NIA Culm Grassland Flood Management Project
Vegetation Monitoring Summary 2020

Devon

Introduction

Culm Grassland is a type of species-rich marshy grassland found in the Culm Measures in northwest Devon and northeast Cornwall. It occurs on poorly-drained neutral and acidic soils on the lowlands and upland fringe, and is also known as rhôs pasture.

Culm grassland is a varied habitat type which can include the following National Vegetation Classification (NVC) community types:

- M16 - *Erica tetralix-Sphagnum compactum* wet heath
- M23 - *Juncus effusus/acutiflorus-Galium palustre* rush pasture
- M24 - *Molinia caerulea-Cirsium dissectum* fen meadow
- M25 - *Molinia caerulea-Potentilla erecta* mire
- M27 - *Filipendula ulmaria-Angelica sylvestris* mire
- M29 - *Hypericum elodes – Potamogeton polygonifolius* soakway
- S3 - *Carex paniculata* swamp
- S27 - *Carex rostrate – Potentilla palustris* tall-herb fen

These NVC communities fall into a number of Priority Habitat types: Purple moor-grass and rush pasture (M23, M24 & M25), Wet heath (M16) and Lowland fen (M27, M29 & S3). M29, S3 and S27 are not found frequently in large areas. On the whole the Culm grassland in Northern Devon is best represented by the Priority Habitat Purple Moor-grass and Rush Pasture.

Culm grassland often transitions to drier communities and at these locations the communities might also show affinities to lowland meadow MG5 (*Cynosurus cristatus - Centaurea nigra* mesotrophic grassland), particularly the *Danthonia decumbens* sub- community. This can form part of the culm 'matrix'.

Culm grasslands tend transition to more agriculturally improved grasslands where M23b (the soft rush dominated rush pasture) starts to become less diverse showing signs of MG10 (*Holcus lanatus- Juncus effusus* rush-pasture). The characteristic here being the lack of / low level of abundance of greater bird's-foot trefoil, common marsh bedstraw and other positive indicator species.

Culm grassland supports some of Devon's most threatened species such as the marsh fritillary, small pearl-bordered fritillary, narrow-bordered bee hawk-moth, curlew, snipe and barn owl.

The Devon Wildlife Trust's (DWT) Northern Devon Nature Improvement Area (NIA) Culm Grassland Natural Flood Management project commenced in 2016 and one of the aims of the project was to create 100 hectares of species-rich wet grassland on the Culm Measures through the application of green hay and seeds collected from species-rich sites. In time it is hoped that the species-rich grasslands created would start to show affinities towards Culm grassland. The vegetation at all creation sites

has been monitored annually since 2016 and 2020 is the final year of the monitoring programme.

Data recently collected by Exeter University suggests that Culm grasslands store more water than improved grasslands. As such the creation of species-rich wet grassland has the potential to enhance the storage of water within the wider countryside.

A PhD student is currently carrying out further research into the water holding capacity of Culm grassland, improved grassland and semi-improved rush pastures (dominated by soft rush). This information coupled with the botanical monitoring data summarised within this report (and future reports) will help to determine the true value of species-rich wet grassland creation with regards to hydrological processes in northern Devon.

Summary of findings

Since 2016 40 sites have been surveyed as a part of the vegetation monitoring programme. Of these sites one was not subsequently worked on by DWT and as such only one year of baseline data was collected. Two additional sites were surveyed which were green hayed / over sown prior to the start of the NIA Culm project. These sites have not been included within the results section of this report. Baseline survey data was gathered at nine sites that were green hayed / over sown autumn 2020.

Of the 30 sites that were over sown or green hayed between 2016-2019 baseline surveys suggest that 3 were 'improved', nine were 'semi-improved – species-poor' and 17 were 'semi-improved good quality with moderate richness' (a baseline survey was not carried out at one site). In 2020 12 of these sites were recorded as being 'species-rich' (of these three are of 'good quality', the remainder being of 'moderate quality'), showing an overall significant shift in classification.

In addition to this there is a general increase in average herb cover and the number of positive indicator species. Some positive indicator species tend to germinate and grow more readily than others at creation sites.

Information from the Level 2 surveys show that creation sites show closer affinities to species-rich wet grassland National Vegetation Classification (NVC) communities.

There are a great number of variables that seem to affect the success of green haying / over sowing including weather (particularly that exposed to seedlings), soil nutrient levels, management and hydrology.

Sites

To date DWT have carried out creation works on 26 sites across northern Devon (refer to Table 1). Multiple fields have been worked on at several sites (Upcott

Grange, East Cranbury, Mill Barton, Headon Farm, Ashridge Court and Chapel Farm).

Table 1: Site summary

Site	Year	Method of creation	Survey methodology
Upcott Grange	2016	Drain disruption, green hayed and over sown	Level 1 & 2
Higher Grinacombe	2016	Over sown	Level 1
Downacarey Bridge	2016	Over sown	Level 1
Higher Goodacre	2016	Over sown	Level 1
Gortleigh	2017	Over sown	Level 1
East Cranbury – Fields 1 - 3	2017	Over sown	Level 1
Brockscombe	2017	Over sown	Level 1 & 2
East Lutworthy	2018	Green hayed and over sown	Level 1
Little Park	2018	Soil stripped, green hayed and over sown	Level 1
Mill Barton – Fields 1 & 2	2018	Green hayed and over sown	Level 1
West Backstone	2018	Green hayed and over sown	Level 1
Poole Batten	2018	Over sown	Level 1
Mudhouse	2018	Green hayed and over sown	Level 1
Hatherleigh Moor	2018	Green hayed and over sown	Level 1
Palmers Ash	2018	Green hayed and over sown	Level 1 & 2
Haddacott Moor	2018	Over sown	Level 1 & 2
Headon Farm	2018	Over sown	Not surveyed*
Kerswell Farm	2019	Green hayed and over sown	Level 1
Culvercroft	2019	Over sown	Level 1
Westhay	2019	Green hayed and over sown	Level 1
Chapel Farm	2019	Green hayed and over sown	Level 1
Ashridge Court	2019	Green hayed and over sown	Level 1
Upcott Grange - Pond field	2019	Green hayed and over sown	Level 1
Hollocombe	2019	Over sown	Level 1 & 2
Meadow Farm	2019	Work not carried out	Level 1 & 2
East Cranbury – Field 4	2020	Over sown	Level 1
Lower Way farm	2020	Over sown	Level 1
The Bulworthy Project	2020	Green hayed and over sown	Level 1
The Cottage	2020	Green hayed and over sown	Level 1
Broadridge Farm – Fields 1 & 2	2020	Green hayed and over sown	Level 1
Ford Farm	2020	Green hayed and over sown	Level 1

Mill Barton – Field 3	2020	Green hayed and over sown	Level 1 & 2
Taw River Dairy	2020	Green hayed and over sown	Level 1 & 2

* A baseline survey was not carried out at Headon Farm in 2018 as plans for over sowing work were finalised in September at short notice.

In addition to the sites in the table above a survey was carried out at Dart Raffe, (two areas, green hayed by the Working Wetlands team in 2012 and 2013) and Headon Trial Plot (oversown with a *Molinia* rich seed mix in autumn 2015 and spring 2016). These sites have not been included in any particular detail within this summary document as a baseline survey was not carried out.

Creation techniques

Species-rich grassland creation has mainly been carried out through over sowing and green haying (i.e. transferring seeds or hay from a species-rich donor site to the receptor site). To increase the chance of seed germination bare ground needs to be created at the receptor site. This is usually carried out through harrowing. There is some evidence (gathered by DWT staff) to suggest that ploughing receptor sites creates niches in which seedlings can grow in a less competitive environment. An MSc student has recently carried out research to determine germination rates of Culm grassland positive indicator species at ploughed and harrowed sites. This data is available from the student who carried out the research.

At one site (Upcott Grange) mechanical works were carried out to disrupt the drainage system in one field. A swing shovel was used to dig down and collapse the drains. The aim being to make the site wetter.

Soil stripping was carried out at one site, Little Park. This was in an attempt to decrease the dominance of creeping buttercup, which was prevalent throughout the creation area. Between 4 and 6 inches of topsoil was removed from the site for seeding in mid July 2018. The soil was used to construct two new hedge banks on the site. Green hay was spread in early September and over sowing took place in early October.

Botanical monitoring methodologies

A monitoring methodology was devised in order to determine changes in vegetation over time following grassland creation works and to determine success in the creation of species-rich swards from grasslands originally found to be of low or moderate richness. The methodology comprises of two survey techniques:

- Level 1 survey: A broadbrush technique based on a survey and assessment methodology used by Natural England to identify the status of land for agri-environment scheme applications. The field is walked and information is gathered at ten random stops including the presence of positive indicator species, % cover of rye-grass and white clover, % cover of wildflowers and the number of species within a $1m^2$ area. This information determines whether the sward is ‘improved’, ‘semi-improved’ or ‘species-rich’.

- Level 2 survey: A more complex and time-consuming methodology involving the use of 30 fixed metal markers which allow the same quadrats to be surveyed in successive years. The % cover of each species within a 1x1m quadrat is recorded along with other information such as the % cover of wildflowers.

For details on these methodologies refer to the 'NIA Culm Grassland Flood Mitigation Project Grassland Creation Monitoring Methodology'.

A list of the Culm grassland positive indicators used as a part of the survey methodology and subsequent assessment is included within Appendix 1.

Each creation site was surveyed annually using the Level 1 methodology but as it was more time consuming a smaller number of sites were monitored annually with the Level 2 methodology. New sites were over sown and green hayed each year and as such the number of sites surveyed increased year on year to 2020, the final year of the monitoring project.

Details on the survey methodology used at all sites is included within Table 1.

Botanical monitoring results and assessment – Level 1 sites

Grassland status

The data gathered from all sites following the Level 1 survey data allows the status of each grassland site to be assessed using Natural England guidelines. These guidelines inform whether a grassland sward is 'species-rich', 'semi-improved' or 'improved' and are usually used to determine which agri-environment option is most suitable. The status of a given grassland is determined by the % cover of rye-grass and white clover, the % cover of wildflowers and the average number of species present per stop / quadrat. Refer to Table 2.

Classification of species-richness under this Natural England assessment guidelines requires the grassland at a given site to pass two of the three following criteria:

1) Cover of rye-grasses and white clover is less than 10%.
2) The sward is species-rich (more than 15 species/m2, including grasses).
3) There is high cover of wildflowers and sedges (more than 30%), excluding white clover, creeping buttercup and injurious weeds.

Table 2: Grassland status at each site using Natural England assessment guidelines

Site	Grassland Status				
	Baseline	Year 1	Year 2	Year 3	Year 4
Upcott Grange (2016)	Improved	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Moderate quality	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Moderate quality

NIA Culm Grassland Flood Management Project
Vegetation Monitoring Summary 2020

Higher Grinacombe (2016)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Moderate quality	Species-rich grassland – Moderate quality	Semi-improved grassland – Good quality with moderate richness
Downacarey Bridge (2016)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Good quality	Species-rich grassland – Good quality	Species-rich grassland – Moderate quality
Higher Goodacre (2017)	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Good quality	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	
Gortleigh (2017)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	
East Cranbury Field 1 (2017)	Semi-improved grassland – Species-poor	Species-rich grassland – Good quality	Species-rich grassland – Moderate quality	Species-rich grassland – Moderate quality	
East Cranbury Field 2 (2017)	Semi-improved grassland – Species-poor	Species-rich grassland – Good quality	Species-rich grassland – Moderate quality	Species-rich grassland – Moderate quality	
East Cranbury Field 3 (2017)	Improved	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Moderate quality	Species-rich grassland – Moderate quality	
Brockscombe (2017)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	
East Lutworthy (2018)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Good quality		
Little Park (2018)	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Good quality	Species-rich grassland – Good quality		
Mill Barton Field 1 (2018)	Semi-improved grassland – Species-poor	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness		
Mill Barton Field 2 (2018)	Semi-improved grassland – Species-poor	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness		
West Backstone (2018)	Semi-improved grassland – Species-poor	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness		
Poole Batten (2018)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness		
Mudhouse (2018)	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Good quality	Semi-improved grassland – Good quality with moderate richness		

