

**SPHAGNUM PLUG MONITORING REPORT**

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**January 2025**

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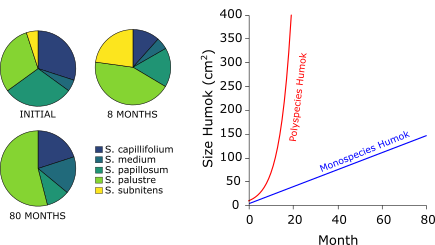
# SUMMARY

In the face of global warming, there is a need for better understanding if the techniques used for peatland restoration have a long-lasting effect on the health of our uplands. A key practice to accelerate recovery processes and return peatlands to a near natural bog state is to, in conjunction with hydrological repairs, accelerate revegetation by inoculating greenhouse-grown *Sphagnum* propagules onto bare peat. Some *Sphagnum* species are known to be natural coloniser. It then essential to find which recipe – i.e. *Sphagnum* mix, is best for each environment in order to optimise restoration.

This report presents the result of a short-term project focused on the evolution in size and composition of on upland peatland soils in Nidderdale National Landscape (NNL). We used BeadaHumok™ or Humok, micro-propagated *Sphagnum* grown to produce dense clumps containing many *Sphagnum* strands several centimetres long. After 9 months, Humoks made of different *Sphagnum* species see their initial ground cover increase by 1800%. On the other hand, after 80 months, Humoks with a single *Sphagnum* species are 250% greater than their original. Such high rates allow for the creation of a moss carpet spreading throughout the heather and cotton grass. Sphagnum cover provides both a way to stop erosion and slow the release of greenhouse gas into the atmosphere.

Regardless of the type of vegetation community that surround them (i.e. heather dominated or graminoid dominant peatlands), most Humoks or group of Humoks composition are dominated by chunky species (S. palustre and S. medium). Other *Sphagnum*, such as S. subnitens, are likely good species that can help the moss establish itself within the first year. Our study demonstrates that to establish a durable moss cover on damage peat soil, a mix of more chunky *Sphagnum* species might be best suited for the job.

We conclude that the current methodology of *Sphagnum* recolonization of damaged peat conducted by the Yorkshire Peat Partnership seems appropriate for a rapid (< 1years) revegetation process. The current *Sphagnum* mix used (Yorkshire mix) is adequate for heather dominated peatlands but some modifications could be implemented to maximise restorations impacts.



Evolution of introduced Sphagnum species from inoculation and growth.

# INTRODUCTION

Inoculation of *Sphagnum* moss in degraded peatlands is an essential part of the revegetation process. Although the spread and colonisation of peatland species might increase naturally following hydrological restoration (i.e. rise of the water table), the application of vegetation plugs – sphagnum, but also cotton grass and small shrubs – can accelerate this recovery process. Inoculation of *Sphagnum* has been used for more than 10 years by peatland practitioners. Although some studies have shown some *Sphagnum* are better suited to be first coloniser on damaged uplands, i.e. low water table, altered peat chemistry (e.g. Chirino et al., 2006; Grosvernier et al., 1997; Luken, 1987), little data exists on the success rate of Sphagnum inoculation using greenhouse-grown species (e.g. Carroll et al., 2009; Capron et al., 2018).

Better knowledge on which mixes of *Sphagnum* species are the most successful when planted for restoration projects is of great importance. In the face of global warming, peatland practitioners might want to favour the spread of climate change resilient species (Breeuwer et al., 2008; Loisel et al., 2012, Ritson et al. 2025) to ensure the long-term impact of peatland restoration.

To fill this knowledge gap, our project aimed to (1) monitor what *Sphagnum* species have grown most successfully from polyspecies hummocks planted in different habitats as part of restoration and (2) quantify the growth rate of monospecies and polyspecies *Sphagnum* hummocks. To that end, we designed a monitoring protocol which we tested on four Nidderdale National Landscape (NNL) upland peat bogs.

The results of this project will help improve the peatland restoration program’s efficiency of restoration regarding sphagnum planting.

# METHODS

## Site Locations

*Sphagnum* Humok monitoring took place at four sites in Nidderdale National Landscape between October 2024 and December 2024: Denton Moor, Scar House Moss, Katty White’s Allotment and the Swinton Estate (**Figure 1a**).

Denton Moor straddles the parishes of Denton, Blubberhouses, and Great Timble within Nidderdale AONB. In total the site covers an area of approximately 455Ha (SE144521). The dominant vegetation community recorded across the site was dry heath (H9), 51%. Common heather, *Calluna vulgaris*, is estimated to be present across 76% of the site, and most of the heather present is over 30cm tall (**Figure 1b**). Acid grassland (M25, M23b, U4) makes up 17% of the site. Common heather and hare’s tail cotton grass dominant blanket bog accounts for 9% of the site. The land was previously managed as a grouse moor through a programme of rotational burning with some grips dug for drainage. It was also let to a farmer for sheep grazing. Seven years ago the shooting tenancy was ended and management of the heather as before continued up until 2020 but no heather has been cut since. Sheep numbers were decreased some years ago and since 2018 no sheep have been grazed on the moor. Restoration work (e.g. grip and gully blocking) at Denton Moor started in July 2024.

Scar House Moss is situated within the parish of Stonebeck Up and covers an area of approximately 94 ha (SE066760). M19 (*Calluna vulgaris-Eriophorum vaginatum* blanket mire) is the most common NVC category 32% (**Figure 1c**). Followed by M20 (cotton grass) at 30%, acid grassland (M23b, U6) at 26% and dry heath (H9, H12) at 10%. The site has a history of overgrazing and rotational burning for grouse shooting. Restoration work (e.g. grip and gully blocking, hagg reprofiling) at Scar House Moss started in October 2022 and is now finished.

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**Figure 1** – (a) Outline of the Nidderdale National Landscape (dashed line); (b) Denton Moor; (c) Scar House Moss; (d) Katty White’s Allotment; (e) Swinton Estate (Masham Colsterdale Moor) –‘Swinton Sphagnum’ research project monitoring plot.

