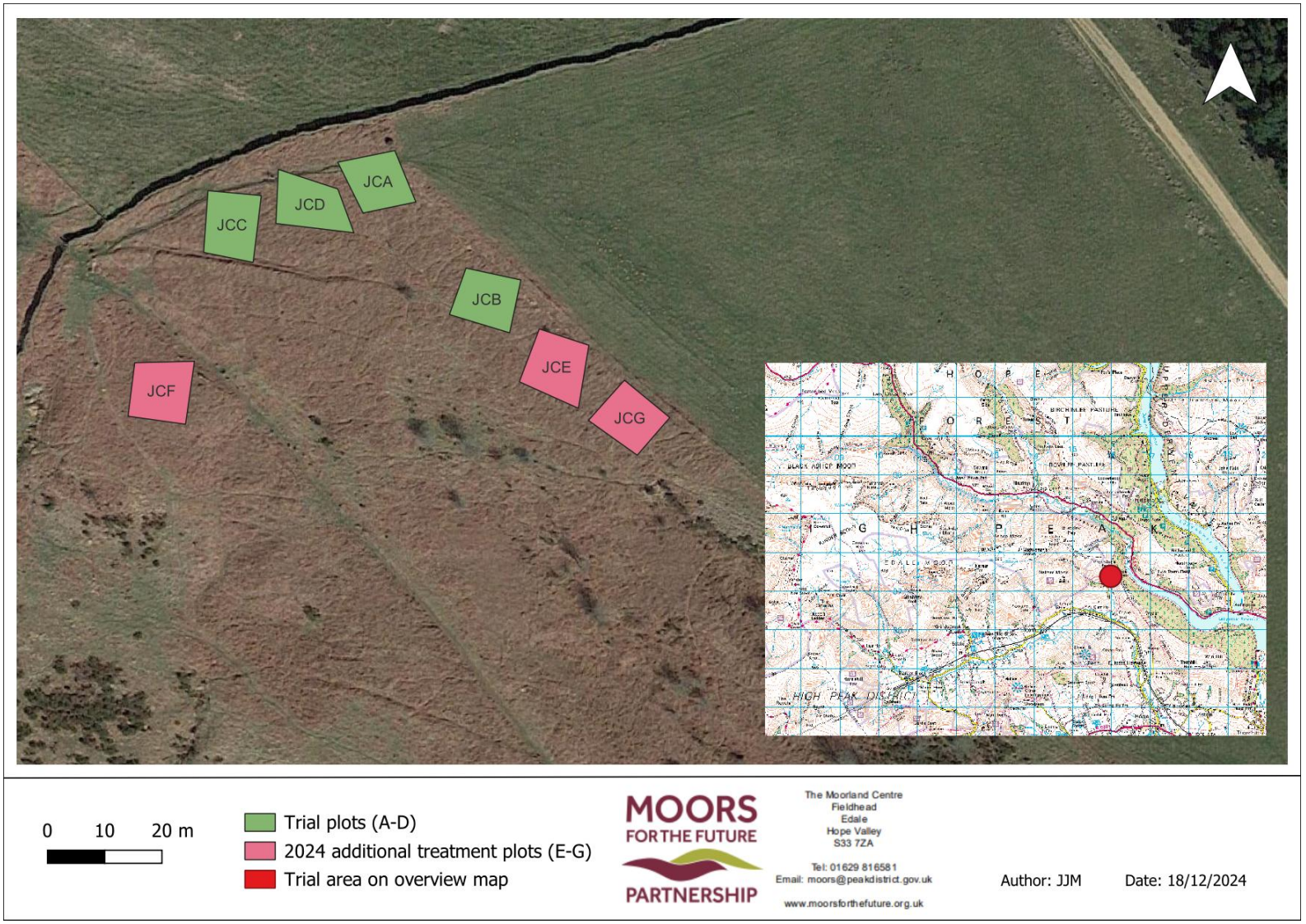

Figure 1. Location and layout of bracken trial at Jaggers Clough, High Peak, Derbyshire.

2.2. Treatment regimes

2.2.1. Cutting

Four monitoring plots (A, B, D and a control C) were identified at locations suitable for cutting (see Figure 1**Error! Reference source not found.**). The trial used a Before-After-Control-Intervention design (BACI) based on the four monitoring units (plus additional 2024 plots) receiving treatments as outlined below in Table 1.

Table 1: Established in 2022, four monitoring locations at Jaggers Clough; centres of 10 x 10 metre plots

Plot ID	Intervention type	Plot size (m)	Year established	Easting	Northing
JCC	Control (no treatment)	10 x 10	2022	415961	387378
JCA	Single cut in August	10 x 10	2022	415986	387387
JCB	Single cut in August	10 x 10	2022	415975	387384
JCD	Single cut in August	10 x 10	2022	415975	387384

Cutting took place in a two-week window in mid-late August (15th – 31st), beginning in August 2022, and was repeated annually to date (2024). The treatment used a remotely driven flail, as pictured below in Figure 2 to cut and mulch the above-ground parts of the plant. Mulch was left in place.

Figure 2. Example of cutting at Jaggers Clough. A) Remotely driven flail B) 10 x 10 plot after cutting

2.2.2. Additional treatments

Three additional treatment types were added to the trial in summer 2024. These were suggested by land managers at an event to view the trial site which was held in 2023, and have been added to allow comparison to the single-cut treatment detailed above. The additional treatments were:

- Cutting once a year in mid-summer (July) and removing the mulch from the plot. Soil treatment added post-cut aiming to correct for nutrient deficiencies which may be inhibiting the growth of other species (e.g. grasses). Soil treatment based on the results of initial soil laboratory analysis and applied at a rate of 0.2 kg m^{-2}. This plot was located downslope from other test plots due to the possibility of treatment leaching.
- Cutting twice a year in mid-summer and late summer. Removing mulch from the plot.
- Crushing twice a year in mid-summer and again in late summer.

Table 2. Established in 2024, three additional monitoring locations at Jaggers Clough; centres of 10 x 10 metre plots

Plot ID	Intervention type	Plot size (m)	Year established	Easting	Northing
JCE	Single cut in mid-summer with arisings removed, soil treatment applied to adjust chemistry	10 x 10	2024	416018	387352
JCF	Cut twice in mid and late summer, arisings removed after 1st cut	10 x 10	2024	415949	387347
JCG	Crushed twice, in mid and late summer	10 x 10	2024	416030	387342

2.2.3. Grazing

Sheep grazing at low density was present on the site, presenting an additional experimental variable which within the parameters of this trial could not be controlled for, as it was impractical to remove stock or fence the plots. However, this does make the trial site representative of the conditions likely to be present on many other sites where bracken may be cut.