Hatherleigh Moor (2018)	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Good quality	Semi-improved grassland – Good quality with moderate richness		
Palmers Ash (2018)	Improved	Semi-improved grassland – Species-poor	Semi-improved grassland – Good quality with moderate richness		
Haddacott Moor (2018)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness		
Headon (2018)	N/A	Species-rich grassland – Good quality	Species-rich grassland – Good quality		
Kerswell farm (2019)	Semi-improved grassland – Species-poor	Species-rich grassland – Moderate quality			
Culvercroft (2019)	Semi-improved grassland – Species-poor	Semi-improved grassland – Good quality with moderate richness			
Westhay (2019)	Semi-improved grassland – Species-poor	Species-rich grassland – Good quality			
Chapel Farm Field 1 (2019)	Semi-improved grassland – Species-poor	Species-rich grassland – Moderate quality			
Chapel Farm Field 2 (2019)	Semi-improved grassland – Species-poor	Semi-improved grassland – Good quality with moderate richness			
Ashridge Court Field 1 (2019)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness			
Ashridge Court Field 2 (2019)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness			
Ashridge Court Field 3 (2019)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness			
Upcott Grange Pond Field (2019)	Semi-improved grassland – Good quality with moderate richness	Species-rich grassland – Moderate quality			
Hollocombe (2019)	Semi-improved grassland – Good quality with moderate richness	Semi-improved grassland – Good quality with moderate richness			
Meadow Farm (not restored)	Semi-improved grassland – Good quality with moderate richness	Not surveyed			
East Cranbury Field 4 (2020)	Semi-improved grassland – Good quality with				

	moderate richness				
Lower Way (2020)	Semi-improved grassland – Good quality with moderate richness				
The Bulworthy Project (2020)	Semi-improved grassland – Good quality with moderate richness				
The Cottage (2020)	Semi-improved grassland – Good quality with moderate richness				
Broadridge Field 1 (2020)	Semi-improved grassland – Good quality with moderate richness				
Broadridge Field 2 (2020)	Semi-improved grassland – Good quality with moderate richness				
Ford Farm (2020)	Semi-improved grassland – Species-poor				
Mill Barton Field 3 (2020)	Semi-improved grassland – Species-poor				
Taw River Dairy (2020)	Semi-improved grassland – Good quality with moderate richness				

Table 1 shows that 16 sites have been shown to have developed 'species-rich' grassland swards at some point since restoration was carried out. Of those 12 were found to have a 'species-rich' sward in 2020. Four sites (Higher Grinacombe, Higher Goodacre, Hatherleigh Moor and Mudhouse) have been classified as 'species-rich' since over sowing / green haying but in 2020 were classified as 'semi-improved'. This highlights that a number of the sites are borderline between these two classification types.

In 2020 67% of 2016 sites were species-rich, 50% of 2017 sites were 'species-rich', 27% of 2018 sites were 'species-rich' and 40% of 2019 sites were 'species-rich'. This suggests that restoration swards show greater affinities to being 'species-rich' as time passes after restoration. There is likely to be a time whereby this factor is less significant. Herb cover is a key factor in determining species-richness and wildflowers need time to establish and take up space in order to increase herb cover, which requires time. Annual species however, such as yellow rattle, can create a quick increase in herb cover.

All three 2016 sites developed into a 'species-rich' sward in 2018. In 2019 Upcott Grange came out as 'semi-improved' but in 2020 only Higher Grinacombe came out as 'semi-improved'. In 2019 Higher Grinacombe was not managed and as a result the sward has become more grass dominated and the amount of yellow rattle has

reduced. This caused a reduction in herb-cover which resulted in a classification down grade to 'semi-improved' grassland.

Three 2017 sites (out of six) were classified as 'species-rich' in 2018. This was surprising, particularly for East Cranbury as this site was fairly species-poor and grass dominated in 2017. All three East Cranbury fields came out as 'species-rich' in both 2019 and 2020. The herb cover at these fields was greatly increased as yellow rattle growth here was very successful. This was the main cause of the change in classification. Interestingly the herb cover was high at all three East Cranbury fields in 2020 but in addition to this Fields 2 and 3 were calculated as supporting (on average) more than 15 species per $1m^2$, which is another of the criteria when identifying species-rich grasslands.

Higher Goodacre moved from 'species-rich' in 2018 back to 'semi-improved' in 2019 and 2020, likely due to the seedlings seen in 2018 not surviving to adulthood. This site is very dry during the summer months, becoming saturated in the winter with much standing water. These conditions may be a bit too extreme for the numerous seedlings that were recorded in 2018.

Higher Goodacre had an average herb cover of 27% in 2019 and 28.3% in 2020, which is close to the threshold of 30%. It also had an average number of 14 species per stop in 2019 and 13.5 in 2020, which is also close to the threshold of 15. These values combined with the fact that white clover and rye-grass cover is low highlights how close this grassland is to being classified at 'species-rich'.

Brockscombe and Gortleigh have remained 'semi-improved' for four consecutive years. Gortleigh is close to being classified at 'species-rich' (2020 average herb cover of 28.6% and average number of species per stop 14.8). Brockscombe, despite supporting Culm grassland in the recent past, is not as close (2020 average herb cover of 16.55% and average number of species per stop 14.44).

Four 2018 sites came out as 'species-rich 'in 2019, though of these Mudhouse and Hatherleigh Moor came out as 'semi-improved' in 2020. Little Park and Headon retained their 'species-rich' classification and East Lutworthy upgraded from 'semi-improved' to 'species-rich'. In 2020 the average % cover of rye-grass and white clover at Mudhouse exceeded the threshold of 10%, increasing quite significantly from 2019 resulting in the site being downgraded to 'semi-improved grassland'. At Hatherleigh Moor the average number of species per stop dropped to below 15 resulting in a 'semi-improved' classification. The herb cover here is high though and is expected to increase above the 30% threshold in the coming years.

Four of the ten 2019 sites were classified as 'species-rich' in 2020 (Kerswell Farm, Westhay, Chapel farm 1 and Upcott Grange Pond Field), a single year after restoration works were carried out.
All 2020 sites are classified as semi-improved grassland as a baseline.

Generally, the sites seem to have high values for 'number of species per stop' the year following over sowing / green haying and then this value falls the following year.

This is considered likely to be due to seedling death. Seedlings are very sensitive to desiccation, competition and herbivory and it seems as if there is a low chance of survival to adulthood. In the case of purple moor-grass it is unknown if the seedlings survive, as this species is easier to spot as a seedling and as an adult plant.

% cover of wildflowers

The changes in average % cover of wildflowers at each site is shown in Graph 1. Baseline data collected at the 2020 sites was not included. The data gathered between 2016-2020 clearly demonstrates that sites regularly show an increase in herb/wildflower cover following restoration works. Some sites show a decrease in wildflower % cover in Year 1, possibly due to the damage caused by harrowing, but all sites have shown to have an increase by Year 2. All three 2016 sites show a reduction in herb cover in Year 4, which may possibly be due to a reduction in yellow rattle abundance. This species tends to have an intense flush of growth in the first few years followed by a reduction in cover.

Graph 2 shows how % cover of wildflowers has changed on average, for all sites, between baseline surveys and subsequent annual surveys. On average, prior to restoration works, sites have 11.19% cover of wildflowers, this increases to 13.77% in Year 1, 33.77% in Year 2, 38.35% in Year 3 and 44.16% in Year 4.

Priority Habitat positive indicator species

Grassland status (whether it is semi-improved or species-rich, or the quality of species-rich grassland) can be assessed by the presence and frequency of Priority Habitat positive indicator species (at a field scale). The total number of Purple moor-grass and Rush Pasture (PMGRP) positive indicator species for each site is shown on Graph 3.

Graph 3 shows that almost all sites show an increase in the number of PMGRP indicator species the year following creation works. The three 2016 sites that have been surveyed five times show that this number tends to plateau off or reduce slightly suggesting that some species don't tend to survive for the long term on these sites. An example is meadowsweet, a species seen as a seedling on numerous sites in 2018, which subsequently was seen very little in 2019 and 2020. Upcott Grange, however, was found to have another increase in the number of PMGRP positive indicators in 2020. This can be explained in part by small fenced off area that was not surveyed in 2019 being surveyed again in 2020 and several positive indicators were seen there.

Graph 4 shows how average numbers of PMGRP positive indicators change, for all sites, between baselines surveys and subsequent annual surveys. On average, prior to restoration works, sites have 4.8 PMGRP indicators, increasing to between 7.5 in Year 1, 6.8 in Year 2, 7.3 in Year 3 and 9.3 in Year 4. The reason for the slight dip in Year 2 in unknown but is likely to be due to seedling mortality. Although the graphs plateauxs slightly it is good to see that the values (on average) increase further in Years 3 and 4. This data does not consider the frequency of these indicator species.

Graphs 5 and 6 show a similar trend to Graphs 3 & 4 but takes into consideration indicator species from a broader spectrum of Priority Habitats (PMGRP, Lowland Meadow and Lowland Fen). The number of all positive indicators also tends to plateaux slightly following an initial significant increase in Year 1.

Species recorded per stop

The data collected from Level 1 and Level 2 surveys enables the calculation of the average number of species recorded at each stop. As the sites become more species-rich it is expected that this value increases.

Graph 7 shows the average number of species recorded per stop at all sites surveyed. It is possible to see that the number of species per stop increases at all sites when comparing baseline data to that gathered in Year 1 (except at Culvercroft where the value stayed the same). Of the ten 2018 sites, surveyed for three consecutive years, only three of them show another slight increase in the number of species recorded per stop in Year 2. Of the six 2017 sites, surveyed for four consecutive years, the results are variable. Five show an increase in the number of species per stop in Year 3 when compared to Year 2. Of the three 2016 sites that have been surveyed for five consecutive years, the number of species per stop recorded in Year 4 is significantly higher than it was in the baseline surveys but seems to have plateaued out slightly (except Upcott Grange which showed another incremental rise).

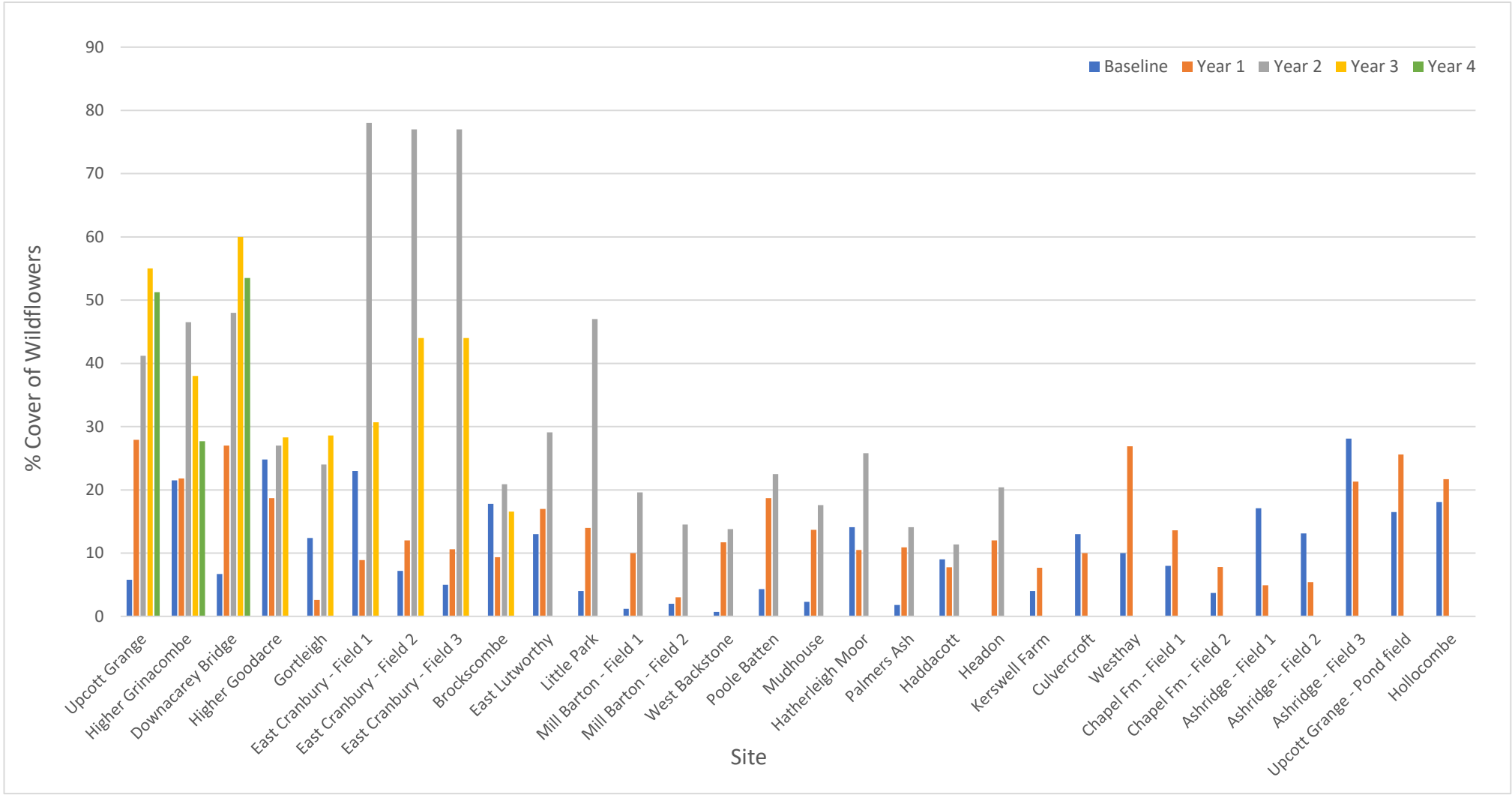
Field Saturation Index

The overall 'Culmyness' of each creation field can be demonstrated by the 'Saturation Index'. A score between 0 and 1 is given to show how 'Culmy' the grassland is, where 0 shows that the grassland is not like Culm and 1 represents a grassland that has all indicators frequently found within all Culm grassland vegetation communities. Even a species-rich example of Culm grassland may score a Saturation Index of 0.5. I.e. a score of 1 is highly unlikely. For a more detailed explanation of Field Saturation Indices refer to the 'NIA Culm Grassland Flood Mitigation Project Grassland Creation Monitoring Methodology'.