Katty White’s Allotment is situated within the parish of Thornthwaite. In total the site covers an area of approximately 397 ha (SE 114 624). 36% of the site falls into blanket bog categories M20 and M19. H9 (*Calluna vulgaris-Deschampsia flexuosa* heath) accounts for 20% of the site. The remaining 34% consists of acid grassland vegetation (U4, U6) (**Figure 1d**). The site has a history of overgrazing, rotational burning for grouse shooting and soil disturbance due to bracken removal. Restoration work (e.g. grip and gully blocking, surface bunding) at Katty White’s Allotment started in January 2024 and is now finished.

The Swinton Estate (Masham Colsterdale Moor) (**Figure 1e**) is situated within the parishes of Colsterdale, Healey, Caldbergh with East Scrafton and Ilton-cum-Pott. It covers an area of approximately 2,274 hectares and the OS Grid Reference for the centre of the site is SE 11165 79041. Common heather dominates the landscape and most of vegetation communities falls in the NVC M19 and H9. Most of the site Masham Colsterdale Moor is managed as a grouse moor through a programme of rotational burning. The moor is also managed by grazing sheep. Restoration work (e.g. grip and gully blocking, hagg reprofiling) took place between the end of 2016 and the beginning of 2017. For the purpose of our project, we used Sphagnum Humok planted during the ‘Swinton Sphagnum’ research project (Hinchley et al., 2021). The aim of the ‘Swinton Sphagnum’ project was to test the field application of different *Sphagnum* mosses re-introduction methods in the context of restoration projects carried out in the Yorkshire Dales, where the starting point of restoration is not bare peat but a vegetated surface. the ‘Swinton Sphagnum’ project was funded by Yorkshire Water (YW) for the period August 2017 to September 2020 and was led by the Yorkshire Wildlife Trust’s (YWT) Yorkshire Peat Partnership (YPP) staff.

## Sphagnum inoculation

### BeadaHumok™

Where there is a lack of a suitable donor site, *Sphagnum* propagules are available from a single horticultural supplier (Micro-propagation Services (E.M.) Limited) under the BeadaMoss® brand which have been grown using micropropagation techniques from fragments of locally sourced material. These come in several forms for use in a range of moorland restoration conditions. YPP has trialled these products on different moorland sites and now only supports BeadaHumok™ in our restoration works. BeadaHumok™ or Humok are micro-propagated *Sphagnum* grown to produce dense clumps containing many *Sphagnum* strands several centimetres long. It a very versatile product: the composition of Humok can be changed according to restoration needs (**Table 1**). YPP principally uses the Yorkshire mix, a polyspecies mix made of five different *Sphagnum*. Other peat partnerships, e.g. Moors for the Future, use more elaborate mixes, i.e. the Moorland mix, containing ten *Sphagnum* species. On the other hand, during the ‘Swinton Sphagnum’ research project, only monopsecies Humok were used.

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Yorkshire mix (%) | Moorland mix (%) | Swinton Estatea |
| *S. capillifolium* | 30 | 8-15 | 5 |
| *S. magellanicum* | 5 | 1-3 | 1b |
| *S. papillosum* | 30 | 8-15 | 5 |
| *S. palustre* | 30 | 20-25 | 5 |
| *S. subnitens* | 5 | 5-10 | 1b |
| *S. cuspidatum* | *-* | 8-15 | - |
| *S. denticulatum* | *-* | 1-3 | - |
| *S. fimbriatum* | *-* | 8-15 | - |
| *S. squarrosum* | *-* | 1-3 | - |
| *S. tenellum* | *-* | 1-3 | - |

**Table 1** – Composition of the Humoks. The Yorkshire mix was used on Denton Moor, Katty White’s allotment and Scar House Moss. The Moorland mix was used in the study by Caporn et al. (2018) and is currently used by Moors for the Future. For the Swinton Estate, only monospecies Humoks were used. a: number of monospecies plugs per square meter; b: Each square meter contains either one S. magellanicum or one S. subnitens

### Polyspecies Humok

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Site | Planting date | Monitoring | Month since inoculation | Humok type | Number of Humok monitored |
| Denton Moor | 04/11/2024 | 06/12/2024 | 1 | Yorkshire mix | 37 |
| Scar House Moss | 23/02/2024 | 23/10/2024 | 8 | Yorkshire mix | 30 |
| Katty White's Allotment | 30/01/2024 | 18/11/2024 | 9 | Yorkshire mix | 33 |
| Swinton Estate  (Masham Colsterdale Moor) | 21/02/2018 | 07/01/2019 | 10 | Monospecies | 149\* |
| 21/02/2018 | 06/02/2019 | 11 | Monospecies | 11\* |
| 21/02/2018 | 07/02/2020 | 23 | Monospecies | 45\* |
| 21/02/2018 | 02/03/2020 | 24 | Monospecies | 78\* |
| 22/02/2018 | 24/10/2024 | 80 | Monospecies | 64 |

**Table 2** – Studied sites, monitoring days, time since inoculation (month) and type of Humok used. \*Data from the ‘Swinton Sphagnum’ research project

At Denton Moor, Scar House Moss and Katty White’s allotment, Humoks with a Yorkshire mix composition were planted, according to YPP Technical specifications, on wet bare peat areas, poorly vegetated areas or heather-cutting areas as part of the restoration work. Humoks were applied at a rate of 0.25 to 1 per m2. Humoks were planted by hand, bedded into the peat so that they were flushed with the ground surface. Date of planting and number of Humoks monitored are shown in **Table 2**.

### Monospecies Humok

On Swinton Estate, at Masham Colsterdale Moor, Humoks made of a single *Sphagnum* species were planted as part of the ‘Swinton Sphagnum’ research project. The Humoks were applied in a 4 x 4 m study plot at a density of 16 Humok per m2 (5 *S. capillifolium*; 5 *S. papillosum*; 5 *S. palustre*; and either 1 *S. subnitens* or 1 *S. medium*). Heather was removed before planting via mowing or burning. Date of planting and number of Humoks monitored are shown in Table 2. These Humok have been monitored in 2019 and 2020 (Hinchley et al. 2021). We included some of these data on Humok size in the current study.

