MOORS FOR THE FUTURE PARTNERSHIP

A REPORT INTO THE IMPACTS CUTTING COTTON GRASS (*ERIOPHORUM SPP*) HAS ON THE GROWTH RATE OF SPHAGNUM MOSS SPP

MoorLIFE 2020

Prepared by:

Moors for the Future Partnership, November 2022

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Introduction

This report sets out the results associated with the cotton grass cutting trials which were undertaken as part of the MoorLIFE 2020 project. The trial aimed to determine if cutting areas of blanket bog dominated by common cotton grass *(Eriophorum angustifolium)* or hare's tail cotton grass *(Eriophorum vaginatum)*, had a positive impact on the growth rate of Sphagnum moss. The purpose of this trial was to inform future land management practices on the subject for land owners and practitioners.

Most blanket bog habitats within the South Pennine Moors (SPM) Special Area of Conservation (SAC) are defined as being in an unfavourable – recovering condition using Natural England's Common Standards Monitoring (Heinemeyer et al, 2019). It is essential that successful Sphagnum moss inoculation takes place in order to improve blanket bogs to a healthy and favourable condition. Sphagnum moss is a key species in the restoration of these blanket bogs as it helps to regulate overland flow of water, rewet blanket bogs and reduce flash flooding further down the system (Holden et al, 2008), undertake carbon sequestration (New Scientist, 2012) and helps to restore the acrotelm (Moors for the Future Partnership, 2022).

Planting Sphagnum moss into graminoids such as cotton grass can be beneficial for the Sphagnum moss by regulating light, temperature and humidity, creating the right sort of microclimate for growth (Tuittila et al, 2000). However, in areas dominated by vascular plants it has been shown that competition for nutrients and light exists between the vascular plants and Sphagnum moss to the point where it can retard growth of the Sphagnum plugs (Pouliot, R. et al, 2010) depending upon the gramionoid present. (Guêné-Nanchen, M., 2017).

1. Methodology

The trial was set up on six sites (three dominated by hare's tail, three dominated by common cotton grass) across the SPM SAC, see Appendix 1. The sites were chosen based upon similar site characteristics, including slope, aspect and the dominance of the relevant cotton grass species present. To determine the dominance of individual cotton grass species a "W"-shaped walkover survey was undertaken of the proposed area, and the DAFOR (Dominant Abundant Frequent Occasional Rare) scale used to determine the level of vegetation cover, and an additional category of "very rare" was added to the scale.

Once the sites were identified each site was set up using the following design, see figure 1 and 2 below.

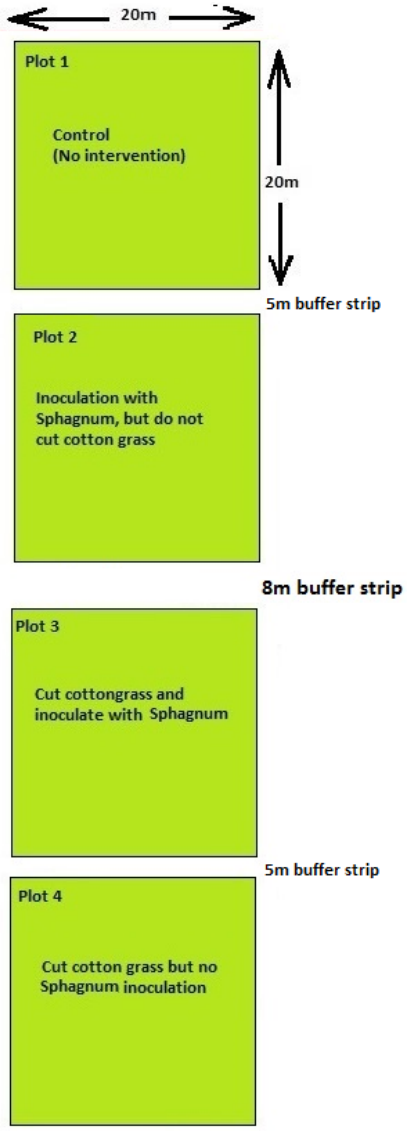

Figure 1 – Plan of treatment area

Figure 2 – Overview of one of the treatment areas

Within each plot 5 randomly located 2m x 2m fixed point quadrats were set up, with up to 36 mixed Sphagnum moss plugs planted randomly in each of the quadrats, in plots 2 (not cut and planted) and 3 (cut and planted), see figure 1 above.

Figure 3 – Example quadrat

Additionally Sphagnum moss was planted at a density of 1 plug per 8m^2 across the length of plot 2 (not cut and planted) and plot 3 (cut and planted). Where this additional planting clashed with a quadrat the plug was not planted.

In each site plots 3 (cut and planted) and plot 4 (cut not planted) were cut on the same day using a LV600 Green Climber with an attached flail head.

Prior to cutting and planting, the quadrats were surveyed to obtain baseline data and identify if any "wild" Sphagnum moss were present in or around the quadrats. After the plugs had been planted a second survey was undertaken to determine the baseline cover of Sphagnum moss plugs. This survey was necessary due to a discrepancy between the planned planting regime, and the actual final plug plant locations (see Section 1.1.1, below). The sites were then surveyed annually to identify the change in cover and species composition.