3. Methodology

3.1. Experimental design

Vegetation diversity was monitored annually in mid-July before treatments at all trial plots, including a control plot where no treatment took place. Treatments varied across plots and they are summarised in Table 3 below.

Table 3. Summary of annual treatments for each plot

Plot ID	Cut mid-summer	Cut late summer	Arisings removed	Crushed mid-summer	Crushed late summer	Soil treatment
JCA	-	✔	-	-	-	-
JCB	-	✔	-	-	-	-
JCC	-	-	-	-	-	-
JCD	-	✔	-	-	-	-
JCE	-	✔	✔	-	-	✔
JCF	✔	✔	✔	-	-	-
JCG	-	-	-	✔	✔	-

The trial plots were located in an area estimated to be representative of the highest density of bracken across the whole site, and were selected within a contiguous area of bracken for ease of cutting and monitoring. Buffers of at least two metres were left between each plot to minimise the influence of treatments to adjacent plots due to the underground network of rhizomes characteristic of bracken. All plots are approximately 10 x 10 m squares (as the landscape and trees allowed) and approximately north to south orientated. Each of the four corners was marked out with a yellow plastic ground-level marker, anchored with a metal pin. These were chosen as stakes were likely to be damaged by sheep and/or cutting machinery.

3.1. Monitoring of control and single late cut plots (2022 plots)

No fixed ground markers could be used inside the plots, due to the need to cut the site annually and the risk of markers being lost or damaging the cutting machinery. Therefore, only the four corners were marked and an alternative way to locate quadrats was used.

Baler twine was stretched taut and temporarily run between the diagonally opposing corners of the plot square; and quadrats were placed at fixed positions along each line: one group of four with their outmost corners at two metres from each corner marker; and another group at five metres from each corner marker, as shown in Figure 3 below. This allowed a relatively accurate position of the fixed 50 cm quadrats to be identified on an ongoing basis without the need for hardware in the ground within the plot.

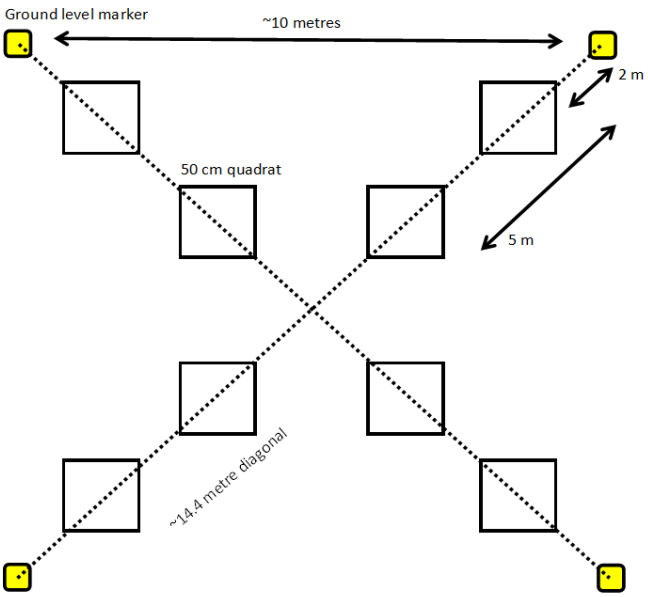

Figure 3. Plot layout showing positioning of 50cm quadrats (not to scale)

The 8 x 50 cm quadrats represent a sample of around ~2% of the plot spread in a systematic way over the treatment area. The quadrats were widely spaced within the plot, to eliminate any interference from neighbouring plants. The initial high bracken density meant that a sub-divided metal quadrat such as that shown in Figure 4 below was able to rest on top of the bracken canopy without flattening the plant stems.

Figure 4. Sub-divided metal 50 cm quadrat

At each quadrat location, % cover was estimated for any flora present. Bracken cover was estimated from the canopy, and other species on the ground beneath the canopy. Bracken litter cover was also estimated. The height of the tallest bracken frond within each quadrat was recorded, as a proxy for plant productivity. Finally, a fixed-point photograph was taken from one corner of each plot, giving a general visual overview of bracken cover.

Baseline monitoring was carried out in July 2022, before the first treatment – during the period when bracken cover and height was around its annual peak. Subsequent monitoring was carried out annually, each July within the same two-week window; before the treatment took place in August.

3.2. Monitoring of additional treatments (2024 plots)

The proportion of each plot sampled was increased to ~16% for the additional treatment plots, with four 2 x 2m quadrats positioned inwards from each plot corner (N-S orientated), negating the need for baler twine and increasing accuracy of their placement and efficiency of monitoring. This adjusted set-up can be seen in Figure 5 below.

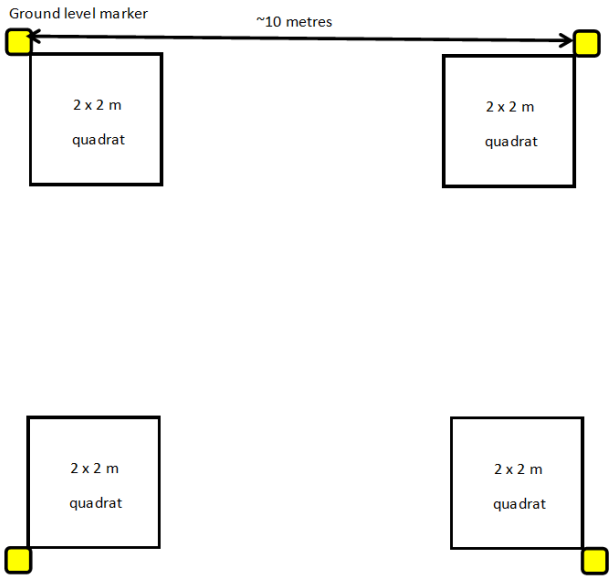

Figure 5. Plot layout showing positioning of 2m quadrats (not drawn to scale)

In all other ways the monitoring protocol was identical to the 2022 plots, with % cover being estimated for bracken, litter and any other species present. Baseline monitoring was carried out in July 2024, before the first treatment – during the period when bracken plant height is around its peak. Subsequent monitoring will be carried out annually, each July within the same two-week window prior to the first treatment in mid-July.

A summary of the monitoring schedule to date for all plots is shown below in Table 4.

Table 4. Annual monitoring in July showing year and plot

Plot ID	2022	2023	2024
JCA	✔	✔	✔
JCB	✔	✔	✔
JCC	✔	✔	✔
JCD	✔	✔	✔
JCE	-	-	✔
JCF	-	-	✔
JCG	-	-	✔

4. Data analysis

Percentage cover from each of the quadrats within each treatment plot was used to create average values (mean and median); and compared to the values from the control site to create a relative cover value (treatment – control). There were three treatment replicates. Frond height data was treated in the same way as above.