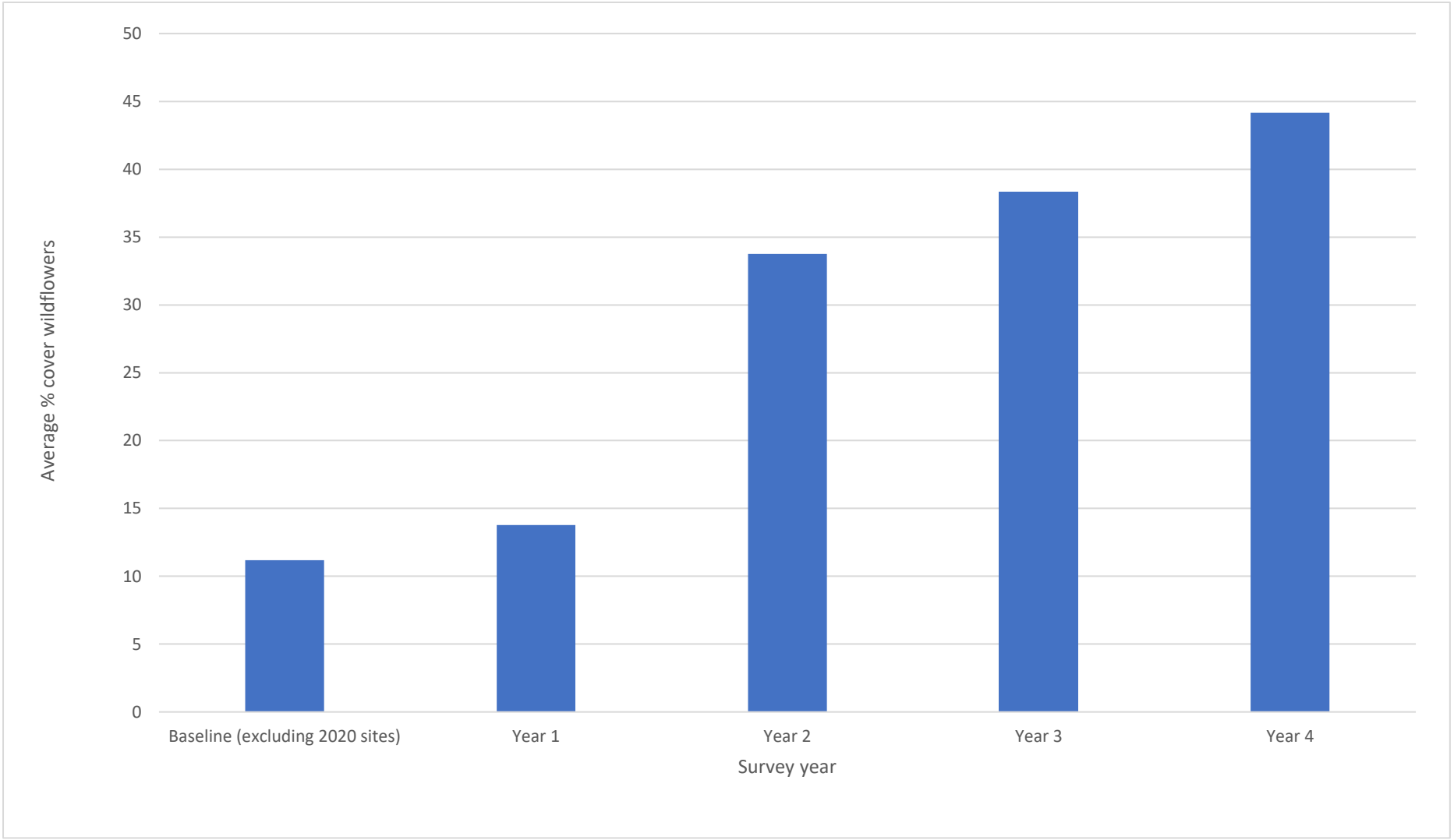
Saturation Indices do not refer solely to positive indicator species but also to more common species that are frequently occurring within Culm grassland communities. Graph 9 shows that of all three 2016 sites surveyed for five consecutive years there has been a similar pattern. The Saturation Index has increased in Years 1 and 2 and showed a slight decline in Year 3. For two of these sites the value then increased again in Year 4. Of all six 2017 sites that have been surveyed for four consecutive years there has been a sequential increase in Saturation Index values until Year 3, when the value reduces again.

NIA Culm Grassland Flood Management Project
Vegetation Monitoring Summary 2020

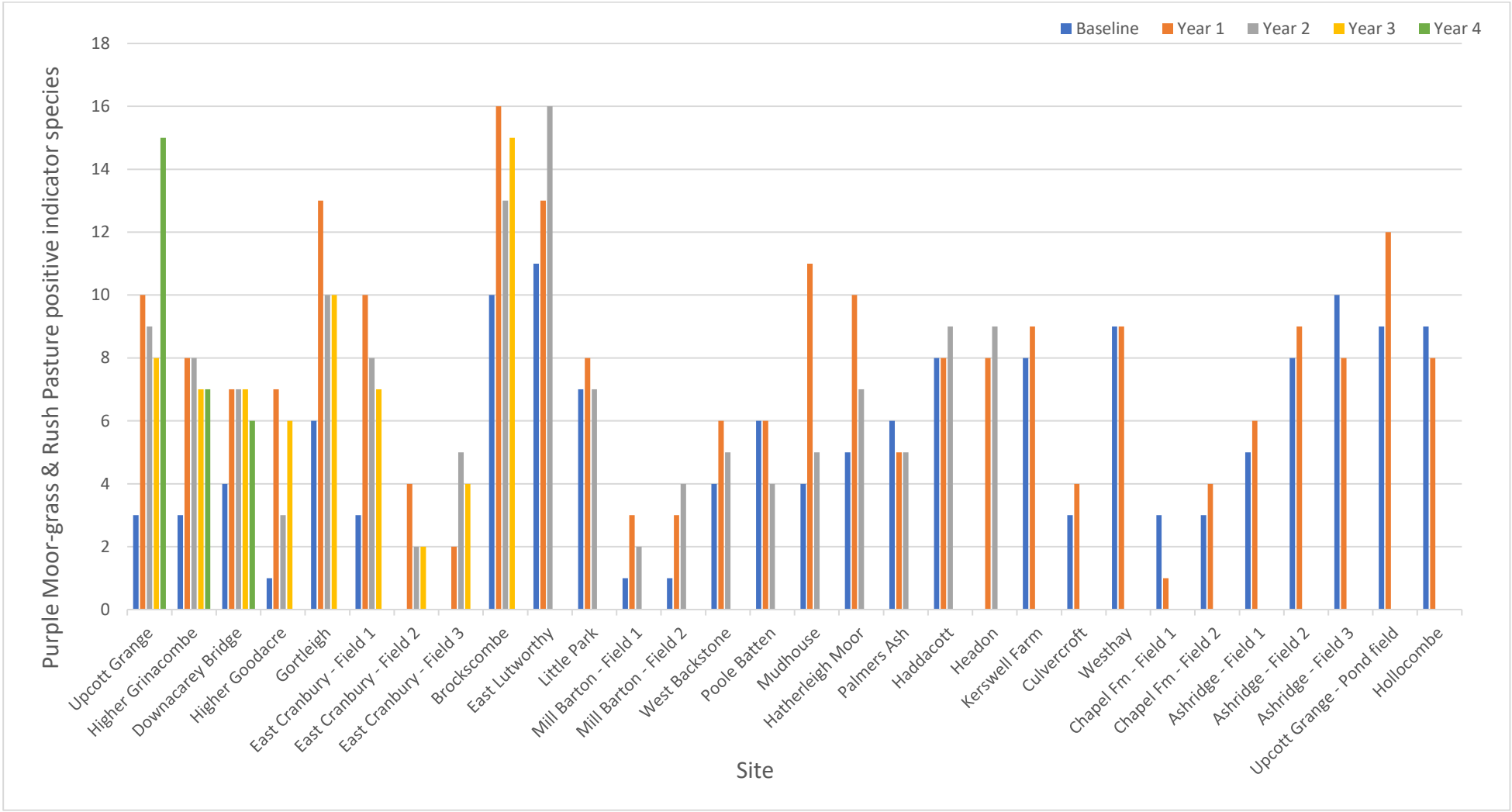
Graph 1: Average wildflower cover values at creation sites from 2016-2020 (baseline data for 2020 sites not included)



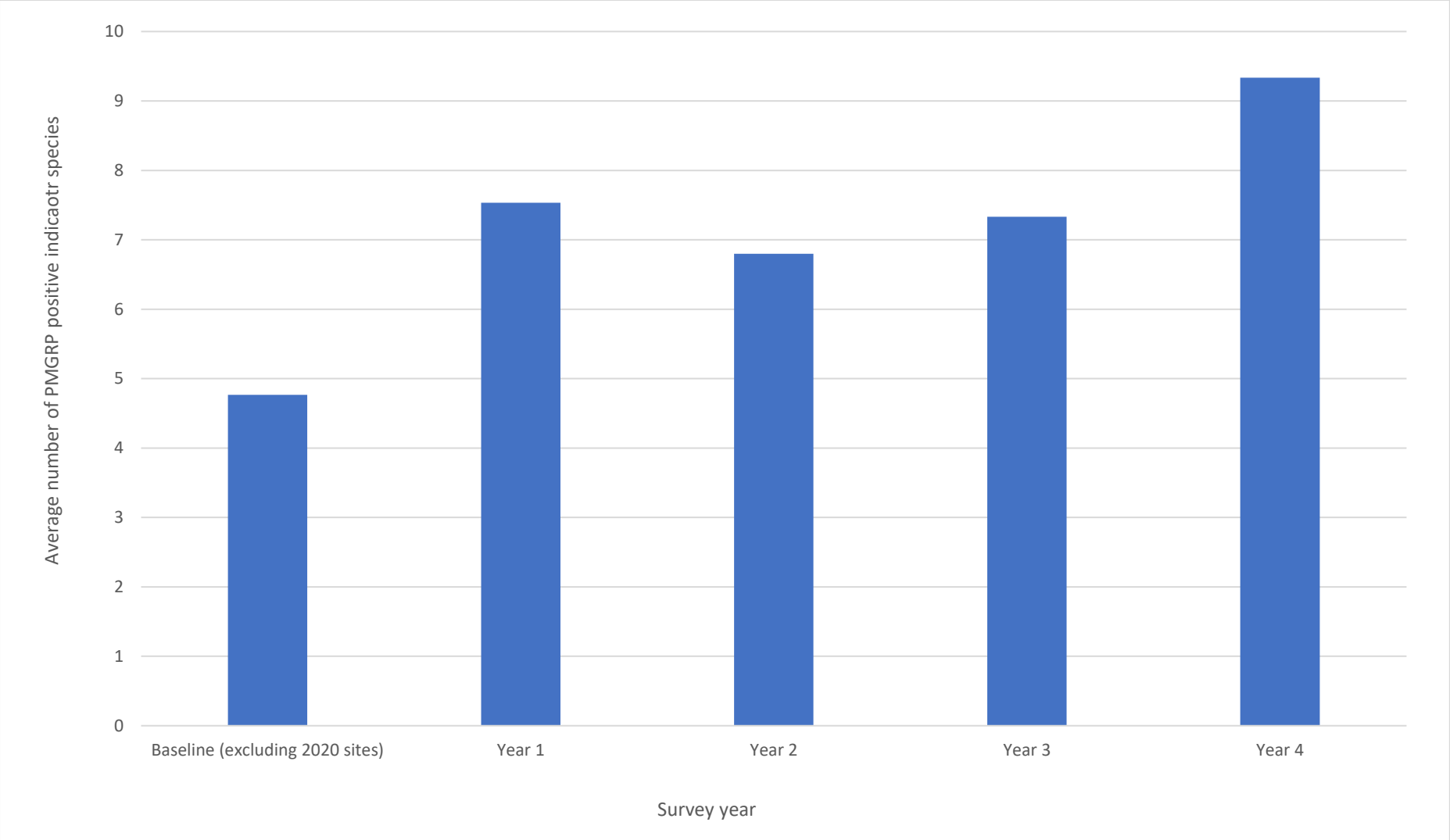
Graph 2: Average % cover of wildflowers for all sites in baseline surveys and subsequent annual surveys