1.1. Potential issues

1.1.1. Sphagnum planting

The Sphagnum moss plugs were planted by the same contractor on all sites. An initial pre-start meeting with the contractors was undertaken to explain the methodology and demonstrate the Sphagnum moss planting methodology before the contractor undertook the work across all sites. Some of the quadrats did not receive the full 36 plugs due to the contractor aligning the quadrats incorrectly, meaning that some plugs were planted outside of the quadrats. Most of the quadrats received 30+ plugs of Sphagnum moss, with only 10 out of 60 quadrats receiving less than 30 plugs, with the lowest recorded at 15 plugs. All remaining quadrats received at least 25+ plugs of Sphagnum moss. Due to the minimal amount of plugs missing in most quadrats, the different amount of Sphagnum moss plugs should have a limited impact upon the trial's results. This is due to the number of replicates across all sites, which will allow any bias to be removed when averaging Sphagnum moss cover.

1.1.2. Additional sphagnum planted

As identified above all quadrats did not receive the same number of Sphagnum moss plugs, in year 2 the surveyors therefore decided to dig up any plugs they found planted outside the quadrat, and re-planted them inside the quadrat, causing an unintentional increase in Sphagnum moss that was not specified within the experimental design. The surveyors did note down how many additional plugs were added at each quadrat, see table 1 below. The data show that the main locations to receive plugs were the uncut plots for both the common and hare's tail cotton grass sites. Analysis suggested that the impact on total cover was minimal with the highest additional plugs added representing just 0.96% of total cover.

Table 1: Table showing the impact of the additional plugs per quadrat that received the additional plugs

Cotton grass type	Cut / uncut	Quadrat No	No of Sphagnum plugs moved into quadrat	Total % Sphagnum cover	Area per plug (cm)	Area covered by all Spahgnum plugs moved	Percentage of total cover	New % cover
Common	Not cut	BAM 2.1	1	7	81	81	0.20	6.80
Hares	Not cut	FBM 2.1	6	4	64	384	0.96	3.04
Hares	Not cut	FBM 2.2	3	4.5	64	192	0.48	4.02
Hares	Not cut	FBM 2.3	4	2	64	256	0.64	1.36
Hares	Not cut	FBM 2.4	3	4	64	192	0.48	3.52
Hares	Cut	FBM 3.1	4	4.5	49	196	0.49	4.01
Common	Not cut	LGH 2.2	2	5	49	98	0.25	4.76
Common	Not cut	LGH 2.4	2	6	49	98	0.25	5.76
Hares	Not cut	SLM 2.2	6	2	36	216	0.54	1.46
Hares	Not cut	SLM 2.3	3	2	36	108	0.27	1.73
Common	Not cut	SPM 2.4	1	1.5	NR	0	0.00	1.50

1.1.3. Wildfires

For the hare's tail cotton grass sites a wildfire occurred on Marsden Moor causing 666ha of damage (Titterton et al, 2021), including the trial site on Linsgreave Head (see figure 6 below). Due to the damage it caused a decision was made to remove this site from future analysis.

Figure 4 – Photograph showing the damage to the trial site on Linsgreave Clough

2. Results

2.1. Hare's tail cotton grass plots

2.1.1. Sphagnum cover

The initial survey showed 0% average Sphagnum moss cover in all quadrats. Immediately after the Sphagnum moss was planted this increased to an average of 1% for plots 2 (planted not cut) and 3 (planted and cut). After planting occurred the total average Sphagnum moss cover increased year-on-year (graph 4) to 6.8% for plot 2 (planted not cut) and 17.8% cover for plot 3 (planted and cut) in year 5, a difference of 11% cover between the cut and uncut quadrats. On two of the hare's tail cotton grass sites there was a gradual average increase in Sphagnum moss cover in plots 1 (Control) and 4 (Cut, not planted) that peaked at 0.5% in year 5

A two-tailed t-test undertaken on the individual quadrat data indicated that there was a statistical difference in the growth rate of Sphagnum moss between the uncut and cut plots in year 5, with a p value of 0.019, which is below the alpha value of 0.05.