The additional 2024 treatment plots were not be replicated; but a larger sample area (16%) within each plot will be monitored, and an average value of the four quadrats within each plot will be created.

5. Results

5.1. Single cut plots

Results for four key metrics are presented here: Bracken canopy cover, bracken litter cover, non-bracken cover and bracken frond height, which is used as a proxy for plant productivity.

5.1.1. Bracken cover

After two years of cutting once per year in late summer, there was no significant difference (Mann-Whitney U non-parametric test p = <0.05) evident in bracken canopy cover in any of the plots. Summary statistics are presented below in Table 5.

Table 5. Mean % cover of bracken at each experimental plot in July each year prior to cutting. Values represent the mean of n = 8.

Year	Plot A	Plot B	Plot C (control)	Plot D
2022 (baseline)	97.5	92.0	90.6	91.5
2023	91.3	99.0	98.0	99.5
2024	96.9	95.6	93.1	94.4

Figure 6. Fixed-point photographs of plot A at time of monitoring in summer 2022 (A) and 2024 (B). No significant change in canopy cover was found.

Figure 7 below shows the average (mean) bracken canopy cover at each plot remains relatively static over three monitoring periods before, during and after two years of treatment.

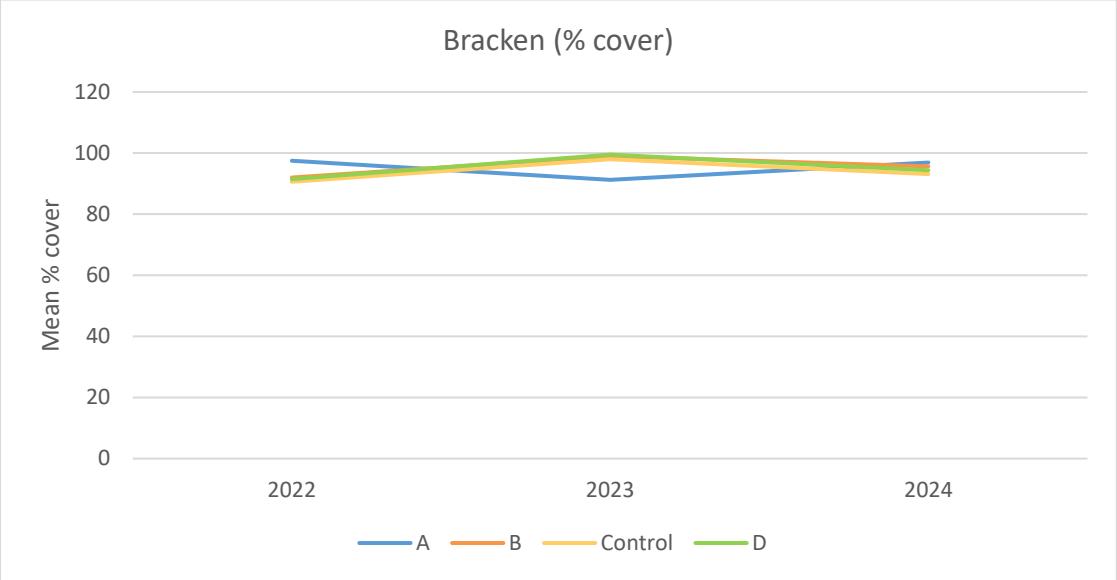

Figure 7. Bracken cover at experimental plots. Cover is mean of n = 8

Figure 8 below compares cover of the bracken canopy at baseline (before initial treatment in 2022) to cover after two treatment periods (after – before third treatment in 2024), relative to the control site where no treatment took place. The median value of each

'before' box plot has been normalised to zero to allow clear comparison of all three 'after' box plots.

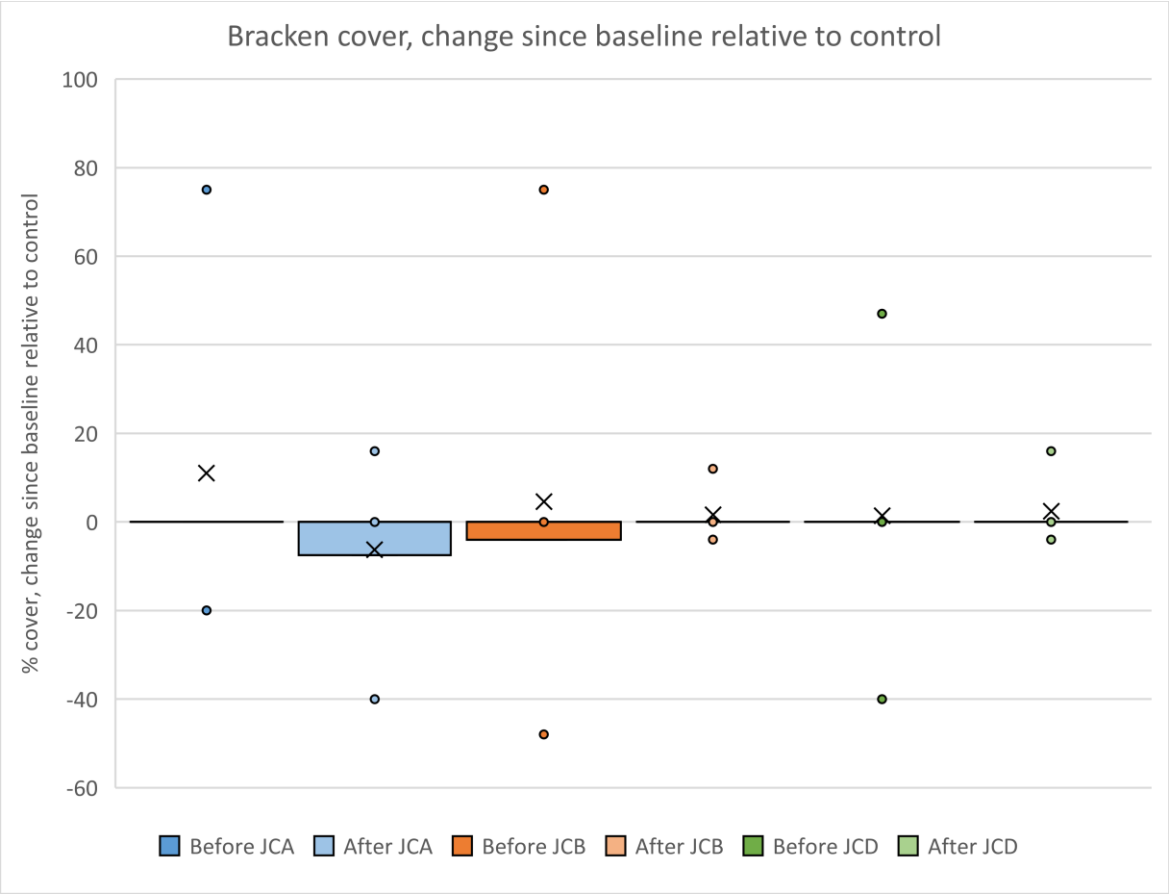

Figure 8. Box and whisker plots showing change in bracken cover relative to control before the start of treatment (2022) and after two years of cutting (2024). The median value of the 'before' plots has been normalized to zero.