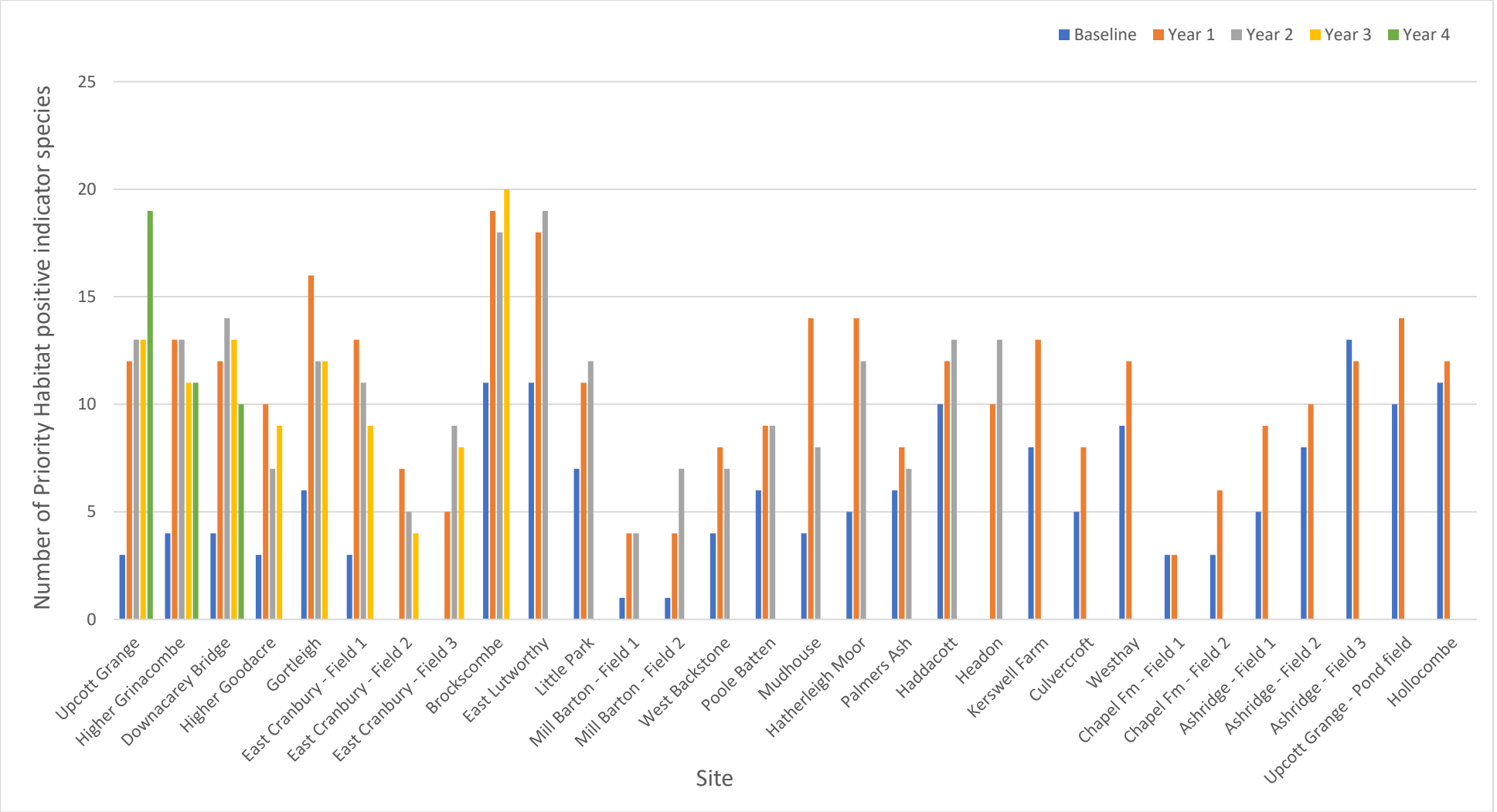
Graph 3: Total number of Purple moor-grass & rush pasture positive indicator species present at creation sites from 2016-2020 (baseline data for 2020 sites not included)



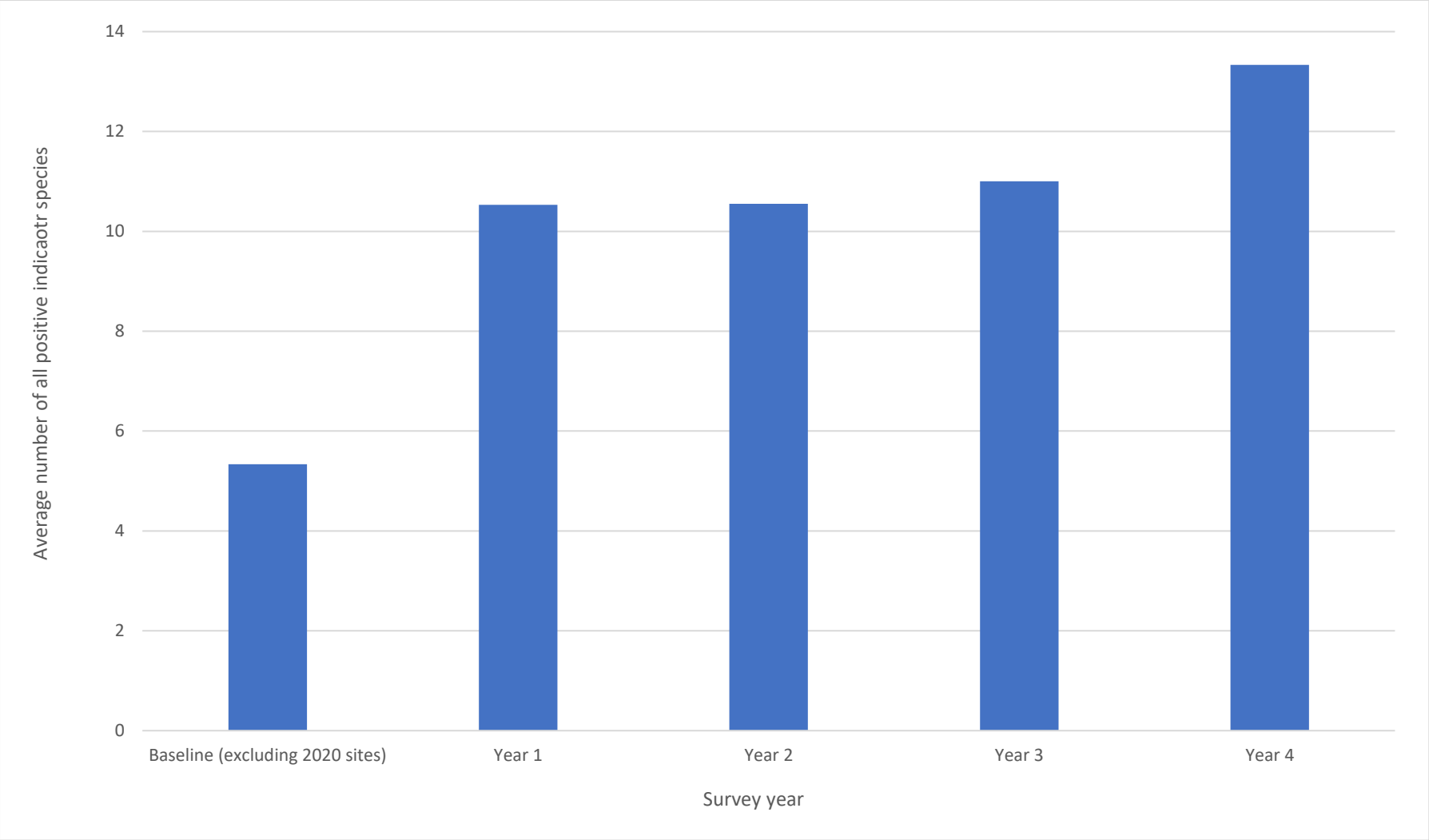
Graph 4: Average number of Purple Moor-grass & Rush Pasture positive indicators for all sites in baseline surveys and subsequent annual surveys



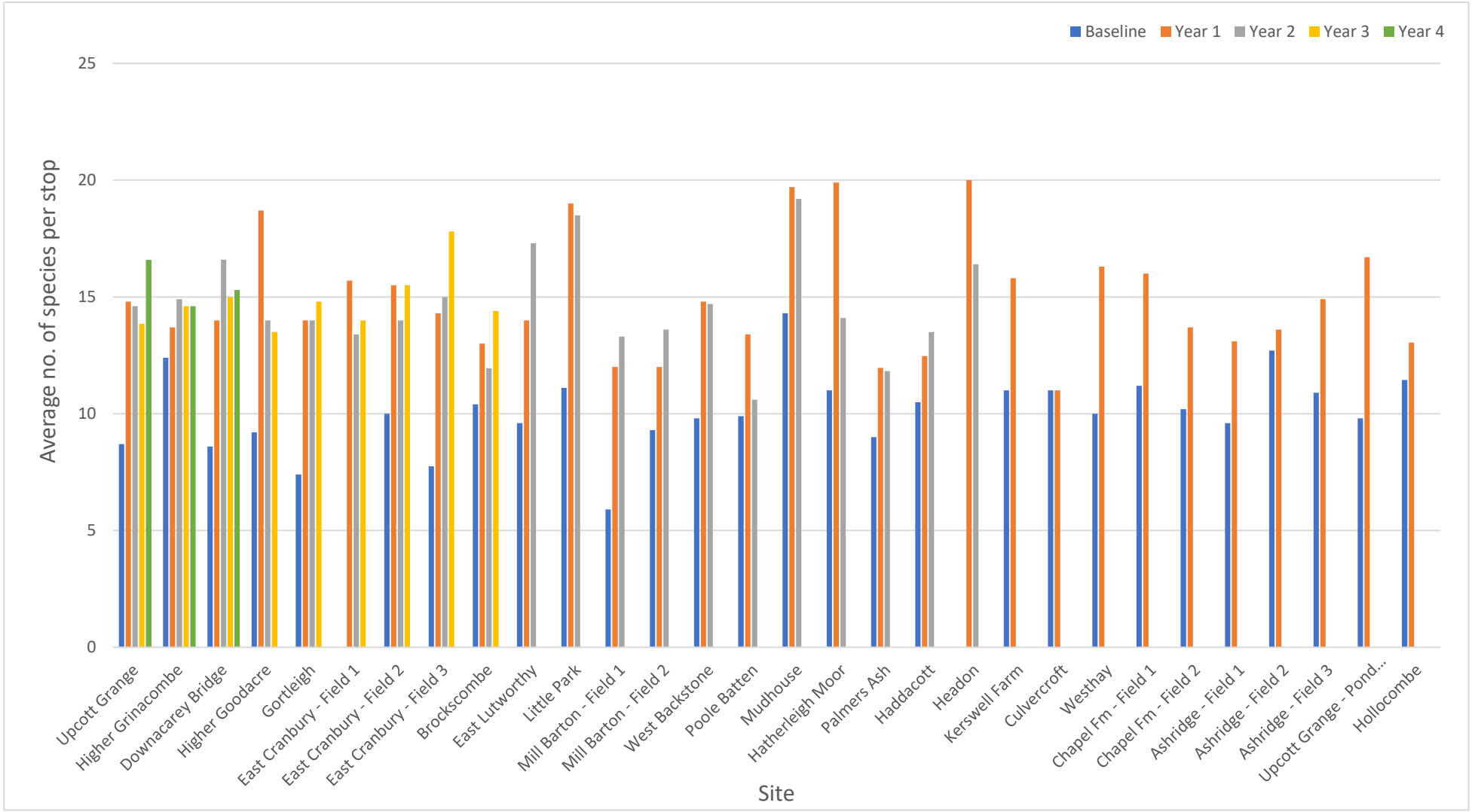
Graph 5: Total number of positive indicator species (PMGRP, Lowland Meadow and Lowland Fen) present at creation sites from 2016-2020 (excl. 2020 sites)