## Monitoring protocol

To quantify the successful implantation of *Sphagnum* plugs, a set of information of the surrounding environment was recorded: (1) The presence of a live or dead Humok. (2) Assessment of the vegetation community in the direct vicinity of the *Sphagnum* plug, 2 m x 2m quadrat (with the plug at the centre). (3) Length and width dimensions and one height dimension, taken from the base of the Humok; (4) a photograph every five Humoks, taken from above with a graduated marker for scale. (5) If the *Sphagnum* Humoks have been recently planted (i.e. Denton Moor) no further work is needed as the initial composition of the mix is known (**Table 1**). (6) If the Humok are older and individual species can be identified, their proportion within a given Humok is recorded. Data were collected using a Kobo form (<https://www.kobotoolbox.org/>) and location of the monitored Humoks were recorded on a QGIS project. The raw data are available in the appendix (**Table S1**)

# RESULTS

## Field observations

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**Figure 2** – National Vegetation Classification (NVC) communities for the studied sites at the monitoring locations. M17:Wet Bog; M19: Calluna vulgaris dominated; M20: Eriophorum angustifolium dominated; M25: Acid grassland (Molinia dominated); ; U2: Acide grassland (Avenella flexuosa dominated); U6: Acid grassland (Juncus dominated)

Monitored Humoks at Denton Moor, Scar House Moss and Swinton Estate were planted on *Calluna vulgaris – Eriophorum vaginatum* blanket mire (M19) and to a lesser extent Eriophorum vaginatum blanket mire (M20) (Figure 2). On the other hand, the vegetation surrounding the Humoks at Katty White’s allotment is principally M20 with *Molinia caerulea – Potentilla erecta* mire (M25), *Eriophorum vaginatum* blanket mire (M17), J*uncus squarrosus - Festuca ovina* grassland (U6) and U2 *Avenella flexuosa* grassland (U2).

At Denton Moor, Humok still displayed their un-matured, young, bright green colour (**Figure 3a**), making the identification of *Sphagnum* species difficult. However, because they were recently planted, the Humok composition should not be different from that of the Yorkshire mix.

A collage of different plants

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Figure 3 – Sphagnum Humoks. (a) Denton Moor, 1 month after planting; (b) Scar House Moss, 8 months after planting; (c) Katty White’s Allotment, 9 months after planting; (d-f) Swinton Estate. (d) Inoculation in the monitoring plots (2018 – month 0); (e-f) 80 months after planting. Humoks from Denton Moor, Scar House Moss and Katty White’s Allotment have an intial Yorkshire mix composition. Humoks from Swinton are monospecies. Scale: 5 cm for all but for (d), scale: 50 cm.

At Scar House Moor and Katty White’s allotment, most of the Humoks were mostly uniform in shape and colour (**Figure 3b-c**).

In the monitoring plots at the Swinton Estate, we were able to identify single Humoks planted 80 months prior (**Figure 3d-e**). The Humoks were weaved through heather and cotton grass. At the time of monitoring, the chunky Sphagnums (*S. papillosum, S. palustre* and *S. medium*) were starting to display their autumnal colours, making identification easier. Because of the planting density, some Sphagnum Humoks joined into a single moss carpet through the cotton grass and the heather (**Figure 3f**). As no edges could be properly determined, no data were collected on these larger moss.

96% of the overall Humok monitored were healthy. The 4% remaining were either bleached or dried out. These unhealthy Humoks were the only ones located on gently sloping bare peat. However, not enough data on slopping or exposure was collected to identify these as determinant factors.

## Composition

### Polyspecies Humok

The average composition of the observed Yorkshire mix Humoks varies slightly between the two studied sites, Scar House Moss (NVC: M19) and Katty White’s Allotment (NVC: M20) (**Figure 4a**). In both cases, *S. palustre* (44-52%) dominates the compositions. *S. medium* (1%) is found in similar quantity and *S. capillifolium* and *S. papillosum* are more abundant at Katty White’s Allotment (11-12 %) than at Scar House Moss (27%). *S. subnitens* seems to thrive better on peatland dominated by *Calluna vulgaris* (M19) (23%). Although not part of the original mix, *S. fallax* was found in very small quantity in some of the Humoks on Katty White’s Allotment. *S. fallax* is present in large quantity on the site and might have contaminated the planted Humoks.

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**Figure 4** – Post planting species monitoring on Yorkshire mix Humoks. (a) Average Humok composition in Scar House Moss and Katty White’s Allotment post planting. (b) Results of T-test between the Shannon’s diversity index of the intitial Yorkshire mix composition and and the observed Humok compositions. Monitored Humoks significantly different from the original mix have T-test p-value <0.05 . Monitored Humoks similar to the orignal mix have T-test p-value >0.05. sph\_fal: S. fallax; sph\_sub: S. subnitens; sph\_pal: S. palustre; sph\_pap: S. papillosum; sph\_med: S. medium; sph\_cap: S. capillifolium.

An ANOVA two way factor test on Scar House Moss at 8 months and Katty White’s Allotment at 9 Months indicates the nature of the site as a significant impact on the resulting Humok composition (p-value: 10-7) (**Table S1**).

The overall diversity of *Sphagnum* between the two sites is very similar, Shannon’s diversity indices (H) (Shannon & Weaver, 1949; Magurran, 2004) 1.52 and 1.49 for Scar House Moss and Katty White’s Allotment respectively (T-test p-value: 0.697). Each monitored Humok was compared to the original Yorkshire mix composition using a T-test. After 8 months, 70% of the Humoks from Scar House Moss have a *Sphagnum* composition significantly different from the starting one (**Figure 4b**). After 9 months, 88% of the Humoks from Katty White’s Allotment have a *Sphagnum* composition significantly different from the starting one (**Figure 4b, Table S1**).

### Monospecies Humok

80 months after inoculation, we observed six different species within the monitoring plots at the Swinton Estate: *S. capillifolium* (33%); *S. medium* (22%); *S. papillosum* (19%); *S. palustre* (66%); *S. fallax* (2%); *S. fimbriatum* (2%) (**Figure 5a**). *S. subnitens* was notably absent.

About 70% of all the observed Humok retained their initial composition, i.e. monospecies species composition. *S. capillifolium*, *S. papillosum* and *S. palustre* were found in all the observed Humok, with *S. palustre* being often the most abundant (**Figure 5b**).