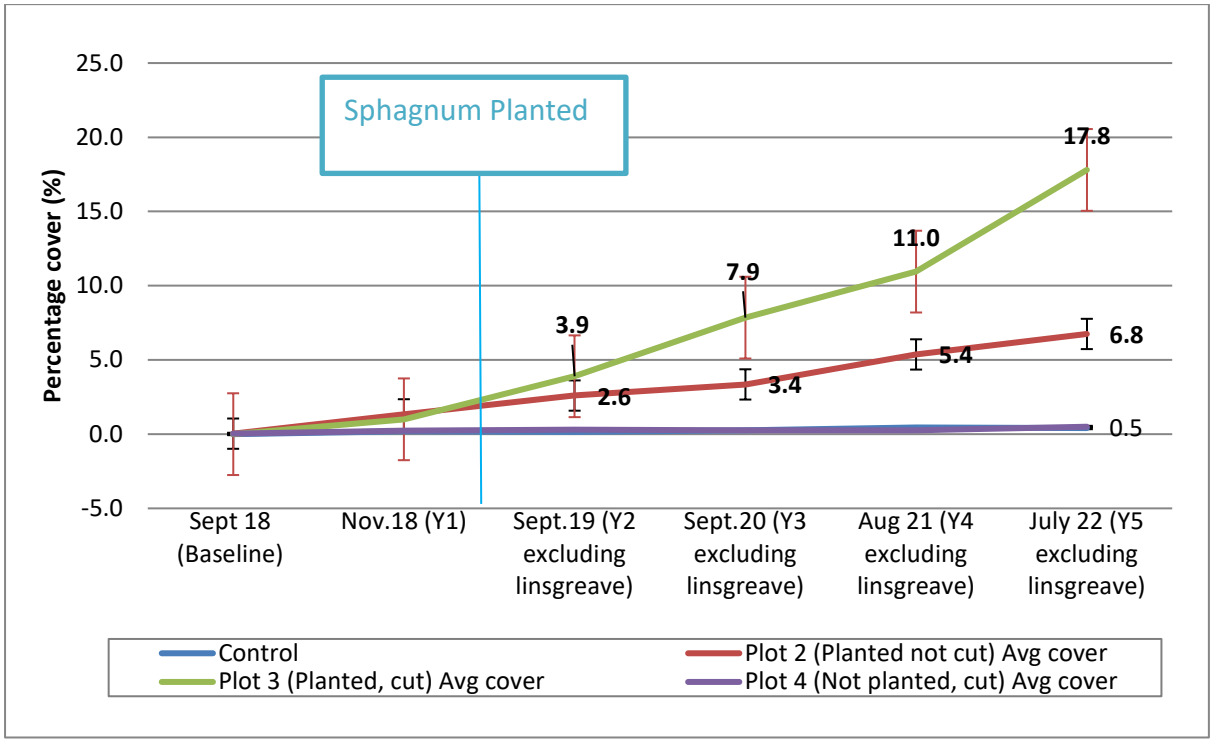

Figure 5 – A graph to show the percentage Sphagnum moss on all hare's tail cotton grass sites. Error bars show standard error calculations

Analysis of individual site data showed that average Sphagnum moss cover in the cut plots increased compared to the uncut plots for both sites year on year. In year 3 the difference in Sphagnum moss growth rate between cut and uncut plots started to plateau on the Sliddens Moss but continued to increase on Featherbed Moss. These trends reversed after Year 4 and diverged dramatically between the sites in year 5 (see Figure 6).

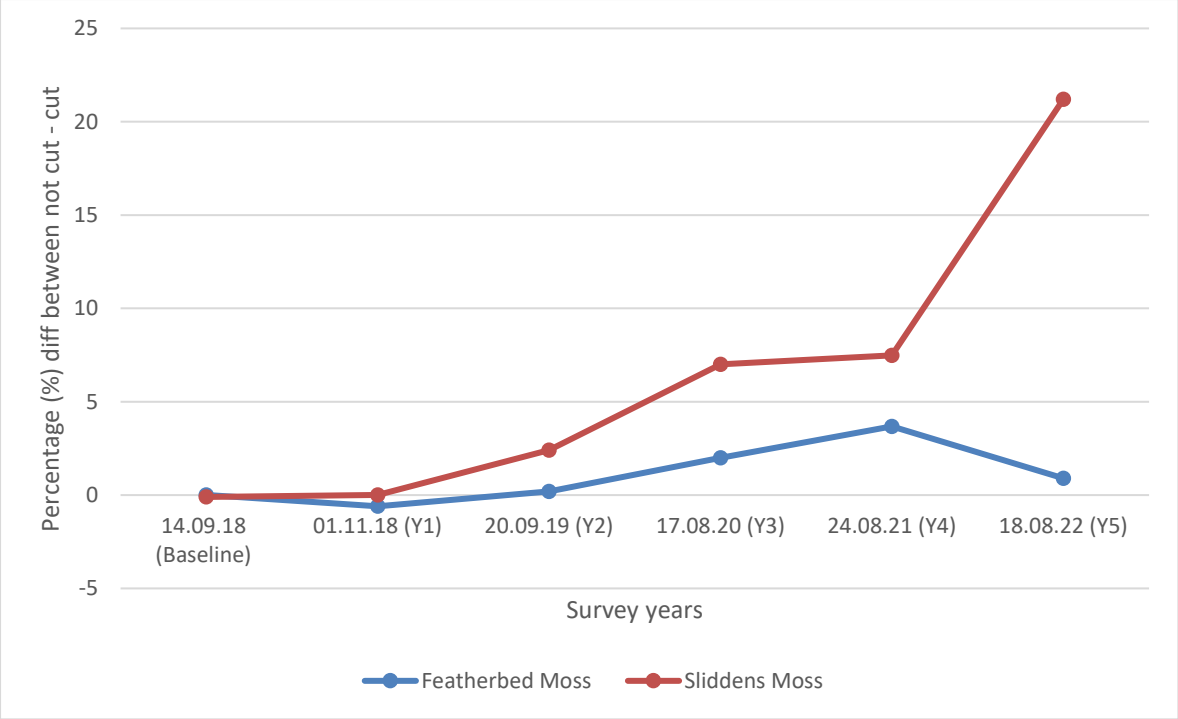

Figure 6 – A graph showing the difference in Sphagnum growth rates for the uncut vs cut plots at both sites

Figure 7 identifies a moderately strong negative correlation between the dominance of hare's tail cotton grass and Sphagnum moss cover for both cut and uncut plots, with Sphagnum moss cover decreasing the more dominant hare's tail cotton grass became. Assessment of the r^2 correlation values indicates that the effect was stronger for the cut site compared to the uncut sites.