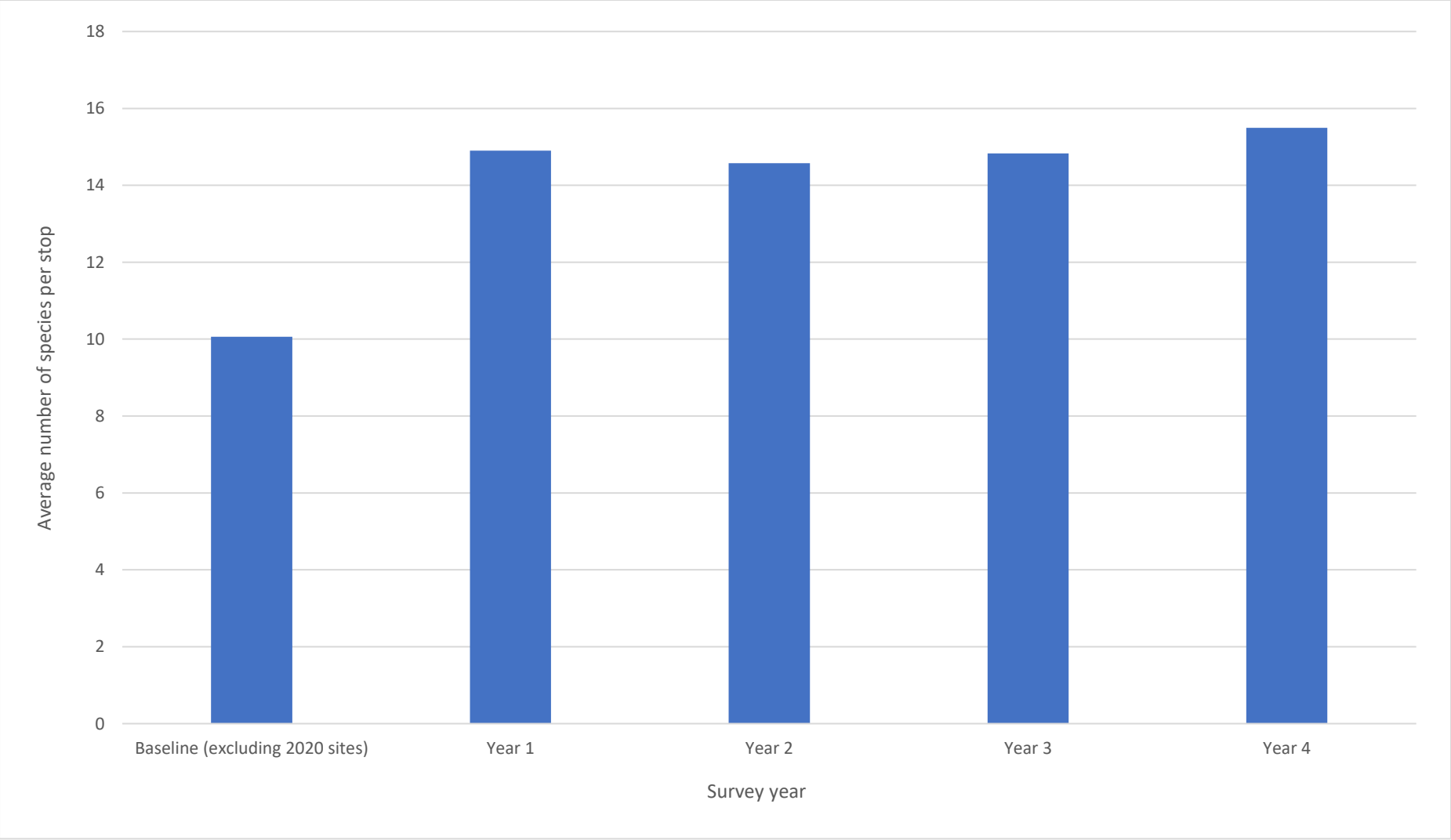
Graph 6: Average number of all positive indicators for all sites in baseline surveys and subsequent annual surveys



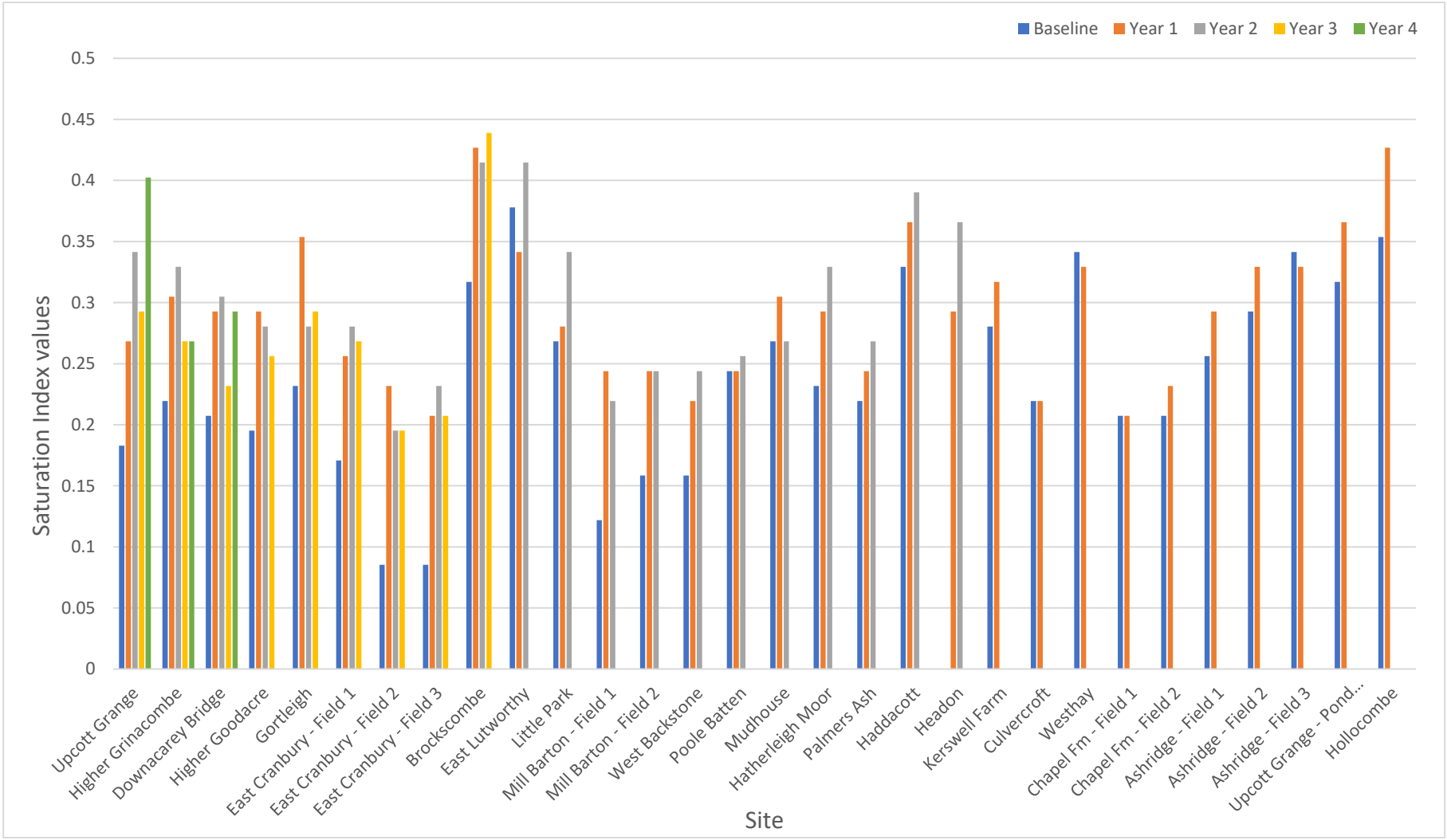
Graph 7: Average number of species recorded per stop at creation sites from 2016-2020 (excluding baseline data for 2020 sites)



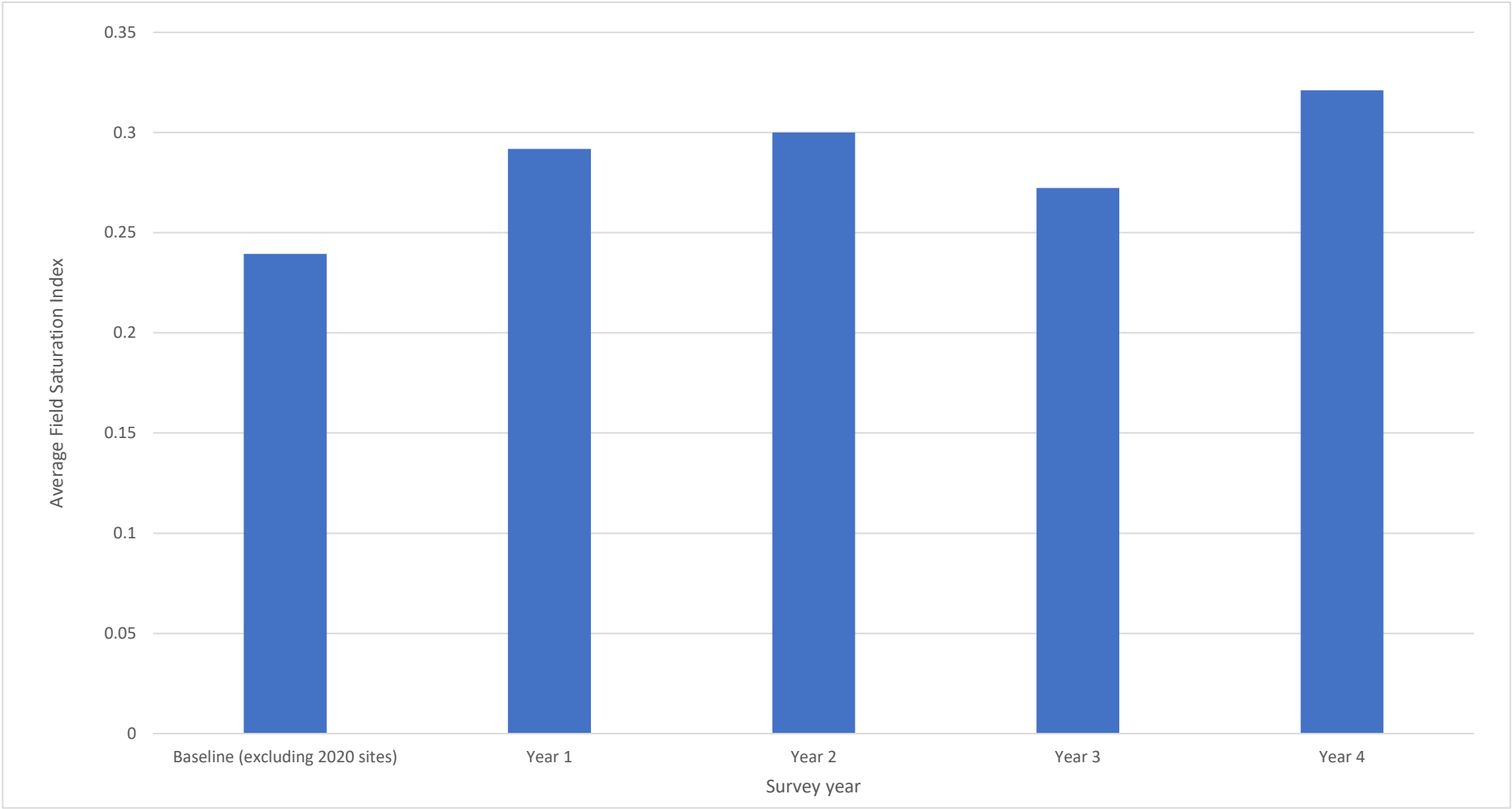
Graph 8: Average number of number of species per stop for all sites in baseline surveys and subsequent annual surveys



Graph 9: Field Saturation Index at creation sites from 2016-2020 (excluding baseline information from 2020 sites)



Graph 10: Average Saturation Index value for all sites from baseline surveys and subsequent annual surveys



In 2020 all sites (except two, Culvercroft and Chapel Farm – Field 1) were found to have Field Saturation Index values that were larger than they were during baseline surveys of the same site. This shows that the fields are showing greater affinities to Culm grassland communities.

Graph 10, which summarises the average Saturation Index values for all sites in each year following restoration shows a steady increase each year following restoration works.