The planting density of *S. medium* and *S. subnitens* was 1 per square meter whereas other *Sphagnum* species were planted at a density of 5 per square meter. Despite a lower starting count, *Sphagnum medium* was found in varying proportions in 22% of the observed Humoks (**Figure 5a-b**). On the other hand, no *S. subnitens* was recorded, neither as a monospecies Humock nor as part of a mix. This could indicate that *S.medium* might be a better long-term coloniser than *S. subnitens*. Alternatively, sampling bias should not be excluded to account for the lack of recorded *S. subnitens*.

A graph of different types of sphagnum

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**Figure 5** – (a) Frequency of Sphagnum species observed on the Swinton Estate (b) Proportion of Sphagnum species (%) in the observed Humoks (e.g. 1 Humok with 100% S. fimbriatum). Sph\_fim: Sphagnum fimbriatum; sph\_fal: Sphagnum fallax; sph\_pal: Sphagnum palustre; sph\_pap: Sphagnum papillosum; sph\_med: Sphagnum medium; sph\_cap: Sphagnum capillifolium

Although not part of the original mix, *S. fallax* was found in very small quantity in one of the Humoks and *S. fimbriatum* was found as a monospecies Humok (**Figure 5b**). Both these *Sphagnum* species can naturally occur on *Calluna vulgaris* dominated peatlands. Their presence could also be the result of the inoculation of contaminated *Sphagnum* Humoks.

### Sphagnum species abundance evolution

We compared the abundance of the different species within polyspecies Humoks at the time of inoculation - i.e. Yorkshire mix composition, and at monitoring. We used to T-tests to assess which *Sphagnum* species are more likely to thrive, which ones remain stable and which ones tend to disappear (**Table S3 & S4**).

At Scar House Moss, the proportion of *S. medium* (5 to 7%) and *S. papillosum* (30 to 23%) in the Humok remained unchanged whereas *S. subnitens* (5 to 30%) and *S. palustre* (30 to 58%) experienced net gain (**Figure. 6a**). On the other hand, we observed a slight loss in *S. capillifolium* (30 to 15%). At Katty White’s Allotment with the exception of *S. palustre* (30 to 66%), the proportion of all the other *Sphagnum* species in the Humok remained unchanged 9 months after inoculation (**Figure 6b**).

In the monitoring plots at the Swinton Estate, we compared the abundance of monospecies Humok per m2 between the time of inoculation and 80 months after. As we could not monitor every single *Sphagnum* per plot, we were only able to provide an average estimate of species gain or species loss. *S. palustre* experienced a net gain (29 to 53%). *S. medium* abundance increased (6 to 16%), and *S. capillifolium* (29 to 20%) and *S. papillosum* (29 to 10%) decreased over time. However, *S. subnitens* appeared to be absent.

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**Figure 6** – Comparison between the initial Humok composition and the observed composition post-planting. (a) Scar House Moss; (b) Katty White’s Allotment; (c) Swinton Estate. For (a-b), the classification into gain-stable-loss categories results from T-tests (gain and loss: p-value <0.05, stable: p-value > 0.05). For the Swinton Estate, percentages represent the amount of monospecies Humoks per square metre. Sph\_fim: Sphagnum fimbriatum; sph\_fal: Sphagnum fallax; sph\_pal: Sphagnum palustre; sph\_pap: Sphagnum papillosum; sph\_med: Sphagnum medium; sph\_cap: Sphagnum capillifolium

## Growth rate

Based on the data collected on poylspecies Humoks in NNL, *Sphagnum* growth (i.e. surface area – cm2) appears to be exponential, with an increase in Humok size of 1800 % between month 1 and month 9, from 4.7 cm2 to 84.8 cm2 (**Figure 7a**). This rate is similar to that estimated by Capron et al. (2018). In the cotton grass dominated blanket bog from the Peak District, the authors observed the size of the *Sphagnum* Humok increased by more than 1000% after a year, from 10.2 cm2 to 175 cm2 (**Figure 7a**). It is unlikely that the Sphagnum keep the same growing rates after a couple of years. We would expect the horizontal growth rate to plateau. The original size of the monospecies Humoks was not recorded in the ‘Swinton Sphagnum’ research project (month 0). We retrieved their original sizes using image analyses on photographs taken on the day of inoculation (**Figure 3d**) and Image software (Schneider et al., 2012). The original size of the Humok was identical than that of the polyspecies Humocks, 4.6 cm2 vs 4.7 cm2.

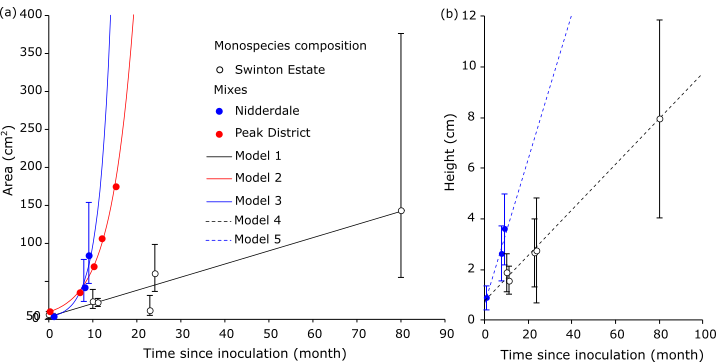


Figure 7 – Sphagnum Humok growth curve. (a) Humok cover area (cm2). (b) Humok height (cm). Data for the Peak District from Caporn et al. (2018). Model 1: quadratic fit (R2: 0.87); Model 2 and 3: exponential fit (R2: 0.99 and 0.93 respectively); Model 3 and 4: linear fit (R2: 0.99 and 0.94 respectively). Error: 95% confidence interval.

The growth of monospecies Humok is best fitted with quadratic model modelled (**Figure 7a**), suggesting periods of slower growth or recession. T-tests indicates that there was significant increase in size between inoculation and year one (months 10 and 11), from 53.0 cm2 to 22.6 cm2 (T-test p-value: 10-31). By year two (months 23 and 24), Humoks were 800% bigger than their original size (T-test p-value: 10-28). By year six (80 months), the size of the Humok had increased by 3100% compared to their original size (T-test p-value: 10-11).