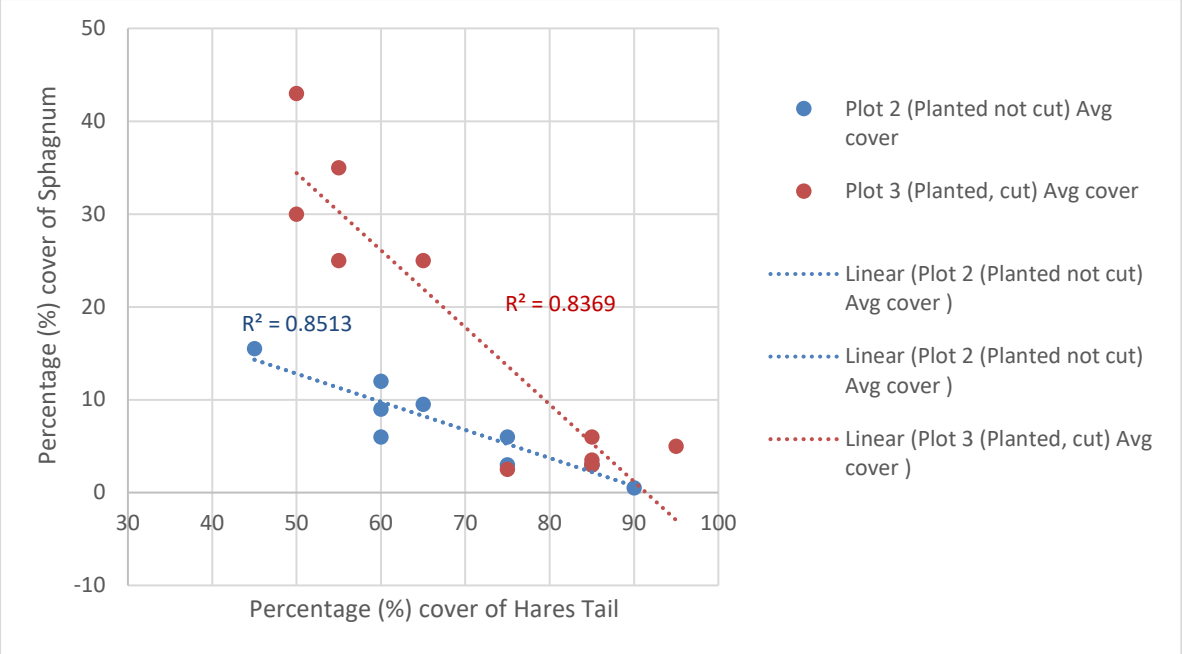

Figure 7 – A graph comparing the cover of Sphagnum to hare's tail cotton grass cover for individual quadrats on Sliddens Moss and Featherbed Moss

2.1.2. Hare's tail cotton grass heights

The heights of the hare's tale cotton grass relative to control, indicated that there was a 10 to 25cm reduction in height immediately after cutting (see Figure 8). The heights then steadily increased to a consistent height around year 3, at the general level of the baseline height. The exception to this is within the "planted and cut" quadrats where the heights remain approximately 9cm below the baseline.

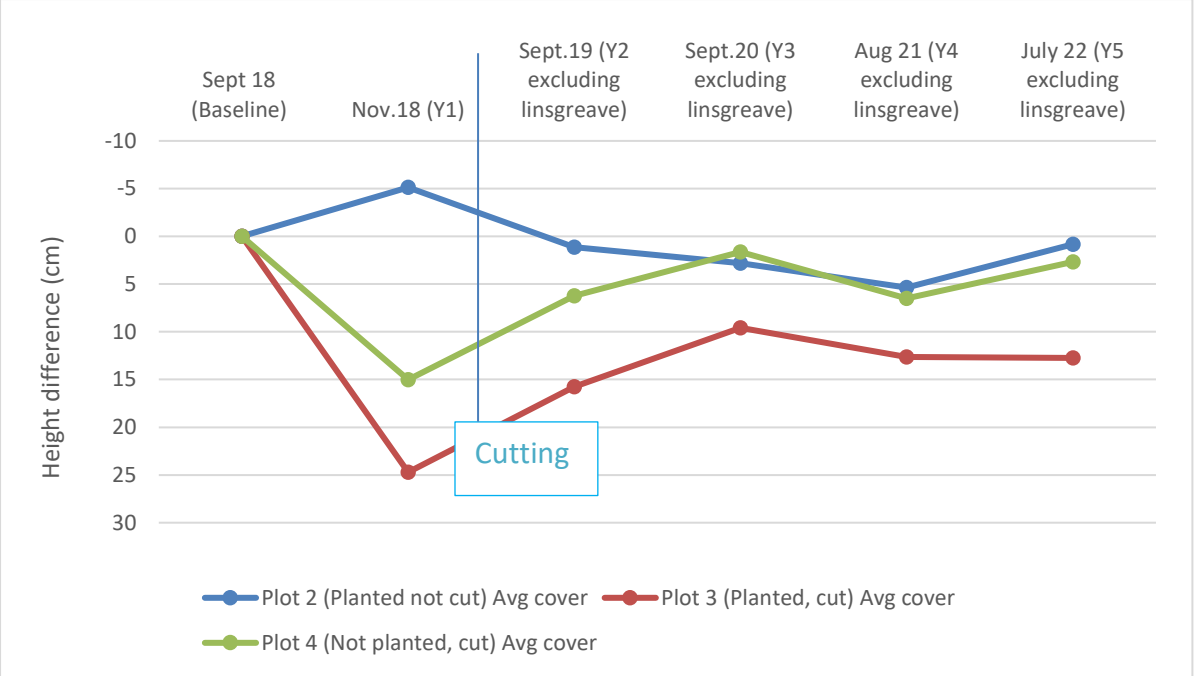

Figure 8 – A graph showing the difference in height of hare's tail cotton grass relative to control for all plots

2.2. Common cotton grass plots

2.2.1. Sphagnum moss cover

Results indicated that during the baseline survey no Sphagnum moss cover was found in any of the plots for the common cotton grass-dominated areas. For those plots that were planted with Sphagnum moss average cover increased to 7.3% by year 4 for plot 2 (planted, not cut) and 9.8% for plot 3 (Planted, cut). Sphagnum cover then significantly increases in plot 3 (planted, cut) to 18.3%, whereas cover in plot 2 (planted, not cut) slightly increases to 8%.