Figure 9 shows the difference between mean cover values for 2022 (before treatment) to 2024 (after 2 years of cuts). It can be seen that although plot A shows a small relative reduction in cover, plot B and D show a very small increase. None of these changes are statistically significant.

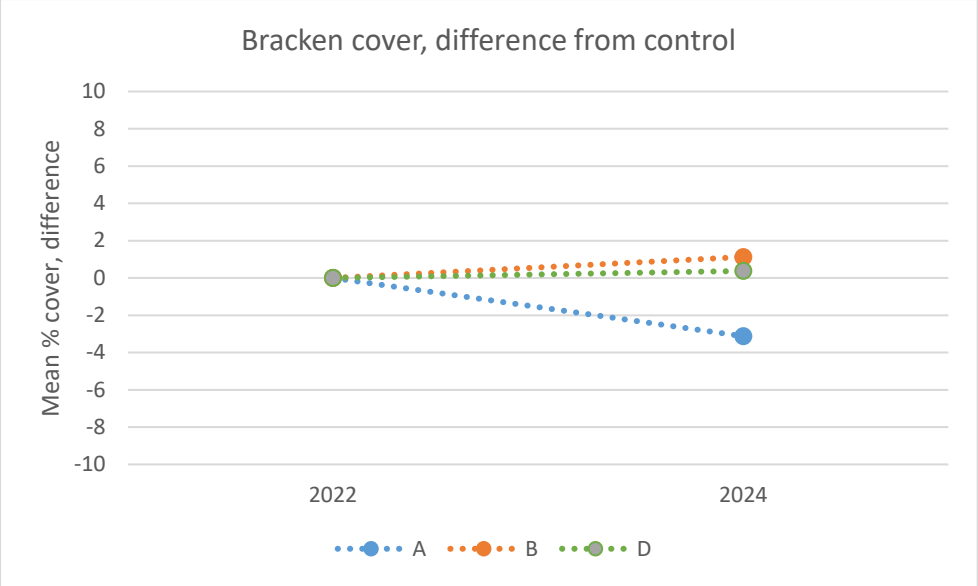

Figure 9. Mean bracken cover difference from control, baseline normalized to zero. Data points represent difference between means of n=8

No statistically significant differences in bracken canopy cover were noted after two years of treatment.

Table 6. Statistical testing for Bracken cover

Values in the table are p-values resulting from the non-parametric Mann-Whitney U test for differences between the control and treatment plots. Significant differences at p < 0.05 are highlighted in grey; marginally significant values are lighter grey.

Year	Plot A	Plot B	Plot D
2022	1	0.7001	0.7001
2024	0.5651	0.9537	0.9537

5.1.2. Bracken frond height

Bracken frond height (mean of the tallest frond within each quadrat) was used as a proxy for plant productivity. After two years of cutting once per year in late summer, there was a significant difference (Mann-Whitney U Non-parametric test p = <0.05) evident in bracken frond height in all three treatment plots. Summary statistics are presented below in Table 7.

Table 7. Mean height (cm) of the tallest bracken frond within each quadrat at each experimental plot in July each year prior to cutting. Values represent the mean of n = 8.

Year	Plot A	Plot B	Plot C (control)	Plot D
2022 (baseline)	119.8	123.1	139.6	128.8
2023	109.9	113.1	117.9	118.3
2024	85.3	88.1	116.9	97.6

Figure 10 below shows the average (mean) bracken frond height at each plot is reduced over three monitoring periods before, during and after two years of treatment. However, the mean height at control also reduced between years 0 and 1 (2022 and 2023).

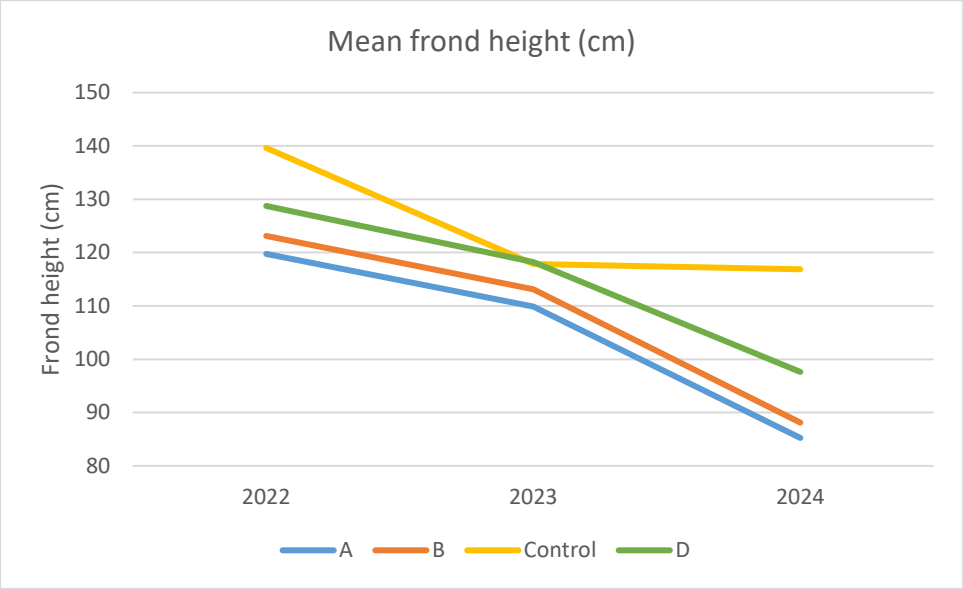

Figure 10. Bracken frond height at experimental plots. Cover is mean of n = 8

Therefore Figure 11 shows the treatment frond heights relative to the control site before (2022) and after (2024) two years of treatment. A small reduction in both mean (~8 – ~12cm) and mean frond height can be seen in all three treatment plots relative to the control site, and this reduction was statistically significant at all plots.