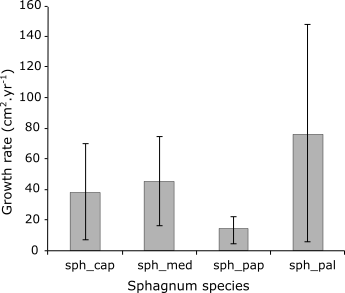


Figure 8 – Growth rate for different Sphagnum species from the Swinton Estate. Sph\_pal: Sphagnum palustre; sph\_pap: Sphagnum papillosum; sph\_med: Sphagnum medium; sph\_cap: Sphagnum capillifolium. Error: 95% confidence interval.

Despite a similar original height at inoculation, i.e. ~ 1cm, polyspecies Humok and monospecies Humok heights follow linear trends that seem to depart from each other after 8 to 11 months (**Figure 7b**). It is possible that the greater diversity of *Sphagnum* species in the polyspecies Humok favour the creation of larger, higher hummocks more rapidly.

Monospecies Humoks monitoring gave us the opportunity to quantity *Sphagnum* clump growth rate – i.e. surface cover (cm2.yr-1), per species (**Figure 8**). Despite apparent disparities, an ANOVA test between the different species (**Table S5**) indicates there are some significant differences in growth rates between species. We used a T-test to identify which Sphagnum species growth the fastest (**Table S6**). While *S. capillifolium* and *S. medium* growth rates are similar, *S. papillosum* is the slowest growing of all Sphagnum and *S. palustre* grows faster than *S. capillifolium* and *S. papillosum.*

# CONCLUSION

Our project studied the evolution in size and composition of greenhouse-grown *Sphagnum* propagules on upland peatland soils in Nidderdale National Landscape.

Results showed that after 8 to 9 months the composition of polyspecies Humok depends significantly on the type of vegetation already present. Regardless of the main vegetation category, Humoks became dominated by *S. palustre*, often at the expense of *S. papillosum*. While the Humock composition on the cotton-grass dominated peatland (Katty White’s Allotment) mostly remained unchanged, Humock planted on the heather dominated peatland (Scar House Moss) had a significantly higher proportion of *S. subnitens* than originally. After 7 years, the abundance of *S. palustre* and *S. medium* Humoks at Swinton Estate also demonstrate that more chunky Sphagnum species might be best suited to reestablishing a moss carpet on damaged peat soils. On peatland managed for grouse moor shooting (i.e. Scar House Moor and Swinton Estate), *S. medium* tends to outcompete some *Sphagnum* (e.g. *subnitens*) and is a better coloniser in the long-term. However, *S. subnitens* could have been thriving earlier in the restoration process giving a chance for the Humok to properly establish itself. This is not the case on graminoid dominant peatland, however, where *S. subnitens* is near absent almost a year after inoculation.

*Sphagnum* inoculation using polyspecies mixes might lead to a faster lateral spread of the moss ground cover than inoculation using monospecies moss plugs. Polyspecies Humoks appear to growth exponentially, however we lack long-term data to confirm this trend. It is also worth noting that polyspecies and monospecies Humok were not planted using the same methodologies (following restoration and monitoring procedure respectively). Site altitude, aspect and weather might have also contributed to these differences in growth rates.

In conclusion, although more observations need to be collected and more data integrated, the current methodology of *Sphagnum* recolonization of damaged peat, when conducted by the Yorkshire Peat Partnership seems appropriate for a rapid (< 1years) revegetation process. The current *Sphagnum* mix used (Yorkshire mix) is adequate for heather dominated peatlands. Some modifications to the mix could be made when working on cotton grass dominated peatlands.

# REFERENCES

Breeuwer, A., Heijmans, M. M., Robroek, B. J., & Berendse, F. (2008). The effect of temperature on growth and competition between Sphagnum species. *Oecologia*, *156*, 155-167.

Caporn, S. J. M., Rosenburgh, A. E., Keightley, A. T., Hinde, S. L., Riggs, J. L., Buckler, M., & Wright, N. A. (2018). Sphagnum restoration on degraded blanket and raised bogs in the UK using micropropagated source material: a review of progress. *Mires and peat an online journal*, *20*.

Carroll, J., CAPORN, S., & EADES, P. (2009). *Sphagnum in the Peak District: current status and potential for restoration*. MOORS FOR THE FUTURE PARTNERSHIP.

Chirino, C., Campeau, S., & Rochefort, L. (2006). Sphagnum establishment on bare peat: the importance of climatic variability and Sphagnum species richness. *Applied Vegetation Science*, *9*(2), 285-294.

Grosvernier, P. H., Matthey, Y., & Buttler, A. (1997). Growth potential of three Sphagnum species in relation to water table level and peat properties with implications for their restoration in cut-over bogs. *Journal of applied ecology*, 471-483.

Hinchley, D., Ritson, J., Thom, T. (2021) Assessing the ecosystem services impacts of Sphagnum introduction on open blanket bog habitats at Masham-Colsterdale Moor, North Yorkshire. 1-26.

Loisel, J., Gallego-Sala, A. V., & Yu, Z. (2012). Global-scale pattern of peatland Sphagnum growth driven by photosynthetically active radiation and growing season length. *Biogeosciences*, *9*(7), 2737-2746.

Luken, J. O. (1985). Zonation of Sphagnum mosses: interactions among shoot growth, growth form, and water balance. *Bryologist*, 374-379.

Magurran, A., 2004. *Measuring Biological Diversity*. Oxford: Blackwell.

Ritson, J. P., Lees, K. J., Hill, J., Gallego-Sala, A. & Bebber, D. P. (2025) Climate change impacts on blanket peatland in Great Britain. <https://doi.org/10.1111/1365-2664.14864>

Schneider, C. A., Rasband, W. S., & Eliceiri, K. W. (2012). NIH Image to ImageJ: 25 years of image analysis. *Nature methods*, *9*(7), 671-675.

Shannon, C. E., and Weaver, W., 1949. *The Mathematical Theory of Communication*. Urbana: University of Illinois Press.