For the common cotton grass sites plots 1 (control) and plot 4 (not planted, cut) also see an increase in average Sphagnum moss cover. In plot 1 (control) this increased by 0.1% by year 5 and for plot 4 (Not planted, cut) it increased by 0.1% in year 1, peaked in year 2 at 0.5%, then steadily decreased back to 0.1% in year 4 before increasing once more to 0.7%. These changes in plots 1 (control) and plot 4 (not planted, cut) can be attributed to two specific factors: a.) Potentially a slight change in quadrat orientation during the second survey, and b) Surveyors missing the "wild" Sphagnum moss in the baseline survey, due to the small amount of Sphagnum moss present and other vegetation obscuring it.

Comparison between the Sphagnum moss growth in the cut and uncut plots indicated that the Sphagnum moss in the cut plots on average covered 10.3% more of the surface area than the uncut plots (See Figure 9). A t-test undertaken for the individual quadrat data in year 5 determined that this was not a statically significant result, as the p value was 0.12 which is above the alpha value of 0.05.

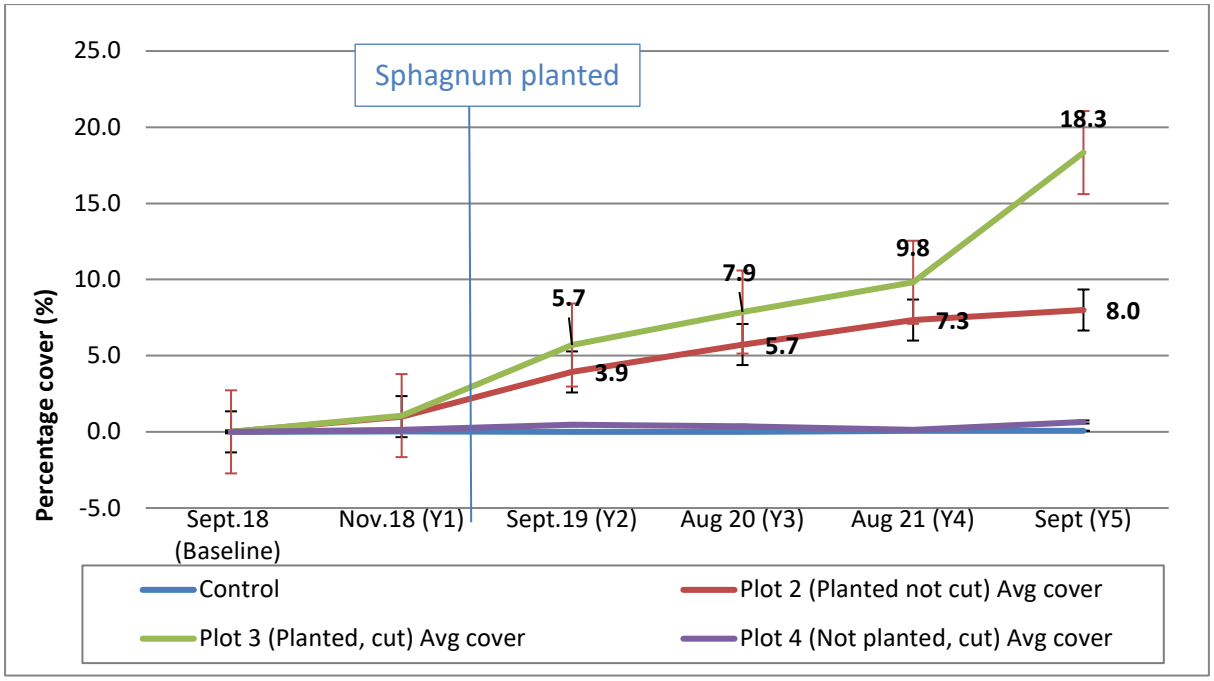

Figure 9 – A graph to show the percentage Sphagnum Moss on all common cotton grass sites. The error bars show standard error

Investigation of the individual quadrat data (Figure 10) revealed that average Sphagnum moss cover in the cut plots increased year on year when compared to the uncut plots at all sites except Black Ashop Moor. For Black Ashop Moor average Sphagnum moss cover initially followed the trend set at the other sites, but then slowed with average Sphagnum moss growth in the uncut sites being more vigorous than the cut sites. It is not known why this occurred. Furthermore on Linsgreave head Sphagnum moss cover increased by 16.7% between years 4 and 5, and on Slippery Moss increased by 8% between years 4 and 5, this is however not seen on the Black Ashop Moor site as there is only a 0.8% increase in Sphagnum moss cover within this time period.