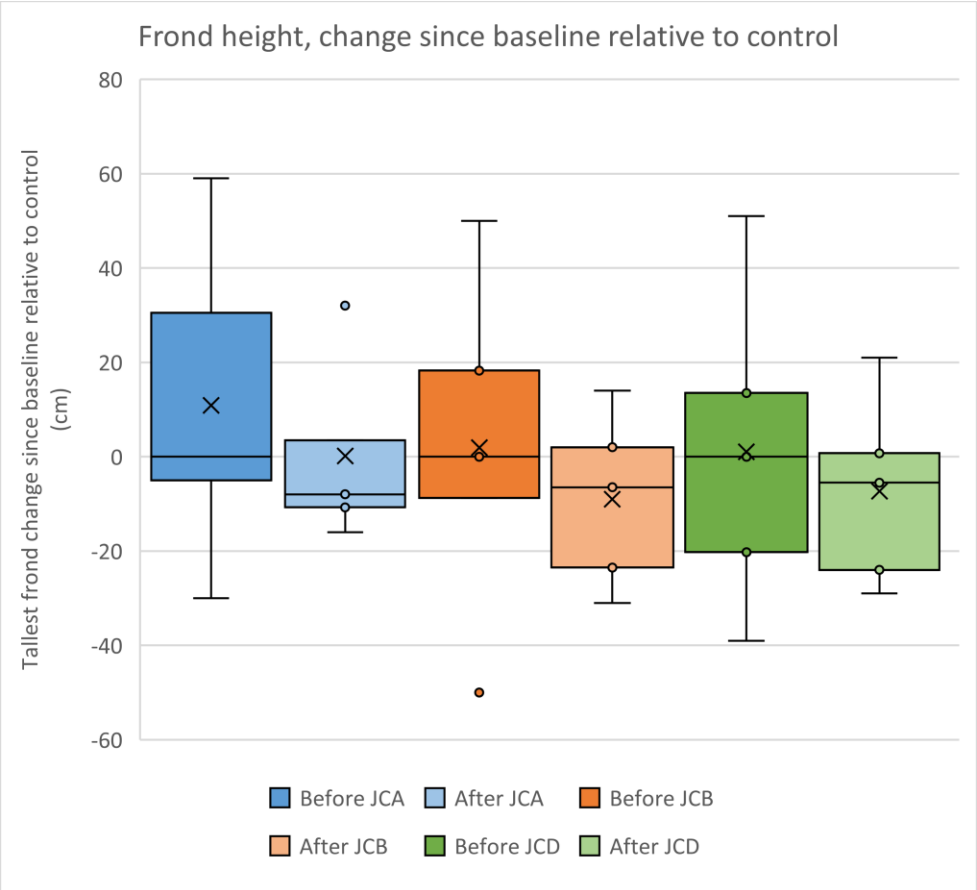

Figure 11. Box and whisker plots showing change in bracken frond height relative to control before the start of treatment (2022) and after two years of cutting (2024). The median value of the 'before' plots has been normalized to zero.

Figure 12 shows the difference between mean cover values for 2022 (before treatment) to 2024 (after 2 years of cuts). It can be seen that all treatment plots show a small reduction in frond height of between ~8 cm and ~12 cm. These changes are statistically significant at all three plots.

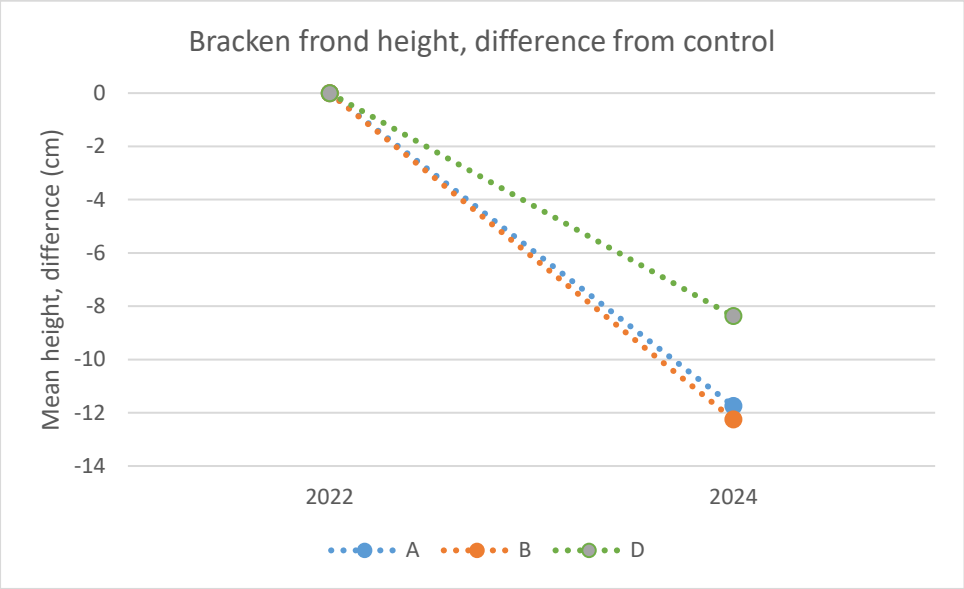

Figure 12. Mean bracken frond height difference from control, baseline normalized to zero. Data points represent difference between means of n=8

Table 8. Statistical testing for bracken frond height

Values in the table are p-values resulting from the non-parametric Mann-Whitney U test for differences between the control and treatment plots. Significant differences at p < 0.05 are highlighted in grey; marginally significant values are lighter grey.

Year	Plot A	Plot B	Plot D
2022	0.03983	0.05741	0.4596
2024	0.0003108	0.0003108	0.02374

5.1.3. Bracken litter cover

After two years of cutting once per year in late summer, there was a significant difference (Mann-Whitney U Non-parametric test p = <0.05) evident in bracken litter in all three plots. Summary statistics are presented below in Table 9. Mean % cover of bracken litter at each experimental plot in July each year prior to cutting. Values represent the mean of n = 8.The change observed between year 0 and 1 however was not significant, whereas that observed between year 1 and 2 of the trial was significant.

Table 9. Mean % cover of bracken litter at each experimental plot in July each year prior to cutting. Values represent the mean of n = 8.

Year	Plot A	Plot B	Plot C (control)	Plot D
2022 (baseline)	97	98.8	99.5	100
2023	92.5	100	100	100
2024	43.8	86.1	97.3	74.4

Figure 13 below shows the average (mean) bracken litter cover at each plot did not reduce between year 0 and year 1 of the trial, but significantly decreased (by an average of ~30 percentage points across all plots) between year 1 and 2, after two years of cutting. Plot A (which saw the largest decrease in frond height) also saw the largest decrease in litter from an average of 97% to ~44% (a decrease of ~53 percentage points).