Botanical monitoring results and assessment – Level 2 sites

The additional data gathered at Level 2 sites allow other means of analysis.

National Vegetation Classification (NVC)

The National Vegetation Classification (NVC) can be used as a tool to monitor changes in the overall plant communities present at creation sites. Using computer software (MAVIS) we can compare the NVC communities that are most closely represented by the grassland sward present at each site. The co-efficient values provided by this software show how closely the vegetation on site matches particular NVC communities. The larger the co-efficient value the closer the match. The most similar top ten NVC communities are listed

To date five sites have been surveyed using the Level 2 methodology for two or more consecutive years, namely Upcott Grange, Brockscombe, Palmers Ash, Haddacott and Hollocombe. The NVC data and analysis for these sites is presented below

Upcott Grange:

Table 4: NVC data results for Upcott Grange (2016-20120)

Top ten NVC co-efficients	Year of Survey									
	2016		2017		2018		2019		2020	
	NVC community	Co-efficient	NVC community	Co-efficient	NVC community	Co-efficient	NVC community	Co-efficient	NVC community	Co-efficient
1	MG10a	69.35	MG6a	57.5	MG10a	61.59	MG6a	63.41	MG8d	71.65
2	MG10	65.00	MG6b	55.65	MG6a	59.72	MG6b	62.02	MG6d	69.51
3	MG10b	62.19	MG6	55.09	MG6b	57	MG6	60.71	MG8v2	67.89
4	MG6a	60.75	MG10	54.35	MG6	56.09	MG8	59.87	MG4b	64.37
5	MG11a	55.45	MG10a	53.84	MG10	56.06	MG10	59.21	MG4v2	63.24
6	MG6	54.75	MG8	52.86	M23a	55.49	MG10a	56.6	MG8b	63.2
7	MG7	53.55	MG10c	48.16	MG8	54.23	MG9a	53.2	MG15	6243
8	MG10c	53.14	MG9a	47.92	M23	53.58	MG10b	53.18	MG6b	61.97
9	MG9a	52.83	MG10b	47.53	MG7C	53.1	MG7c	52.4	MG6a	61.82
10	MG7d	51.69	MG7	47.09	MG9a	52.6	MG7	50.99	MG15b	61.68

Colour code key:

NVC communities	Community summary
M23 communities	Purple moor-grass and rush pasture (Culm) NVC communities
MG9, MG10, MG11 & MG15 communities	Wet semi-improved grassland NVC communities
MG6 communities	Dry semi-improved grassland NVC communities
MG7 communities	Improved grassland NVC communities
MG8 & MG4 communities	Other Priority Habitat NVC communities (wet communities)

Without going into too much depth it is possible to see that the grassland at Upcott Grange was largely represented by NVC communities typical of improved and semi-improved grasslands in 2016. In 2017 this was still the case yet there was a shift from wetter communities towards drier communities. This is most likely a result of the soft rush management that took place. In addition MG8 (a wet species-rich grassland community) came up in the top ten in 2017. Although this community is rare in Devon and unlikely to be found (being more common place on the Somerset Levels) it does demonstrate that the community has become more species-rich. In 2018 the grassland showed most affinity towards semi-improved grassland communities but for the first time it is shown to have close similarities to M23 and M23a (Culm grassland rush pasture communities). In 2019 the vast majority of the 'top ten' spots were semi-improved wet and dry grassland communities. The top 3 were MG6 communities, dry semi-improved grassland types. MG8, was fourth on the list, three positions higher than in 2018. Wetter semi-improved grassland communities also feature. M23 did not feature in the top ten, and was thought likely due to the inability to access three of the quadrats which fall within the wetter parts of the site that year. However, in 2020 those three quadrats were accessed and still M23 does not fall within the top ten NVC co-efficients. In 2020 MG4 and MG8 hold five of the top six co-efficient places. MG4, like M8, is a species-rich plant community that is not typical of Devon. MG4 is a floodplain meadow community with marsh foxtail and greater burnet, both of which were recorded at Upcott Grange in 2020.

It is imagined that rush growth at this site, something which is fairly inevitable given the nature of the soil and the climate, would change these co-efficients significantly and the vegetation would start to show affinities towards rush pasture communities (specifically M23). Rush growth (particularly soft rush) is probably supressed currently by the annual hay cuts. Moving to cattle grazing would probably change this and rushes would start to grow again.

Overall the general shift from close affinities to improved and semi-improved grassland communities in 2016 to close affinities to species-rich wet grassland communities in 2020 is a great success, even if those species-rich wet grassland communities are not Culm grassland communities.

Brockscombe:

Table 5: NVC data results for Brockscombe (2017-2020)

Top ten NVC co-efficients	Year of Survey			
	2017	**2018**	**2019**	**2020**

	NVC community	Co-efficient	NVC community	Co-efficient	NVC community	Co-efficient	NVC community	Co-efficient
1	MG10a	66.5	M23	62.28	MG10a	64.86	MG8v2	66.08
2	MG10	64.61	MG10a	61.58	MG10	63.23	MG8d	64.38
3	MG9	58.21	MG10	60.73	MG9a	58.29	MG6d	64.31
4	MG9a	57.33	M23b	60.64	MG9	57.49	MG8b	63.3
5	M23	56.54	M23a	58.69	M23	56.53	MG10a	63.27
6	M23b	55	MG9	57.18	M23b	56.02	MG10	62.35
7	M23a	52.7	MG9a	54.88	MG10c	54.42	MG9a	59.77
8	MG10c	52.56	MG10c	52.29	M23a	52.58	MG14b	58.79
9	M27c	50.82	M27c	51.42	MG6a	51.28	M23	58.79
10	MG9b	50.58	MG8	49.05	MG10b	51.03	MG8	58.38

Colour code key:

NVC communities	Community summary
M23 & M27	Purple moor-grass and rush pasture (Culm) NVC communities
MG9, MG10 & MG14	Wet semi-improved grassland NVC communities
MG8	Other wet Priority Habitat NVC communities
MG6	Dry semi-improved grassland NVC community

The grassland at Brockscombe was largely represented by NVC communities typical of semi-improved wet grasslands in 2017 prior to restoration. In 2018 This was still the case to a degree but Culm grassland communities M23 (a species-rich rush pasture community) features higher up the ranking. In addition to this MG8 (a wet species-rich grassland community) fell within the top ten. In 2019 the picture was similar but for some reason the semi-improved wet grassland communities were more fitting than the Culm grassland communities, possibly as many of the Culm plant seedlings seen in 2018 were not seen again in 2019. There were still affinities with Culm communities though. In 2020 Three of the top four co-efficients were for MG8, and M23 falls in at position number nine. Despite a Culm grassland NVC community (M23) only being positioned 9th it is good that the grassland sward has affinities to a species-rich wet grassland community (MG8).

Palmers Ash:

Table 6: NVC data results for Palmers Ash (2018-2019)

Top ten NVC co-efficients	**Year of Survey**					
	2018		**2019**		**2020**	
	NVC community	**Co-efficient**	**NVC community**	**Co-efficient**	**NVC community**	**Co-efficient**
1	MG10a	61.74	MG6a	63.27	MG15	63.35
2	MG6a	58.28	MG6b	59.16	MG15b	62.09
3	MG10	56.15	MG6	59.16	MG6a	61.7
4	MG11a	55.36	MG10a	59.05	MG4c	61.52
5	MG6	53.93	MG10	57.38	MG8d	61.09

6	MG10b	52.29	MG8	53.15	MG10a	60.21
7	MG6b	51.7	MG7	51.83	MG6d	59.65
8	MG7	49.36	MG10b	51.64	MG8v2	59.27
9	MG9a	48.23	MG11a	50.82	MG10	57.27
10	MG8	48.13	MG7b	50.75	MG15a	57.26

Colour code key:

NVC communities	Community summary
MG9, MG10, MG11 & MG15	Wet semi-improved grassland NVC communities
MG6	Dry semi-improved grassland NVC communities
MG7	Improved grassland NVC communities
MG8 & MG4	Other Priority Habitat NVC communities - wet

In 2018 the grassland at Palmers Ash, prior to restoration works, was most closely represented by wet and dry semi-improved grassland NVC communities. In 2019 this was still largely the case but interestingly MG8 scored fairly highly at the sixth spot, four places higher than in 2018. There was also a bit of a shift from wet semi-improved to dry semi-improved grassland communities at the top of the list which was likely to be due to the weed wiping of the rushes on site.

In 2020, again most of the top ten co-efficients are for wet and dry semi-improved grassland communities, though three of the top ten values are for species-rich wet grassland communities (MG4 & MG8). Also, MG7, an improved grassland community, does not feature within the top ten values in 2020.

Haddacott:

Table 7: NVC data results for Haddacott (2018-2019)

Top ten NVC co-efficients	Year of Survey					
	2018		2019		2020	
	NVC community	Co-efficient	NVC community	Co-efficient	NVC community	Co-efficient
1	MG10a	61.59	MG6b	63.83	MG6d	69.53
2	MG6a	59.72	MG6a	63.22	MG8v2	69.22
3	MG6b	57	MG8	61.36	MG4c	67.44
4	MG6	56.09	MG6	61.09	MG8d	67.33
5	MG10	56.06	MG5a	55.42	MG8b	65.05
6	M23a	55.49	MG9a	54.9	MG4v2	64.11
7	MG8	54.23	MG9	54.14	MG6b	62.7
8	M23	53.58	MG7c	52.81	MG8a	62.47
9	MG7C	53.1	MG3a	52.77	MG4b	62.28
10	MG9a	52.6	MG5a	52.74	MG15b	62.11

Colour code key:

NVC communities	Community summary
M23	Purple moor-grass and rush pasture (Culm) NVC communities
MG9, MG10 & MG15	Wet semi-improved grassland NVC communities
MG6	Dry semi-improved grassland NVC communities
MG7c	Improved grassland NVC communities
MG8 & MG4	Other Priority Habitat NVC communities - wet
MG3 & MG5	Other Priority Habitat NVC communities - dry

The grassland at Haddacott Moor, prior to restoration works in 2018, was most closely represented by wet and dry semi-improved grassland NVC communities (MG6 and MG10). The presence of M23 and M23a (Culm grassland rush pasture communities) within the 'top ten' was a good sign. In 2019 this shifted a little in that the grassland had most affinities with dry semi-improved grassland (MG6) and other Priority Habitat species-rich grasslands, both wet (MG8) and dry (MG5 and MG3). In 2020 seven of the top ten co-efficients are for wet species-rich grassland communities (MG8 and MG4). The top co-efficient is for MG6, a dry semi-improved grassland community.

Although no Culm grassland communities were present within the top ten NVC co-efficients in 2020 it is very positive to see that other species-rich grassland communities feature heavily and this does demonstrate an increase in ecological value of the site.

Rushes and purple moor-grass are characteristic species of Culm grasslands and an increase in these species would result in very different NVC community co-efficients. Due to the soil and climate of northern Devon it is likely that rushes, at the very least, will grow at the site again. The weed wiping carried out in 2018 to aid harrowing for restoration has reduced the amount of rushes present and will have had its own effect on the NVC results.

Ellenberg Values

All plants thrive in a different set of conditions, those that are typical of Culm grassland thrive in wet, unfertile, unshaded and slightly acidic conditions. All plant species native to the UK have been assigned indicator values (Ellenberg values) for a range of abiotic factors (physical conditions). Each factor has a range from 1-9 or 1-12. The factors that we will look at are:

- Light (where 1=deep shade, 5=semi-shade, 9=full light)
- Wetness (where 1=strong soil dryness, 5=moist, 9=wet, 10=aquatic, 12=underwater)
- pH (where 1=extremely acidic, 5=mildly acidic, 9=alkaline)
- Fertility (nitrogen) (where 1=very low fertility, 5=moderate fertility, 9=excessive fertility)

All species recorded during the annual surveys have Ellenberg values which can then provide an average Ellenberg value for each factor for each site. The five sites have been surveyed in detail on more than one occasion ae summarised in Table 8.