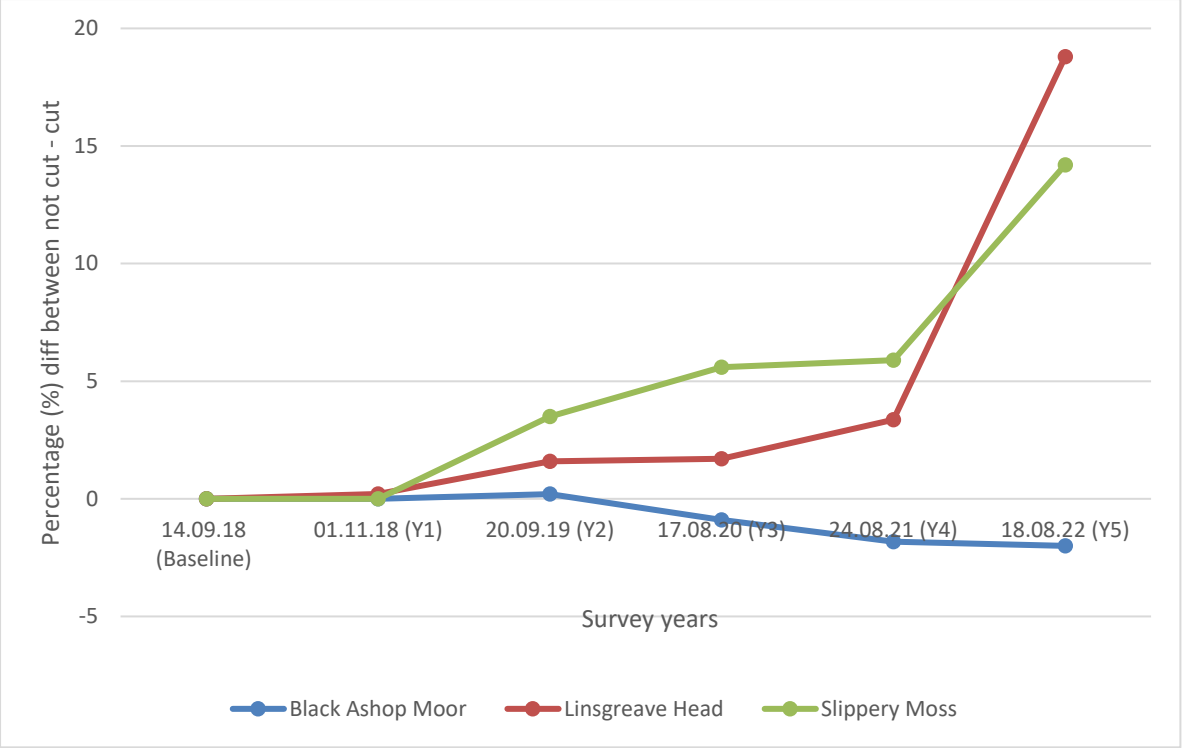

Figure 10 – A graph show the difference in Sphagnum moss growth rates for the uncut vs cut plots for the three sites

A comparison between Sphagnum moss cover and common cotton grass cover indicated a moderate to weak negative correlation (R^2 – 0.018) for the planted and cut plots, whereas the planted, not cut plots show a weak positive correlation (R^2 – 0.09) between the two variables (See Figure 11).

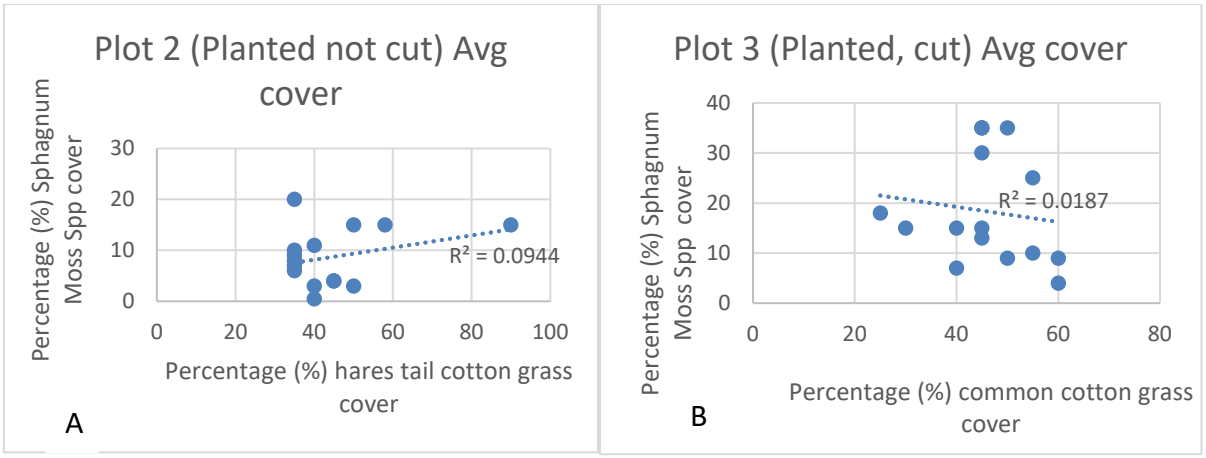

Figure 11 – Graphs showing the comparison of percentage Sphagnum moss cover against percentage common cotton grass cover in A) plot 2 (planted, not cut), B) plot 3 (planted, cut)

2.2.2. Common cotton grass heights

The average height of common cotton grass relative to control sharply decreased between the baseline and year 1, as the sites were cut with the LV600 green climber with flail head. The average heights then quickly increased between year one and year two before growth slowed down in year four, with plot 4 (cut not planted) being 1.15cm shorter than the control, whereas plot 3 is 6.9cm shorter than the control in year five.