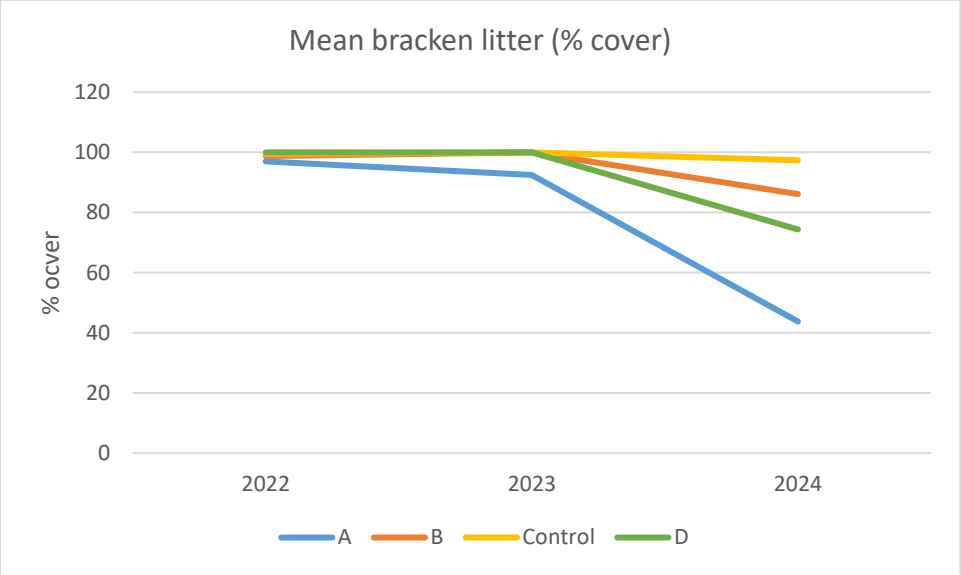

Figure 13. Bracken litter cover (%) at experimental plots. Cover is mean of n = 8

Figure 14 shows the bracken litter cover relative to the control site before (2022) and after (2024) two years of treatment. A reduction in both mean and median litter cover can be seen in all three treatment plots relative to the control site, and this reduction is statistically significant at all plots.

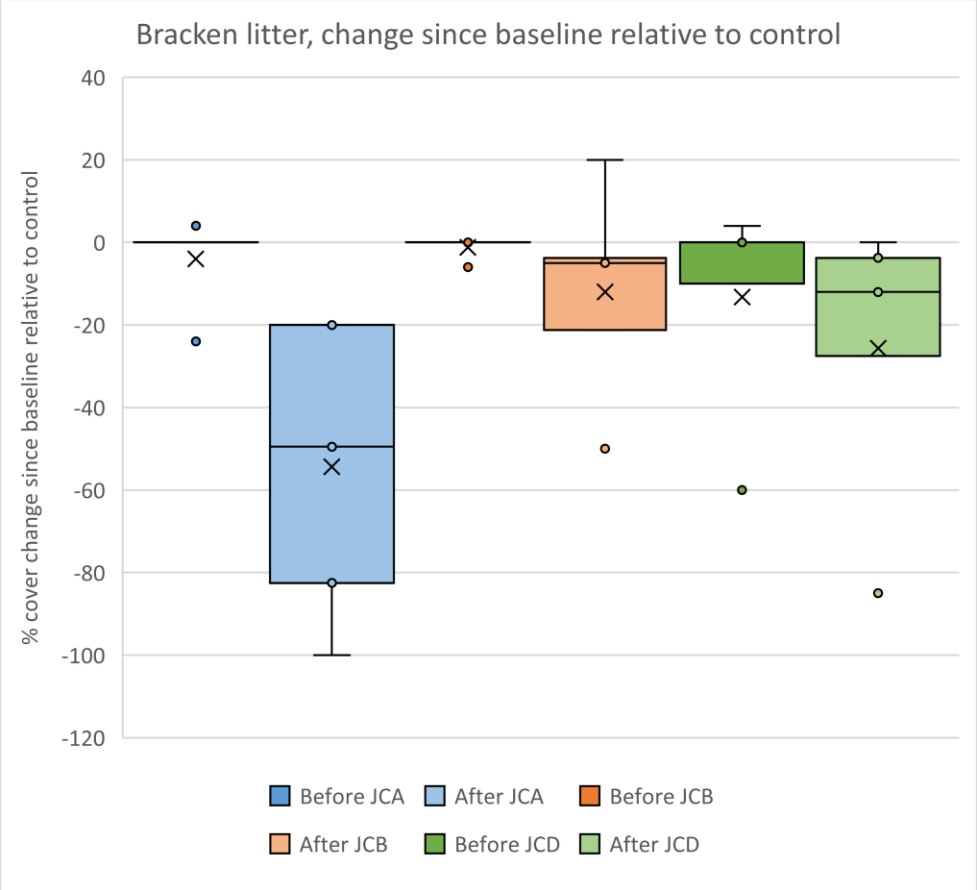

Figure 14. Box and whisker plots showing change in bracken litter cover relative to control before the start of treatment (2022) and after two years of cutting (2024). The median value of the 'before' plots has been normalized to zero.

Figure 15 below shows the difference between mean litter cover values for 2022 (before treatment) to 2024 (after 2 years of cuts). It can be seen that all treatment plots show a reduction in cover of between ~8 % points and ~53 % points. These changes are statistically significant at all three plots.

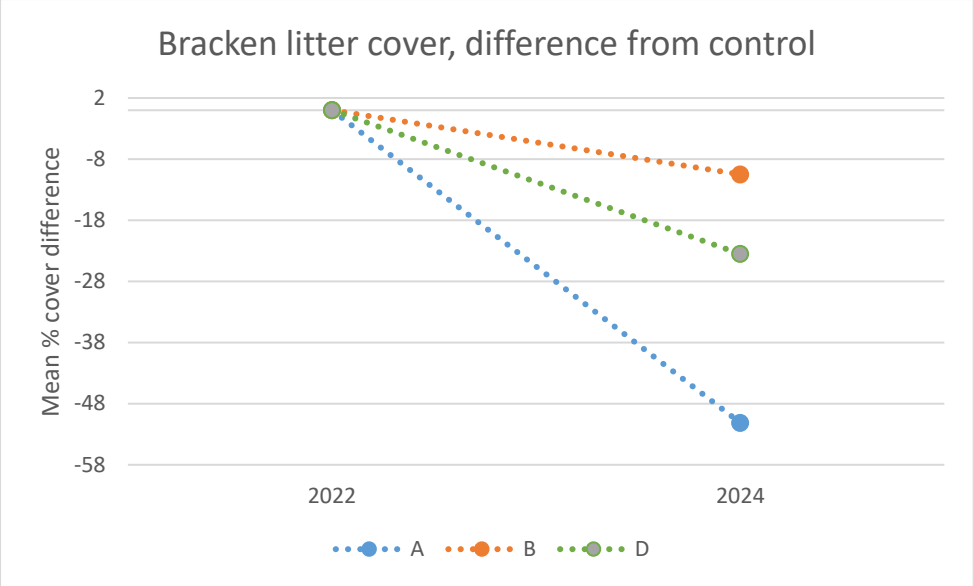

Figure 15. Mean bracken litter cover difference from control, baseline normalized to zero. Data points represent difference between means of n=8

Table 10. Statistical testing for bracken litter cover

Values in the table are p-values resulting from the non-parametric Mann-Whitney U test for differences between the control and treatment plots. Significant differences at p < 0.05 are highlighted in grey; marginally significant values are lighter grey.