# APPENDICES

## A.1. Dataset

Table S1 – Dataset collected during the Autumn 2024. Cond.: Humok condition (H: healty, BS: bleached/stressed); NVC: National Vegetation Classification; L: Length; W: Width; H: Height; Composition (in %) - C: S. capillifolium; M: S. medium; PP: S. papillosum; PL: S. palustre; S: S. subnitens; FX: S. fallax; F: S. fimbriatum.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Date | Site | Cond. | NVC | L (cm) | W (cm) | H (cm) | C | M | PP | PL | S | FX | F |
| 23/10/2024 | SCARH | H | M19 | 4 | 4 | 0.5 | 0 | 0 | 0 | 50 | 50 | - | - |
| 23/10/2024 | SCARH | H | M19 | 9 | 6 | 2 | 5 | 0 | 0 | 40 | 55 | - | - |
| 23/10/2024 | SCARH | H | M19 | 9 | 6 | 1 | 25 | 0 | 0 | 75 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 14 | 12 | 3 | 20 | 0 | 0 | 78 | 2 | - | - |
| 23/10/2024 | SCARH | H | M19 | 9 | 8 | 1.5 | 5 | 0 | 0 | 93 | 2 | - | - |
| 23/10/2024 | SCARH | H | M19 | 10 | 10 | 2 | 30 | 0 | 5 | 63 | 2 | - | - |
| 23/10/2024 | SCARH | H | M19 | 11 | 11 | 3 | 35 | 0 | 5 | 60 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 9 | 8 | 2 | 15 | 0 | 10 | 40 | 35 | - | - |
| 23/10/2024 | SCARH | H | M19 | 10 | 7 | 4 | 15 | 0 | 5 | 80 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 11 | 9 | 3 | 10 | 0 | 0 | 88 | 2 | - | - |
| 23/10/2024 | SCARH | H | M19 | 6 | 5 | 1 | 0 | 0 | 0 | 75 | 25 | - | - |
| 23/10/2024 | SCARH | H | M19 | 8 | 7 | 2.5 | 5 | 0 | 5 | 70 | 20 | - | - |
| 23/10/2024 | SCARH | H | M19 | 7 | 7 | 2 | 5 | 0 | 0 | 95 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 5 | 5 | 1 | 10 | 0 | 40 | 45 | 5 | - | - |
| 23/10/2024 | SCARH | H | M19 | 13 | 10 | 2 | 0 | 25 | 5 | 40 | 30 | - | - |
| 23/10/2024 | SCARH | H | M19 | 10 | 9 | 4 | 10 | 0 | 30 | 60 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 6 | 5 | 1 | 0 | 0 | 0 | 55 | 45 | - | - |
| 23/10/2024 | SCARH | H | M19 | 10 | 8 | 2 | 2 | 0 | 2 | 76 | 20 | - | - |
| 23/10/2024 | SCARH | H | M19 | 13 | 10 | 3 | 3 | 2 | 20 | 50 | 25 | - | - |
| 23/10/2024 | SCARH | H | M19 | 14 | 8 | 3 | 45 | 0 | 40 | 10 | 5 | - | - |
| 23/10/2024 | SCARH | H | M19 | 6 | 5 | 3.5 | 0 | 0 | 0 | 90 | 10 | - | - |
| 23/10/2024 | SCARH | H | M19 | 13 | 12 | 5 | 45 | 0 | 55 | 0 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 9 | 6 | 3 | 18 | 2 | 80 | 0 | 0 | - | - |
| 23/10/2024 | SCARH | H | M19 | 8 | 8 | 3 | 0 | 0 | 0 | 80 | 20 | - | - |
| 23/10/2024 | SCARH | H | M19 | 13 | 12 | 3 | 0 | 0 | 0 | 5 | 95 | - | - |
| 23/10/2024 | SCARH | H | M20 | 14 | 12 | 4 | 15 | 0 | 5 | 35 | 45 | - | - |
| 23/10/2024 | SCARH | H | M19 | 13 | 13 | 4 | 5 | 2 | 5 | 20 | 68 | - | - |
| 23/10/2024 | SCARH | H | M19 | 11 | 10 | 3 | 2 | 5 | 48 | 0 | 45 | - | - |
| 23/10/2024 | SCARH | H | M19 | 9 | 9 | 3 | 0 | 0 | 0 | 55 | 45 | - | - |
| 23/10/2024 | SCARH | H | M19 | 12 | 11 | 4 | 0 | 5 | 0 | 45 | 50 | - | - |
| 24/10/2024 | MASHA | H | M19 | 14 | 13 | 8 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 26 | 28 | 13 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 30 | 25 | 14 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 28 | 26 | 13 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 35 | 31 | 10 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 9 | 10 | 5 | 0 | 0 | 100 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 28 | 20 | 8 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 7 | 7 | 2 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 16 | 11 | 5 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 30 | 25 | 12 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 12 | 14 | 6 | 10 | 10 | 0 | 80 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 22 | 15 | 7 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 20 | 14 | 7 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 13 | 9 | 2 | 0 | 0 | 100 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 25 | 22 | 6 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | BS | M19 | 9 | 7 | 1 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 15 | 10 | 8 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | BS | M19 | 18 | 9 | 3 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 16 | 15 | 10 | 0 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 24 | 22 | 7 | 0 | 0 | 10 | 90 | 0 | - | - |
| 24/10/2024 | MASHA | H | M20 | 30 | 27 | 9 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 33 | 25 | 10 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 42 | 28 | 10 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 48 | 33 | 10 | 70 | 0 | 0 | 30 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 38 | 23 | 11 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 46 | 48 | 12 | 75 | 0 | 0 | 25 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 53 | 43 | 16 | 80 | 0 | 0 | 20 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 43 | 40 | 12 | 10 | 40 | 0 | 50 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 35 | 49 | 11 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 41 | 32 | 9 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 44 | 50 | 15 | 30 | 5 | 55 | 10 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 47 | 32 | 16 | 5 | 25 | 0 | 70 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 57 | 42 | 14 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M20 | 21 | 14 | 5 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M20 | 29 | 20 | 9 | 1 | 0 | 0 | 99 | 0 | - | - |