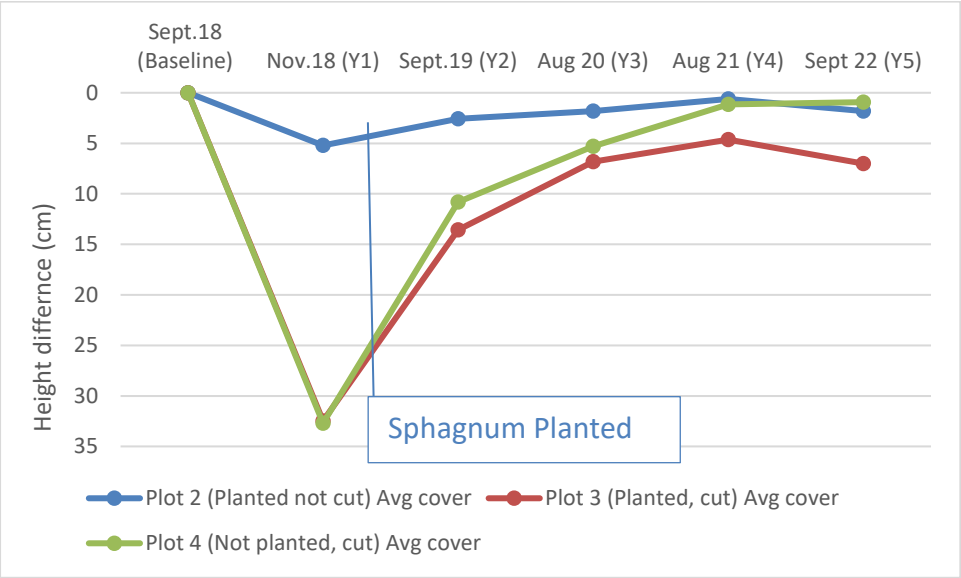

Figure 12 – A graph showing the heights of the average common cotton grass relative to control for all sites

3. Discussion

This research indicated that cutting cotton grass increased the growth rate of Sphagnum moss for both hare's tail and common cotton grass sites, as both showed an increase in average growth when compared to the uncut plots (11% and 10.3% respectively). However, this result is only statistically significant for the hare's tail cotton grass sites with a "P" value of 0.019. This suggest that sward cutting to promote sphagnum growth is not necessary for common cotton grass sites, which is supported by research undertaken by Guêné-Nanchen et al (2017) on Sphagnum moss farming and (Heijmans et al, 2002). Cutting common cotton grass may be an appropriate management tool to achieve other outcomes, but this is beyond the scope of this report.

A possible reason for these results is that cutting hare's tail cotton grass allowed a greater amount of light to reach the Sphagnum moss by removing the dense tussocks, promoting an increase in the growth rate of the Sphagnum moss. This effect was not seen in the common cotton grass sites because of the more open canopy associated with the common cotton grass plant. This reasoning is supported by the trend seen in Figure 7 whereby hare's tail cotton grass cover increases, as the cover of Sphagnum moss decreases for both cut and uncut plots. This relationship has also been seen in multiple studies for vascular plants including Clymo & Hayward (1982), Hayward & Clymo (1983). However Pilkington's et al (2021) research into the growth rate of Sphagnum moss on *Molinia Caerulea* (purple moor grass)-dominated sites does not show the same trends, despite purple moor grass having typically denser tussocks than both cotton grass species, and a similar methodological set up being used in both trials.

Comparison between the cut and uncut plots of Sphagnum moss cover for the individual hare's tail sites show that cutting did not increase Sphagnum growth on Black Ashop Moor whereas cutting did increase the growth rate of Sphagnum moss on the other two sites (Linsgreave Head and Slippery Moss). The reason(s) for this difference in trend are not known, but appear to indicate that there might be a site specific reasons why cutting was not effective on Black Ashop Moor.

Comparing the cut and uncut plots for the individual common cotton grass sites shows a similar trend up until year 5 of the project, when there is a significant difference between the two, with the Sliddens moss site showing a massive increase in Sphagnum growth and featherbed moss showing a decrease, why this should occur is unknown.

Analysis of the height data indicates that it took 3 years for both cotton grass species to return to levels similar to the baseline. Initially this increase in *Eriopheroum spp* height corresponded with a slowdown in the growth rate of Sphagnum moss, as the light levels reduce. This trend however did not continue in year 5, as the Sphagnum moss growth were similar to the first 3 years. It is thought that year 5 could be an anomalous year due to the massive increase in growth rate not matching any other years within the trial, but further data is required to confirm this.

The issues encountered around the planting of Sphagnum moss outside of the quadrats (see Section 1.1.1) should not have invalidated the relationship identified for hare's tail cotton grass as the additional Sphagnum moss plugs artificially increased the Sphagnum moss cover in the uncut plots. This, if anything, would have led to an underestimation of the positive impacts seen from cutting.

Detailed analysis of the individual site data indicate that both hare's tail cotton grass sites have shown an increase in Sphagnum moss cover growth rates in the cut sites compared to the uncut sites, suggesting that this is a genuine effect, as was borne out by the statistical analysis ($p<0.05$; see Fig. 5). However, due to a wildfire that took place on Marsden Moor in 2019 the third replicate was destroyed so was excluded from further analysis, reducing the statistical robustness of the results, especially in light of the anomalously low sphagnum growth seen on Black Ashop Moor with respect to the other two common cotton grass sites, Linsgreave Head and Slippery Moss (Fig. 10).