Year	Plot A	Plot B	Plot D
2022	1	1	0.3816
2024	0.0009698	0.01786	0.03291

5.1.4. Non-bracken vegetation cover

After two years of cutting once per year in late summer, there was a significant or marginally significant difference (Mann-Whitney U Non-parametric test p = <0.05) evident in cover of non-bracken vegetation (combined cover of all vegetation types present aside from bracken) in two of the three plots. Summary statistics are presented below in Table 11. Table 9. Mean % cover of bracken litter at each experimental plot in July each year prior to cutting. Values represent the mean of n = 8.The change observed between year 0 and 1 however was not significant in any treatment plot, whereas that observed between year 1 and 2 of the trial was significant or marginally significant in two of the treatment plots.

Table 11. Mean % cover of non-bracken vegetation at each experimental plot in July each year prior to cutting. Values represent the mean of n = 8.

Year	Plot A	Plot B	Plot C (control)	Plot D
2022 (baseline)	3	2	1.5	8.5
2023	10.125	1.25	2.75	5.125
2024	51.75	14.25	5.75	27.5

Figure 16 below shows the average (mean) non-bracken vegetation cover at each plot did not significantly increase between year 0 and year 1 of the trial, but increased (by an average of ~26 percentage points across all plots) between year 1 and 2, after two years of cutting. Plot A (which saw the largest decrease in frond height and litter) also saw the largest increase in other vegetation litter from an average of 3% to ~52% (an increase of ~49 percentage points).

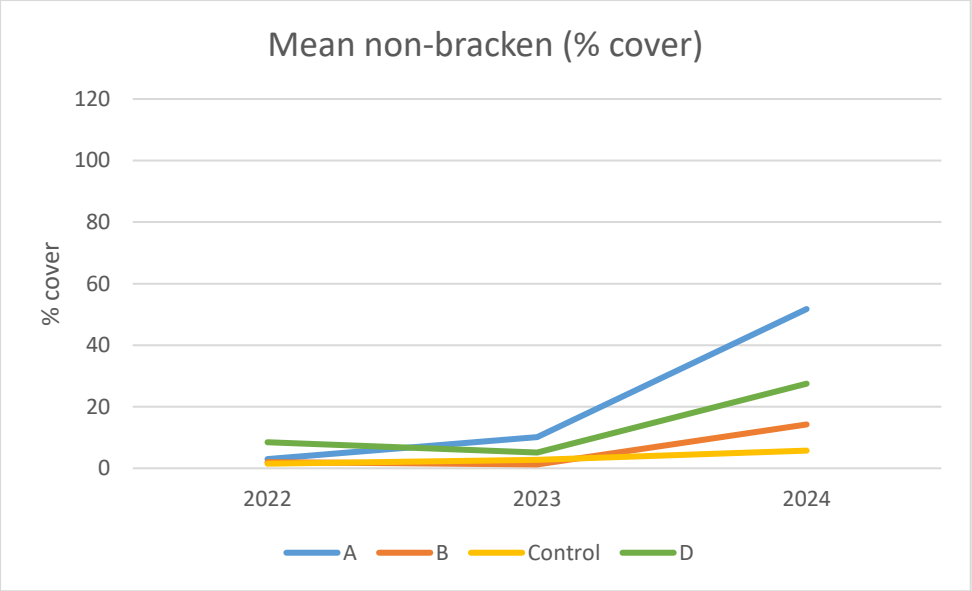

Figure 16. Non-bracken vegetation cover (%) at experimental plots. Cover is mean of n = 8

Figure 17 shows non-bracken cover relative to the control site before (2022) and after (2024) two years of treatment. An increase in both mean and median non-bracken cover

was seen in all three treatment plots relative to the control site, and this reduction was statistically significant at plots A and marginally significant at plot D.

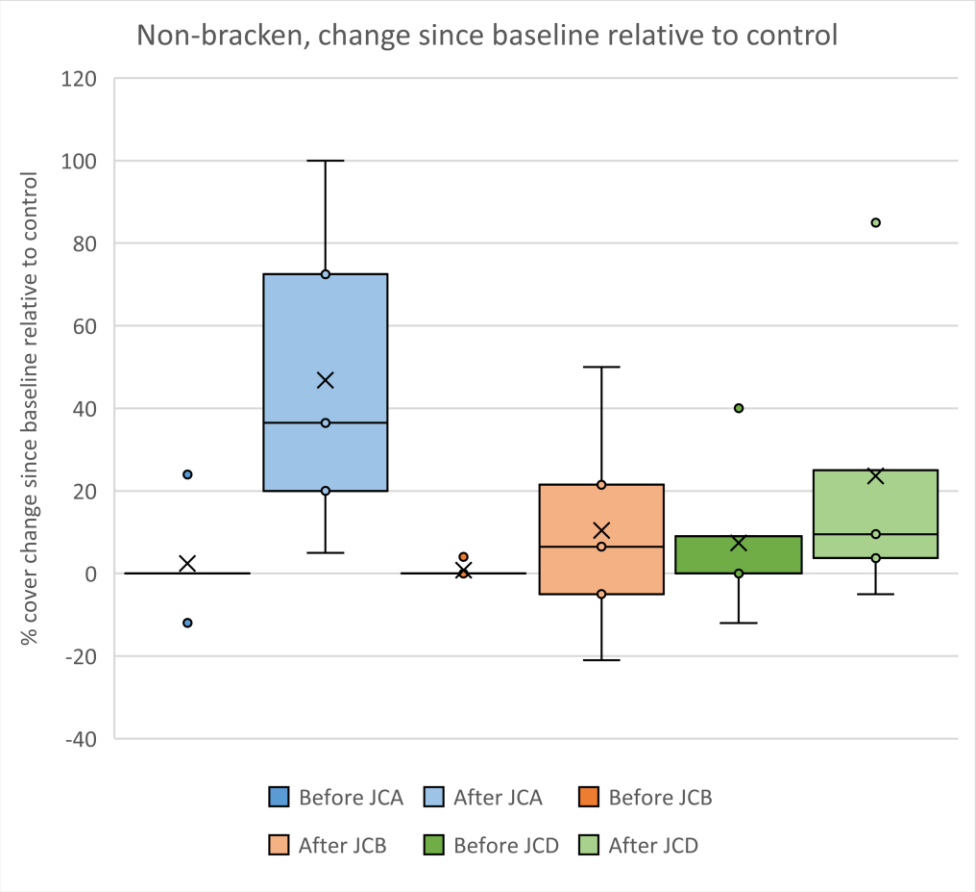

Figure 17. Box and whisker plots showing change in non-bracken vegetation cover relative to control before the start of treatment (2022) and after two years of cutting (2024). The median value of the 'before' plots has been normalized to zero.