Table 8: Average Ellenberg Values for Level 2 sites surveyed more than once

Site	Year	Average Ellenberg Values			
		Light	Wetness	pH	Fertility
Upcott Grange	2016	7.43	5.65	5.82	5.35
	2017	7.10	5.79	5.94	4.94
	2018	7.12	6.24	5.56	4.55
	2019	7.08	5.58	5.95	4.73
	2020	7.04	5.80	7.97	4.73
Brockscombe	2017	6.75	5.80	5.32	4.91
	2018	4.45	4.04	3.75	3.42
	2019	6.78	6.17	5.62	5.18
	2020	6.64	5.94	5.00	4.60
Palmers Ash	2018	7.54	7.32	5.87	5.24
	2019	7.13	5.78	6.12	5.21
	2020	7.13	5.97	6.26	5.32
Haddacott	2018	6.89	6.24	5.56	4.55
	2019	6.89	5.94	5.71	4.86
	2020	6.90	6.01	5.80	4.91

In general, Ellenberg values suggest that the site at Upcott Grange has become:

1) Slightly shadier (probably as the grassland was tightly grazed by sheep in 2016)
2) Slightly wetter
3) The acidity is gently fluctuating but not showing any significant trends (2016-2019), but increasing significantly suggesting an increase in alkalinity (not sure why this value has changed in this way)
4) Less fertile (this should happen naturally over time as the field isn't being fertilised any more but the plants that we introduced to the site are typical of low nutrient environments are will bring this score down by being present)

Collapsing drains using a swing shovel should be making Upcott Grange wetter, though 2018, 2019 and 2020 had hot dry spring and early summers which may have reduced the effect of these actions.

In general between 2017 and 2020, Ellenberg values suggest that Brockscombe stayed fairly consistent when it comes to the amount of light that the plants present were exposed to. The wetness values suggest that the site fluctuated slightly being wetter in 2018 and 2019 than in 2017 and 2020. The pH values stayed fairly consistent and the fertility values have decreased slightly.

Between 2018 and 2020 Ellenberg values suggest that Palmers Ash has become:

- Slightly shadier
- Drier (this is probably due to the weed wiping of the rushes. Rushes were recorded in 2018 and as they are wet-loving plants will have brought this score up a bit. Rushes were largely absent in 2019 and 2020)
- More alkaline
- Very slightly more fertile

Between 2018 and 2020 the Ellenberg values suggest that Hadacott has become:

- Drier (this is probably also due to the weed wiping of the rushes)
- Very slightly more alkaline
- Very slightly more fertile (the reason for this result is unknown, but it is very slight)

As we have 'artificially' introduced new plant species to all sites it is expected that average Ellenberg values would change. As such those changes highlighted above do not suggest changes in the physical conditions at each of the sites. This effect should however wear off in time as only species that are supported by the conditions at the site will survive for the longer term. Only species growing on site can influence the overall Ellenberg value for the site.

Purple moor-grass

Most of the plant communities that fall under the Culm grassland habitat type are characterised by the abundance of rushes (particularly sharp-flowered rush and jointed rush) and / or purple moor-grass. The success of restoration to species-rich wet grassland in northern Devon is therefore dependent to some degree upon the germination of these species at receptor sites.

Purple moor-grass is the only truly deciduous grass in the UK and all leaves die back annually in winter. Grasslands dominated by purple moor-grass tend to have a thick humic layer. A PhD that is currently underway may shed some light as to whether the presence of this organic humic layer affects water flow and water retention in purple moor-grass dominated Culm sites.

Purple moor-grass has been shown to successfully germinate on recently ploughed land within a damp semi-improved sward at Headon Trial Plots, near Dunsdon National Nature Reserve (this research has been undertaken by DWT). Most restoration sites in northern Devon are prepared prior to over sowing / green haying through harrowing which results in less bare ground than ploughing.

The land at Headon Trial Plots was ploughed and harrowed to a fine tilth in the autumn of 2015. Prior to works the field supported semi-improved grassland which had experienced quite a lot of sheep grazing. The southern half of the plot was sown in autumn 2015 with a purple moor-grass dominated seed mix collected from DWT's Ashmoor (boardwalk field). The plots were sown (in total) with 11kg of seed. The northern half of the plot was sown in spring 2016. Both the autumn sown and spring

sown areas were split into four sub-plots and four different treatments were applied (giving eight different treatments in all):

- Seeds raked in
- Seeds raked in and covered in fleece
- Seeds left on surface of soil
- Seeds left on surface of soil and covered in fleece

All fleece material was removed in May 2016. Each autumn half of the trial plot is cut and the material removed. This is done so that each sub-plot has had half of the sward left unmanaged (since 2015) and half has experienced an annual 'hay cut'.

A survey was carried out at Headon Trial Plots in 2020 and found that this site supports a sward which is the closest to Culm grassland vegetation that has been created through over sowing / green haying to date by DWT. Purple moor-grass was recorded at 7 or the ten stops during the survey. Ten PMGRP positive indicator species were recorded along with an average herb cover of 60.5%. The positive indicator species were found to be well established. Five of the PMGRP indicators were frequent and two were occasional.

The results gathered to date shows that purple moor-grass seedlings have been recorded at restoration sites following works (see Table 3, below). Grass seedlings are particularly tricky to find, particularly if present within a grassland sward. There is a high chance that this species (and other grasses introduced to sites) have been under recorded. The true success of purple moor-grass establishment will only be known once a number of years following restoration works, when purple moor-grass becomes more notable, being larger and starting to flower (though this will be easier to see if the plants are not cut for hay). The number of germinating seeds that do not successfully survive long enough to reach this stage, however, will remain largely unknown.

Table 3: Purple moor-grass germination at restoration sites surveyed to date

Site	**Year of restoration works**	**Year**				**Notes**
		2017	2018	2019	2020	
Upcott Grange	2016	Seedlings seen (0/30 quadrats)	Not seen	Not seen	Adult plants seen (1/30 quadrats)	In 2017 seedlings were seen on site with a rare distribution. They were not however present at any of the 30 fixed quadrat locations. Adult plants were seen within one quadrat in 2020
Higher Grinacombe	2016	Not seen	Not seen	Not seen	Not seen	
Downacarey Bridge	2016	Not seen	Not seen	Not seen	Not seen	
Higher Goodacre	2017	N/A	Seedlings seen (2/10 stops)	Not seen	Not seen	In 2018 seedlings were seen and were found at two out of the ten stops (level 1 survey)
Gortleigh	2017	N/A	Not seen	Not seen	Not seen	

East Cranbury Field 1	2017	N/A	Seedlings seen (3/10 stops)	Not seen	Not seen	In 2018 seedlings were seen and were found at three out of the ten stops (level 1 survey)
East Cranbury Field 2	2017	N/A	Not seen	Not seen	Not seen	
East Cranbury Field 3	2017	N/A	Not seen	Not seen	Not seen	
Brockscombe	2017	N/A	Seedlings seen (0/30 quadrats)	Not seen	Adult plants seen (1/30 quadrats)	In 2018 seedlings were seen on site with a rare distribution. They were not however present at any of the 30 fixed quadrat locations. Adult plants were seen within one quadrat in 2020
East Lutworthy	2018	N/A	N/A	Not seen	Not seen	
Little Park	2018	N/A	N/A	Not seen	Not seen	
Mill Barton Field 1	2018	N/A	N/A	Not seen	Not seen	
Mill Barton Field 2	2018	N/A	N/A	Not seen	Not seen	
West Backstone	2018	N/A	N/A	Not seen	Not seen	
Poole Batten	2018	N/A	N/A	Not seen	Not seen	
Mudhouse	2018	N/A	N/A	Seedlings seen (3/10 stops)	Not seen	In 2019 seedlings were seen and were found at three out of the ten stops (level 1 survey)
Hatherleigh Moor	2018	N/A	N/A	Not seen	Not seen	
Palmers Ash	2018	N/A	N/A	Not seen	Not seen	
Haddacott	2018	N/A	N/A	Not seen	Not seen	
Headon	2018	N/A	N/A	Seedlings seen (3/10 stops)	Not seen	In 2019 seedlings were seen and were found at three out of the ten stops (level 1 survey)
Kerswell Farm	2019	N/A	N/A	N/A	Not seen	
Culvercroft	2019	N/A	N/A	N/A	Not seen	
Westhay	2019	N/A	N/A	N/A	Not seen	
Chapel Fm Field 1	2019	N/A	N/A	N/A	Not seen	
Chapel Fm Field 2	2019	N/A	N/A	N/A	Not seen	
Ashridge Field 1	2019	N/A	N/A	N/A	Not seen	
Ashridge Field 2	2019	N/A	N/A	N/A	Not seen	
Ashridge Field 3	2019	N/A	N/A	N/A	Not seen	
Upcott Grange Pond Field	2019	N/A	N/A	N/A	Not seen	

Hollocombe	2019	N/A	N/A	N/A	Not seen	

To date purple moor-grass seedlings have been seen at six of the 30 fields that restoration works have been carried out upon. It was found as an adult plant at two sites (Upcott Grange and Brocksombe) within fixed quadrats in 2020. These particular plants have therefore been missed during previous surveys, suggesting that this species is likely to have been missed at other sites.

In some instances purple moor-grass seed distribution has been focused upon wetter parts of the site. Saturated ground may promote seed rotting and as such this may have affected subsequent seed germination. The ground at Headon Trial Plots does not get that wet during the winter and has not been seen to hold standing water. As germination and growth of purple moor-grass has been so successful here replicating the conditions at other sites might be worth considering.

Ground preparation techniques and germination

An MSc research project was set up during the autumn of 2017. A randomised plot design was established to determine the effect of ground preparation on Culm seedling germination. Six plots of each of the six following treatments were established:

- Harrow & over sown with seeds
- Plough & over sown with seeds
- Grass left undisturbed & over sown with seeds
- Harrow, no seeds
- Plough, no seeds
- Grass left undisturbed, no seeds

During the summer of 2018 seedlings present within five quadrats at each of the 36 plots were identified and counted. Surprisingly, germination of purple moor-grass tended to be successful within the grassy plots, i.e. those that had not been ploughed or harrowed. Purple moor-grass seedlings were far stockier and substantial when growing in open locations in comparison to those sheltered with a grassland sward. The MSc thesis is available to read for more details.

Conservation of creation sites

As the Level 1 methodology is based upon the Natural England classification system used for agri-environment schemes (to date) it is possible to state that sites that reach and maintain ‘species-rich – good quality’ status should be eligible for inclusion within the GS6 Species-rich Grassland option in Countryside Stewardship Mid Tier. It is thought that maintenance of this status for three years or more would suggest that the community is stable.

The County Wildlife Site (CWS) guidelines for Devon do not mention grassland creation through green haying or over sowing. For a grassland to meet the CWS guidelines it is needed to support 0.5ha or more of a species-rich NVC community that falls within a Priority Habitat, which in this instance would most likely be the dry species-rich community MG5 and the wetter Culm grassland communities M23, M24 and M25. To date the vegetation is only deemed likely to be good enough at Headon DWT Reserve, but the grassland here is far less than 0.5ha in size. Some of the sites are worth considering against the CWS guidelines in the next three to five years including Downacarey and East Lutworthy.

General findings and anecdotal comments

Species-richness: In 2020 12 of the 30 sites surveyed were found to be 'species-rich' (two of the three 2016 sites, 3 of the six 2017 sites, three of the 11 2018 sites and four of the ten 2019 sites. This suggests that overall the development of the sward to 'species-rich' occurs over time following over sowing / green haying.

Several sites (such as Higher Goodacre and Brockscombe (both 2017 sites)) were thought to have nutrient poor soils. Brockscombe was a Culm County Wildlife Site that had been used to keep horses overwinter for several years and the sward at Higher Goodacre (prior to creation works) was herb-rich with lots of greater bird's-foot trefoil. Both sites have largely retained their semi-improved status and although are both close to being classified as 'species-rich' they were classified as 'semi-improved' in 2020. These sites are both very wet and standing water is present during the winter months. Although Culm is a wet habitat it is unknown if Culm plant seeds retain their viability following prolonged waterlogged periods.

Where sites are borderline between 'semi-improved' and 'species-rich' they seem to fluctuate between both classifications, for example Upcott Grange.

An abundance of yellow-rattle can very often be the main reason as to why a site is classified as 'species-rich' as it enhances the herb cover of the sward (such as East Cranbury). Although this may allow the sward to meet the criteria used within the NIA monitoring methodology it is a fairly 'quick and dirty' means of creating 'species-rich' grassland, particularly if the number of Culm grassland positive indicators are low in number and frequency.

Soil: Soil hydrology and nutrient-richness are considered to be significant variables when it comes to the success of species-rich grassland creation. Some of the creation sites have been fairly nutrient-rich having been classified as 'improved grassland' in the baseline survey. Soil samples have not been taken at sites but assumptions were made about the soil by assessing vegetation composition.

Generally speaking the sites that were more improved to start with are those that are slightly drier and these tend to develop into grasslands dominated by yellow rattle with a few other positive indicators. If the grassland becomes species-rich it 'does not have a 'natural' look and it is considered likely that loss of yellow rattle would revert the grassland back to an 'improved' or 'semi-improved – species-poor' sward.