4. Conclusion

In conclusion, the trial suggests that cutting hare's tail cotton grass immediately before planting would increase the average growth rate of Sphagnum moss plugs compared to uncut areas, with a 10.3% difference in average Sphagnum moss cover.

The data also suggested a moderate to strong negative relationship between the amount of Sphagnum moss cover and hare's tail cotton grass cover, with Sphagnum moss growth rate decreasing as hare's tail cotton grass cover increases.

The results however did not show any statistical difference between the average percentage cover of Sphagnum moss on cut areas when compared to uncut areas for common cotton grass cutting sites. Neither did the results show a strong relationship between the density of common cotton grass and Sphagnum moss growth for either the uncut or cut plots.

This study examined the relationship between sphagnum growth and sward cotton grass species, with and without sward cutting. Further study would be needed to understand the relationships with other typically dominant sward species, such as other graminoids, or *Calluna vulgaris*.

The study was impacted upon by a number of external factors, including wildfires destroying one of the hare's tail cotton grass sites. Furthermore, a small number of Sphagnum moss plugs added to quadrats at a later date. Whilst statistically this extra planting was proven to not have an significant impact upon the results, it would be good to undertake the trial on hare's tail cotton grass sites again to confirm the trends found within the study.

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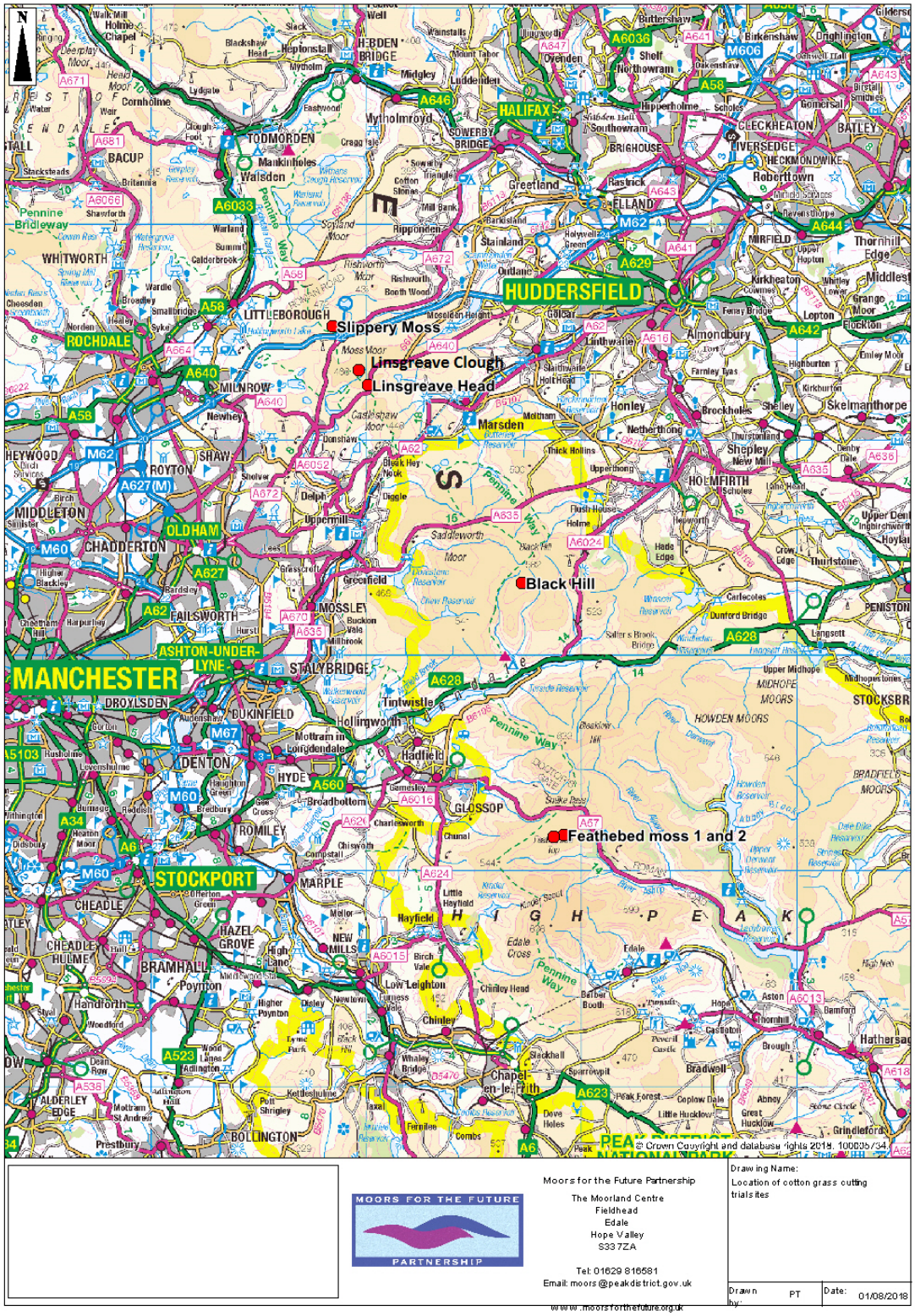
Appendix 1 – Location map



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