Figure 18 below shows the difference between mean non-bracken cover values for 2022 (before treatment) to 2024 (after 2 years of cuts). It can be seen that all treatment plots showed an increase in cover of between ~8 % points and ~39 % points. These changes are statistically significant or marginally statistically significant at plots A and D, but not B, see Table 12 below. In addition, the relative species frequency recorded increased from at least 4 species (individual grass and moss species were not recorded, but grouped) to at least 7, after two years of treatment.

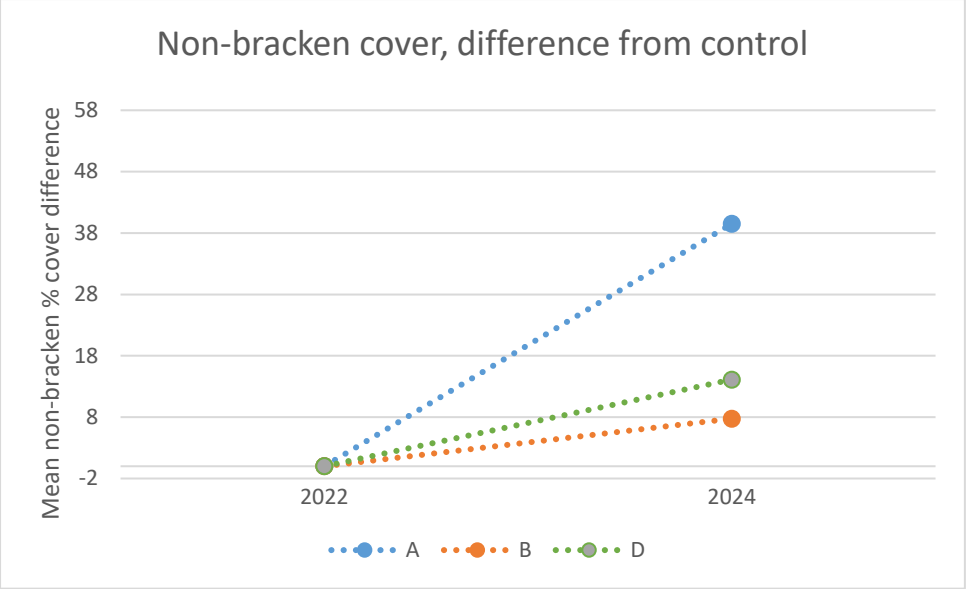

Figure 18. Mean non-bracken vegetation cover difference from control, baseline normalized to zero. Data points represent difference between means of n=8

Table 12. Statistical testing for non-bracken vegetation cover

Values in the table are p-values resulting from the non-parametric Mann-Whitney U test for differences between the control and treatment plots. Significant differences at p < 0.05 are highlighted in grey; marginally significant values are lighter grey.

Year	Plot A	Plot B	Plot D
2022	1	1	0.2697
2024	0.001961	0.08399	0.05171

5.2. Additional treatments, summary of baseline results

In July of 2024, three additional experimental plots (E, F and G) were established to test additional treatments including soil chemistry adjustment, removing arisings and crushing (see Table 2 for treatment specifications). Before the initial treatment took place, plots were surveyed using the same monitoring protocol but an adapted sampling strategy as detailed in paragraph 3.2 above. A summary of results is presented below, and will form a baseline against which future annual survey results could be compared.

Table 13. Mean values at each experimental plot in July of the baseline prior (2024) to treatment. Values represent the mean of n = 4.

Metric	Plot E	Plot F	Plot G
Bracken cover (%)	89.9	80.5	93
Bracken frond height (cm)	109.8	106.1	110.8
Bracken litter cover (%)	99.9	94.7	95.5
Non-bracken vegetation cover (%)	1.5	20.8	4.8

6. Discussion and limitations

After two years of late summer single-cut treatments, no clear reduction in bracken canopy cover was observed. In contrast, a significant reduction in bracken frond height and litter cover was observed; and a significant increase in non-bracken ground flora cover was observed in two thirds of the treatment plots (in addition to an increase in the number of non-bracken ground flora species present). The majority of the change in bracken litter cover and ground flora appeared to occur after the bracken had been cut twice (i.e. two years of cutting), with little clear change after a single year of cutting.

The relatively rapid increase in ground flora after only two years may support the speculations of Milligan *et al*., (2016) which suggested that the ground flora beneath a bracken canopy can be relatively resilient – maintaining a low cover and acting as a 'reservoir' from which spread could take place once conditions changed – for example due to a decrease in litter cover and depth, or an increase in light availability.

The canopy forming structure of bracken (i.e. tall vertical stems with widely spreading leaves mainly situated near the top of the plant) mean that further years of treatment are likely to be necessary to weaken the plants enough to produce a significant reduction in canopy cover, and that results could be achieved more quickly by carrying out multiple cuts each growing season, consistent with the findings of other studies such as Milligan et al., 2016; Alday *et al*., 2013; Marrs *et al*., 1998.

The presence of sheep on the experimental site was a confounding factor which could not be controlled for in this study. The highly selective nature of their grazing meant that they were likely to have moved between plots grazing desired ground flora species, and may have favoured some plots more than others. It is very likely that they would spend more time in treatments plot that the control for example, impacting the recovery of ground flora both in terms of cover and species diversity – but this was not possible to quantify. Furthermore, they may have introduced crushing of bracken via trampling any frond regrowth, which was not also not possible to quantify.

The lack of fixed quadrat markers and use of baler twine and tape measure in the original experimental design meant that it was not possible to relocate the survey location each year with complete accuracy, introducing more noise into the data collected. With this in mind a revised sampling strategy (increasing sample size and using the four corner points as markers) was introduced when adding extra treatments in 2024. Locating close to the edge of the treatment area however is more likely to increase the effects of spread/regrowth from rhizomes located just outside the plots, and this will need to the considered when conducting future analysis.

7. Conclusion

This study has indicated that it is possible to reduce bracken productivity and litter cover, and increase non-bracken ground flora cover after two years of conducting a single cut in late summer, but no reduction in bracken canopy cover has yet been achieved on this site with this regime. Further years of treatment and monitoring would needed to quantify these trajectories on this site.

8. References

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9. List of Figures

10. List of tables