| 24/10/2024 | MASHA | H | M20 | 28 | 17 | 8 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 21 | 15 | 7 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 35 | 23 | 13 | 5 | 0 | 0 | 95 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 25 | 18 | 9 | 0 | 0 | 5 | 95 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 33 | 26 | 11 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 20 | 19 | 7 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 18 | 14 | 7 | 0 | 0 | 10 | 90 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 21 | 19 | 9 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 17 | 13 | 8 | 0 | 0 | 40 | 60 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19 | 16 | 27 | 14 | 2 | 98 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 12 | 12 | 1 | 0 | 0 | 80 | 20 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 18 | 18 | 7 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 22 | 22 | 10 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 12 | 12 | 4 | 0 | 15 | 0 | 84 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 15 | 11 | 8 | 0 | 5 | 0 | 95 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 15 | 14 | 2 | 0 | 0 | 99 | 1 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 23 | 17 | 10 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 27 | 15 | 7 | 33 | 0 | 33 | 34 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 14 | 13 | 2 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 14 | 12 | 2 | 0 | 0 | 98 | 2 | 0 | - | - |
| 24/10/2024 | MASHA | H | M20 | 13 | 12 | 6 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M20 | 16 | 16 | 6 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 7 | 8 | 2 | 0 | 0 | 100 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 23 | 29 | 8 | 0 | 0 | 0 | 100 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 24 | 22 | 10 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | BS | M19c | 9 | 7 | 0.5 | 100 | 0 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 13 | 10 | 3 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 19 | 16 | 5 | 0 | 100 | 0 | 0 | 0 | - | - |
| 24/10/2024 | MASHA | H | M19c | 17 | 12 | 6 | 100 | 0 | 0 | 0 | 0 | - | - |
| 18/11/2024 | KATTYW | H | M20 | 12 | 13 | 4 | 5 | 0 | 95 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 12 | 9 | 4 | 50 | 0 | 0 | 50 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M25 | 10 | 9 | 5 | 10 | 0 | 0 | 90 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 11 | 8 | 2 | 50 | 0 | 45 | 0 | 5 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 10 | 8 | 3 | 25 | 0 | 75 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 7 | 7 | 2 | 7 | 0 | 90 | 0 | 3 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 13 | 12 | 4 | 25 | 5 | 25 | 40 | 5 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 10 | 9 | 5 | 70 | 0 | 25 | 0 | 5 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 13 | 11 | 4 | 85 | 1 | 14 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 15 | 15 | 3 | 10 | 0 | 5 | 83 | 0 | 2 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 6 | 5 | 2 | 5 | 0 | 95 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 12 | 8 | 2 | 10 | 0 | 85 | 0 | 5 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M17 | 12 | 9 | 4 | 15 | 5 | 80 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M17 | 10 | 10 | 3 | 20 | 0 | 80 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M17 | 5 | 4 | 2 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | U6 | 12 | 9 | 4 | 10 | 0 | 5 | 85 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 8 | 6 | 3 | 20 | 0 | 80 | 0 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | U6 | 14 | 10 | 3 | 7 | 0 | 0 | 90 | 3 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 7 | 6 | 2 | 30 | 0 | 15 | 50 | 0 | 5 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 9 | 8 | 3 | 10 | 0 | 0 | 90 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 8 | 7 | 1 | 25 | 0 | 15 | 60 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M25 | 9 | 8 | 3 | - | - | - | - | - | - | - |
| 18/11/2024 | KATTYW | H | M20 | 4 | 4 | 2 | 40 | 0 | 0 | 60 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 9 | 9 | 4 | 10 | 0 | 0 | 90 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 9 | 6 | 5 | 40 | 0 | 0 | 60 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | U6 | 8 | 8 | 3 | 20 | 0 | 10 | 70 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 9 | 8 | 5 | 70 | 0 | 0 | 30 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 12 | 9 | 6 | 20 | 0 | 0 | 80 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | U2 | 10 | 6 | 3 | 40 | 0 | 10 | 50 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 8 | 7 | 4 | 30 | 1 | 5 | 64 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 15 | 13 | 6 | 40 | 0 | 10 | 50 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 14 | 11 | 6 | 50 | 0 | 0 | 50 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 11 | 7 | 7 | 15 | 5 | 30 | 50 | 0 | 0 | 0 |
| 18/11/2024 | KATTYW | H | M20 | 6 | 6 | 3 | 40 | 0 | 0 | 60 | 0 | 0 | 0 |
| 06/12/2024 | DENTO | H | M19 | 4 | 4 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 4 | 2 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 5 | 2 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 5 | 3 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 3 | 0.75 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 3 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 3 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 2 | 2 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 2 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 2 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 2 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 3 | 2 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 2 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 5 | 3 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 6 | 5 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 3 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | BS | M19 | 4 | 2 | 0 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 4 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | BS | M19 | 4 | 3 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 3 | 2 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 5 | 4 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 2.5 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 3 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4.5 | 3 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4 | 2.5 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | BS | M19 | 2.5 | 2.5 | 0.5 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | BS | M19 | 3 | 2.5 | 1 | - | - | - | - | - | - | - |
| 06/12/2024 | DENTO | H | M19 | 4.5 | 3.5 | 0.5 | - | - | - | - | - | - | - |