The sites that are wetter and less nutrient-rich to start with vary, some with a better starting point with relatively good abundance of greater bird's-foot trefoil (e.g. Higher Goodacre and Kerswell Farm), or a variety of positive indicators but at a low abundance (e.g. Haddacott). Some of the wetter grasslands are less diverse with a low abundance of a small number of positive indicators. In general, the sites that are more diverse to start with are more successful when it comes to developing into a 'species-rich' sward.

Weather: 2017, 2018, 2019 and 2020 suffered fairly extreme weather conditions with 2017 having a particularly wet summer, autumn and winter and 2018 having a particularly cold late winter / early spring and a very hot and dry spring and summer. This was followed by a relatively dry 2018/19 winter and a hot and dry spring and early summer in 2019. The winter of 2019 / 2020 was wet and the spring and early summer of 2020 was dry and hot. These conditions are likely to have affected seed longevity, seed germination and development from seedling to adult plant. Weather is considered to be a notable variable, particularly in the first year following over sowing / green haying.

Management: One of the most significant variables when it comes to the species-rich grassland success. It has been noted that grazing tightly with sheep the first winter following over sowing / green haying is particularly significant. The short sward maintained until spring provides seedlings a less competitive environment to establish in. If left unmanaged the seeds are less likely to germinate and those that do are more likely to be outcompeted.

Subsequent management is also important, specifically the annual hay cuts. Higher Grinacombe was left unmanaged in 2019 and in 2020 the site reverted to 'semi-improved' status having been 'species-rich the two subsequent year. This was largely due to reduction in yellow rattle which reduced the average herb cover significantly.

Locating fixed quadrats: Unfortunately, the very accurate Trimble GPS data that was collected at Brockscombe and Upcott Grange in 2017 was not available in 2018. As such not all fixed quadrat markers could be located. 14 of the 20 markers could not be found at Brockscombe and 10 out of 30 markers could not be found at Upcott Grange. Data was collected from a point as close to the original location as possible using a handheld GPS unit.

In 2019 the Trimble was not working very accurately which made marker finding quite hard, particularly where the grass sward was grassy and dense. Ten of the 30 quadrat markers were found at Upcott Grange (and access couldn't be made to a part of the site meaning that no data at all was gathered for three quadrats), six of the 20 quadrat markers were found at Brockscombe, 18 out of 30 at Haddacott and five out of 30 at Palmers Ash.

In 2020 a different metal detector was used which made finding the metal markers a lot easier. As such most of the markers were found.

Vegetation composition and species: Anecdotal comments have been made by Working Wetlands staff and others suggesting that grassland sward composition goes through a period of flux following application of green hay / seeds. For example the addition of yellow-rattle initially prompts an abundance of ribwort plantain. The sward often tends to 'settle down' after a period of several years and this can be encouraged through particular management practices. For example bringing the field back into a grazing regime whereby the abundance of yellow rattle is likely to reduce. During the NIA surveys it has been noticed that ribwort plantain grows densely with yellow rattle. Perennial rye-grass cover also reduces significantly when yellow rattle abundance is high.

Yellow rattle is a species typical of dry Lowland Meadow communities and is not often found in Culm grassland, other than the drier fringes when it grades into drier species-rich grassland. Once established this species increases the herb cover value of the field significantly and is often the main reason as to why it reaches 'species-rich' status. This is the case at the fields at East Cranbury. This hemi-parasitic species has been used as a tool at a number of the creation sites to reduce grass vigour. It is particularly useful at sites where nutrient levels are moderate though it has been advised that this species is not included within the seed mix at sites where nutrient levels are already particularly low, such as Ford Farm.

Greater bird's-foot trefoil is the Culm grassland positive indicator that seems to be found with the greatest abundance at creation sites. Common marsh bedstraw, lesser spearwort, whorled caraway and great burnet also seem to germinate successfully too but tend to be found at lower frequencies (probably as a result of being at a lower abundance within the seed mix). Small numbers of devil's-bit scabious, betony, lousewort, bugle and common valerian have also been found in small numbers occasionally. Meadowsweet and wild angelica have been found to germinate well at some sites though the seedlings don't tend to mature successfully as the number of plants seen reduces the following year.

Very few sedges have been recorded at creation sites (except oval sedge which is found frequently within baseline (and subsequent) surveys). Sedges are characteristic of nutrient poor soils and it is likely that the creation sites in general are too nutrient-rich. Sedges have been seen where clay has been exposed, for example at Upcott grange where the drains were disrupted using a swing shovel.

Common knapweed germinates well at sites where it has been sown, usually taking two or three years to flower. Greater bird's-foot trefoil and whorled caraway also seem to germinate and mature successfully.

At a number of sites white clover cover increases after over sowing / green haying. The reason for this in unknown but could be due to harrowing creating suitable germination conditions for seeds within the seed bank.

Harrowing appears to reduce the frequency and cover of sharp-flowered rush. This species is a key constant in Culm grassland communities and as such not harrowing areas with dense patches of this species is recommended.

Annual hay cutting reduces the vigour of soft rush (and possibly sharp-flowered rush). Although rushes are not often favoured by farmers they do often comprise a major element within Culm communities. They also provide good structural diversity. Encouraging the restoration sites to be brought back into cattle grazing once the fields have established (a few years after over sowing / green haying) is recommended. Grazing should be carried out later in the summer to start with to allow the annuals present to set seed.

Many of the sites are weed-wiped prior to harrowing to remove reduce the dominance of soft rush, this significantly changes the composition of the grassland and reduces the structural diversity of the sward. Some plants seem to benefit from the structural support and shelter provided by soft rush (such as common marsh bedstraw and greater bird's-foot trefoil). Leaving sites with untreated rush may allow the development of a more 'natural' Culm community more quickly.

Purple moor-grass germination: Purple moor-grass seedlings have been recorded at a number of creation sites. They are more difficult to identify in year 2 when they are larger and resemble much of the grassland sward. As predicted previously adult plants were found in 2020 at Upcott Grange and Brockscombe. It is likely that this species has been missed and that more specimens will be readily seen when the plants mature, particularly if the sites start to become cattle grazed as the tussocks should start to form then, making the species more noticeable.

Sharp-flowered rush and jointed rush: Sharp-flowered and jointed rush are both positive indicators and a major component of Culm grassland. There are anecdotal suggestions that sharp-flowered rush increases in cover under an annual hay cutting regime (possibly due to a reduction in soft rush under these conditions), though no evidence has been gathered during the project to suggest that this is the case. Sharp-flowered rush and jointed rush are sometimes negatively affected by weed wiping as they often grows within and amongst dense areas of soft rush. These species were not noted as seedlings during any of the monitoring surveys and the abundance and cover of these species was not noted to have increased significantly at any of the sites.

Dominant creeping buttercup: The sward at Gortleigh was found to be heavily dominated by creeping buttercup in year 1. This was initially thought to be problematic, however under close inspection a significant number of positive indicator seedlings were found growing under the creeping buttercup 'canopy'. It would appear that creeping buttercup provided enough shelter to prevent the seedlings from desiccation during the hot spring and summer of 2018 but not so much shade and competition so that the seedlings could not grow. It is unknown if this would still be the effect in less extreme climatic conditions.

Soil stripping: One site (Little Park) was soil stripped and the soil removed from the field was used to create new hedgebanks. Little Park is considered likely to be one of the most successful sites in the long term. Seven Culm grassland positive indicators and five Lowland Meadow positive indicators were found here in 2020. This is one of three sites that has been recorded as being of 'species-rich – good quality' for two consecutive years. Soil stripping is cost and labour intensive, but creates suitable conditions for Culm grassland plants to germinate and mature.

Ploughing: The vegetation present at Headon DWT Reserve, at a plot ploughed in 2015 and sown densely with purple moor-grass seeds has developed into grassland that is considered likely to have close affinities with NVC community M24 (the most diverse of the Culm grassland communities). Ploughing and creating a seedbed with a fine tilth has been demonstrated here to promote the growth of a Culm grassland community on a site previously supporting semi-improved grassland.

Recommendations

Creation methodology

Although the success of the creation of a 'species-rich' sward depends upon a number of variables the technique used during the creation process has a significant affect.

The ploughed and harrowed test plots at Headon DWT Reserve were very successful indicating that this methodology should be experimented with further. It is recommended that a number of small plots (20m x 3m) are ploughed and harrowed within a field which is harrowed everywhere else. The ploughed plots should be sown thickly with purple moor-grass dominated seed, at the rate sown at Headon DWT Reserve.

Purple moor-grass tussocks can be split into numerous plants that could be used to plug plant sites. This work should be focused within the wetter pockets of fields already worked on. Keeping record of the number of plugs sown would be useful to determine failure rate.

Sharp-flowered rush is a major constituent of Culm grassland and although Kew found that seeds collected from North Devon had a high germination rate this was in artificial conditions. Trying the germinate this species in seed trays would help further understanding of this species and therefore how to successfully introduce it to sites.

Weed wiping can be useful when sites are dominated by thick soft rush tussocks, but wiping it can completely change the nature of a field. Rushes are a significant feature of wet grasslands in Northern Devon and provide good structure. It is recommended that weed wiping is only carried out where absolutely needed and even when a field has dense rush growth leaving parts of the field untreated would be beneficial. Although removing rushes from fields can help get farmers and land managers onboard with DWT's involvement it does effect expectations of what the

field is 'supposed' to look like and may encourage farmers to maintain a rush free sward.

Oxeye daisy seed was bought in and sown on a number of sites to increase colour and diversity. This species is not typical of Culm grasslands or the dry acid grasslands of Northern Devon. As such it is recommended that this species is not included within further creation works.

Yellow rattle can be a very useful tool as it reduces grass vigour. Despite this it is not a typical species of Culm grassland and as such it is recommend that it isn't included within the seed mix used at very wet sites that already show some characteristics of Culm grassland.

It is recommended that additional works are carried out to change the hydrology of creation sites more significantly. Further blocking of drains and ditches would change the hydrology of the site but might also promote the development of communities typical of the wetter Culm grassland communities.

Vegetation monitoring

It is recommended that sites over sown and green hayed between 2016-2020 are continued to be monitored as the information helps to feedback and enhance the creation methodology and also allows swards to be classified, which allows comparison between sites and determination of success, particularly when it comes to species-richness. Results are also informative to landowners and managers.

Both Level 1 and Level 2 monitoring methodologies were fit for purpose, though finding markers as a part of the Level 2 methodology can be difficult and success is dependent upon the equipment available.

All sites have been surveyed annually and this has provided useful information on patterns of change over the first few years following creation works. The future value of continuing to survey annually at each site is considered to be limited however and as such it is recommended that sites are resurveyed between every three and five years. To allow comparison of data it is recommended that the same methodologies already carried out are continued at these sites. It might be necessary that a site is surveyed within the proposed 3-5 year time frame, for example to determine suitable agri-environment scheme options.

Unless significant additional works are being carried out at a particular site it is recommended that future creation sites are only monitored through the Level 1 methodology, due to ease and speed.

Additional monitoring

To date creation site monitoring has focused on the vegetation present. Many of these sites are becoming significantly more herb-rich and there has been a notable

increase in invertebrate diversity and abundance at many sites. It is recommended that invertebrate monitoring at creation sites is considered in the future.

More detailed hydrological monitoring should be carried out, specifically if the hydrology of the site is directly affected through drain / ditch blocking.

Soil nutrient tests were not carried out as phosphorous tests tend not to be very accurate and this is the element that is most critical in a clay soil. Soil testing should be considered on a case by case bases, depending on the location of the site.

Further research

- The affect of mycorrhizal fungi on seed germination and subsequent plant growth in Culm grassland plants
- Determining if yellow rattle significantly parasitises purple moor-grass
- Does swaling affect the viability of purple moor-grass seeds
- Is it possible to germinate sharp-flowered rush ex-situ

For detailed information on all surveys and sites refer to individual site surveys and summary reports.

Appendix 1

Culm grassland positive indicator species:

Bitter vetch
Bog asphodel
Bog-mosses
Bog pimpernel
Bugle
Common skullcap
Common valerian
Cross leaved heath
Devil's-bit scabious
Greater burnet
Greater bird's-foot-trefoil
Hemp agrimony
Jointed rush
Lesser skullcap
Lesser spearwort
Lesser water-parsnip
Lousewort
Marsh/fen bedstraw
Marsh cinquefoil
Marsh marigold
Marsh pennywort
Marsh valerian
Marsh violet
Meadow thistle
Meadowsweet
Orchids
Purple moor-grass
Ragged robin
Rough hawkbit
Saw-wort
Sharp-flowered rush
Sneezewort
Sedges (Small - other)
Sedges (Small blue/green)
Tormentil
Water avens
Water mint
Whorled caraway
Wild angelica