## A.2. Statistical analyses

Table S1 - ANOVA two-factor way test between Scar House Moss at 8 months and Katty White’s Allotment at 9 months.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Species | 93189.76 | 5 | 18637.95 | 43.64692 | 1.34E-35 | 2.237492 |
| Site | 227.2727 | 1 | 227.2727 | 0.532234 | 0.466114 | 3.865789 |
| Interaction | 16307.39 | 5 | 3261.479 | 7.63783 | 7.38E-07 | 2.237492 |
| Within | 163974.3 | 384 | 427.0164 |  |  |  |
| Total | 273698.7 | 395 |  |  |  |  |

Figure S1 – P-values for the T-test conducted on the Shannon’s diversity index between the original Yorkshire mix and Scar House Moss (blue) and Katty White’s Allotment (red). P-values < 0.05 indicate a change in composition since inoculation. P-values > 0.05 indicate similar composition to the original mix.

Table S2 – Swinton Estate: T-test between the original Humok sizes at 0 month and Humok sizes at 10-11, 23-24 and 80 months.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | *0 month* | *10-11 months* | *0 month* | *23-24 months* | *0 month* | *80 months* |
| Mean | 8.146542 | 27.50113 | 8.146542 | 58.6453 | 8.146542 | 475.2886 |
| Variance | 12.17905 | 220.4115 | 12.17905 | 1471.697 | 12.17905 | 220198.1 |
| Observations | 28 | 161 | 28 | 123 | 28 | 64 |
| Hypothesized Mean Difference | 0 |  | 0 |  | 0 |  |
| df | 174 |  | 130 |  | 63 |  |
| t Stat | -14.4101 |  | -14.3407 |  | -7.96351 |  |
| P(T<=t) one-tail | 8.57E-32 |  | 7.42E-29 |  | 2.07E-11 |  |
| t Critical one-tail | 1.653658 |  | 1.656659 |  | 1.669402 |  |
| P(T<=t) two-tail | 1.71E-31 |  | 1.48E-28 |  | 4.13E-11 |  |
| t Critical two-tail | 1.973691 |  | 1.97838 |  | 1.998341 |  |

Table S3 – T-test for the different Sphagnum at Scar House Moss between inoculation and 8 months. sph\_fal: S. fallax; sph\_sub: S. subnitens; sph\_pal: S. palustre; sph\_pap: S. papillosum; sph\_med: S. medium; sph\_cap: S. capillifolium. YM: Yorkshire mix. SCARH: Scar House Moss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | sph\_cap | | sph\_med | | sph\_pap | | sph\_pal | | sph\_sub | |
|  | SCARH | YM | SCARH | YM | 8M | YM | SCARH | YM | SCARH | YM |
| Mean | 15 | 30 | 7 | 5 | 23 | 30 | 58 | 30 | 30 | 5 |
| Variance | 181 | 0 | 81 | 0 | 561 | 0 | 596 | 0 | 598 | 0 |
| Observations | 21 | 30 | 6 | 30 | 16 | 30 | 27 | 30 | 23 | 30 |
| Hypothesized Mean Difference | 0 |  | 0 |  | 0 |  | 0 |  | 0 |  |
| df | 20 |  | 5 |  | 15 |  | 26 |  | 22 |  |
| t Stat | -4.95 |  | 0.50 |  | -1.27 |  | 6.01 |  | 5.00 |  |
| P(T<=t) one-tail | 3.83E-05 |  | 0.319857 |  | 0.112215 |  | 1.19E-06 |  | 2.65E-05 |  |
| t Critical one-tail | 1.724718 |  | 2.015048 |  | 1.75305 |  | 1.705618 |  | 1.717144 |  |
| P(T<=t) two-tail | 7.66E-05 |  | 0.639713 |  | 0.22443 |  | 2.38E-06 |  | 5.3E-05 |  |
| t Critical two-tail | 2.085963 |  | 2.570582 |  | 2.13145 |  | 2.055529 |  | 2.073873 |  |

Table S4 – T-test for the different Sphagnum at Katty White’s Allotment between inoculation and 9 months. sph\_fal: S. fallax; sph\_sub: S. subnitens; sph\_pal: S. palustre; sph\_pap: S. papillosum; sph\_med: S. medium; sph\_cap: S. capillifolium. YM: Yorkshire mix. KATTW: Kattyy White’s Allotment.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | sph\_cap | | sph\_med | | sph\_pap | | sph\_pal | | sph\_sub | | sph\_fal | |
|  | KATTYW | YM | KATTYW | YM | KATTYW | YM | KATTYW | YM | KATTYW | YM | KATTYW | YM |
| Mean | 28 | 30 | 3 | 5 | 43 | 30 | 66 | 30 | 4 | 5 | 4 | 0 |
| Variance | 434 | 0 | 5 | 0 | 1267 | 0 | 380 | 0 | 1 | 0 | 5 | 0 |
| Observations | 32 | 33 | 5 | 33 | 21 | 33 | 22 | 33 | 6 | 33 | 2 | 33 |
| Hypothesized Mean Difference | 0 |  | 0 |  | 0 |  | 0 |  | 0 |  | 0 |  |
| df | 31 |  | 4 |  | 20 |  | 21 |  | 5 |  | 1 |  |
| t Stat | -0.48 |  | -1.63 |  | 1.62 |  | 8.66 |  | -1.58 |  | 2.33 |  |
| P(T<=t) one-tail | 0.319028 |  | 0.088904 |  | 0.060602 |  | 1.12E-08 |  | 0.087344 |  | 0.128881 |  |
| t Critical one-tail | 1.695519 |  | 2.131847 |  | 1.724718 |  | 1.720743 |  | 2.015048 |  | 6.313752 |  |
| P(T<=t) two-tail | 0.638057 |  | 0.177808 |  | 0.121203 |  | 2.24E-08 |  | 0.174688 |  | 0.257762 |  |
| t Critical two-tail | 2.039513 |  | 2.776445 |  | 2.085963 |  | 2.079614 |  | 2.570582 |  | 12.7062 |  |

Table S5 – ANOVA test on the growth rate (cm2.yr-1) between the different Sphagnum species at Swinton Estate.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between species | 22965.51 | 3 | 7655.169 | 2.910053 | 0.044945 | 2.816466 |
| Within species | 115746.2 | 44 | 2630.595 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 138711.7 | 47 |  |  |  |  |

Table S6 – Results T-test on the growth rate between different Sphagnum species at the Swinton Estate. sph\_fal: S. fallax; sph\_sub: S. subnitens; sph\_pal: S. palustre; sph\_pap: S. papillosum; sph\_med: S. medium; sph\_cap: S. capillifolium

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P-value | sph\_cap | sph\_med | sph\_pap | sph\_pal |
| sph\_cap |  | 0.57 | 0.023 | 0.024 |
| sph\_med | 0.57 |  | 0.007 | 0.063 |
| sph\_pap | 0.023 | 0.007 |  | 105 |
| sph\_pal | 0.024 | 0.063 | 105 |  |