HABITAT SURVEY REPORT: TROOPER'S HILL LNR

July 2023

ABSTRACT

An NVC survey was carried out on dwarf shrub heath on the North-South facing slopes of the gully (compartment 13, Troopers Hill Management Plan), followed by a principal component analysis. Dominant vegetation types are determined and associations of plant species with each other and with topographical features are identified, providing a basis for future analysis and monitoring of this exceptionally varied portion of the reserve.

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Introduction

Covering just 8.4ha, Troopers' Hill Local Nature Reserve supports the only significant area of Lowland Heathland, a UK priority habitat, in the Bristol area (FOTH, 2020). Isolation of habitat has cause serious declines for many UK wildlife groups (Maclean, 2010). The reserve's management plan (*ibid.*) divides it into 17 compartments. The gully (compartment 13) is highlighted as ecologically significant, with a mixture of steep and shallow north and south facing slopes and structurally diverse vegetation. However, the existing management plan gives only superficial detail on the distribution of species within the heath that now covers its sides, and no list of bryophyte species is given although they are known to be present there.

The compartment merits study because:

1) Microhabitats could buffer against local extinction due to climate change (Suggitt *et al*., 2018).
2) Bryophytes are underrepresented in data on climate-driven range shifts (Mallen-Cooper *et al.,* 2022). They may have weak dispersal potential (*ibid*) making microrefugia key to local survival (Greiser *et al.*, 2021).
3) Mosses play a central role in a number of ecosystem functions including nutrient cycling, carbon sequestration, decomposition, habitat provision and hydrological function (Rodríguez-Caballero *et al.*, 2018; Turetsky *et al.*, 2012).
4) Trooper's Hill is situated in an urban area, and mosses have been used as indicators of pollution in urban areas (Tretiach *et al.*, 2007).

The survey aimed to:

1) Provide a baseline against which future (climate-driven) change can be measured
2) Identify dominant vegetation types present so that future surveys can determine their relative frequency
3) Identify possible associations between plant species and topography for further study

Survey Methods

Survey methodology was based on the NVC procedures laid out in Rodwell (2006). This survey type was chosen because it is designed for identifying homogeneous stands in the initial phases of characterising a study area. Measuring vegetative cover non-metrically, using a scale, was more practicable than counting individual plants especially for moss species such as *Polytrichum piliferum* where many shoots can derive from the same underground rhizome system (Hobbs and Pritchard, 1987).

To mitigate the subjectivity inherent in NVC surveys, four points roughly 20m apart along the path at the bottom of the gully were predetermined (appendix 1). From each point the surveyor walked due south up the slope, taking one sample quadrat from each homogenous stand of vegetation encountered, then walked north up the opposite slope. This survey's

focus was on healthland, so stands of vegetation where non-heath species dominated within a 1m radius were disregarded.

Using a 50cx50cm quadrat made it possible to capture differentiated homogenous stands within the mosaic that would have been missed by larger quadrats. Each plant species present was recorded and the Braun-Blanquet scale (appendix 2) was used to assign a score of 0-5 for percentage cover. The same scale was used to record percentage of bare soil and rock. Mean vegetation height was calculated by recording the height at each corner of the quadrat and dividing the sum by 4. Maximum vegetation height was also recorded to capture where flowering shoots greatly exceeded the mean. Incline was recorded using a mechanical clinometer. Aspect was captured by using a compass to record the number of degrees away from true north the slope faced (ie. maximum 180^{o}), creating a bounded variable where higher values correlate with increased exposure to sunlight over the course of the day. For brevity this variable was termed “southness”.

The latitude, longitude and altitude of each plot was recorded using the OS Locate mobile application. This was chosen over OS grid reference as it makes the data compatible with international studies on climate change and vegetation shifts. The app is accurate to +/-10m for latitude and longitude and to +/-4m for altitude, so these data cannot be used to accurately compare relative position of quadrats along the 80m transect with a variance in altitude of just 6.5m. However, they are useful for positioning the survey in a wider context.

Results

A total of 16 quadrats was taken (for full results see appendix 3).

Topography and structure

Below is a summary of the topographical and structural data collected, which quantifies the physical diversity of the heathland on the slopes of the gully:

	southness/^{o}	**incline/^{o}**	**max vegetation height/cm**	**mean vegetation height/cm**
min	11	20	1	0
1st quartile	69	28	21	1
mean	117	37	35	12
median	147	35	31	5
3rd quartile	161	44	49	16
max	178	87	90	62
standard deviation	61	16	23	17

Aspect recorded ranges almost from true north to true south, while the slopes are near vertical in places and shallow (20^{o}) in others. Broom (*Cytisus scoparius*) was responsible for the greatest maximum height, and moss species for the lowest.

Plant species

Species encountered were mostly within those mention by the 2020 management plan (FOTH), and all within the *Calluna vulgaris-Erica cinerea* or H10 heath community (Rodwell, 1992). 69% of quadrats contained one of the two eponymous constant species: Ling (*Calluna vulgaris*) or Bell (*Erica cinerea*) heather. Constant species mentioned by Rodwell (1992) for this community but not found during the survey were *Potentilla erecta* and *Vaccinium myrtillus.*

Four bryophyte species were encountered, of which the first three were not mentioned in the management plan:

Dicranum scoparium, Broom fork-moss
Grimmia pulvinata, Grey-cushioned grimmia
Hypnum cupressiforme, Cypress-leaved plait-moss
Polytrichum piliferum, Bristly haircap

Identification was confirmed with an expert using a microscope. *D. scoparium*, *H. cupressiforme* and *P. piliferum* were all the dominant plant species with a Braun-Blanquet score of 5 in at least one quadrat, and *G. pulvinata* was the most abundant plant with a score of 2 in the only quadrat where it was recorded on bare rock.

Grass and forb species were encountered in 50% of quadrats, though their score never exceeded 2. All of these were within the H10 community.

One quadrat fell on an area dominated by broom, but was still included as the species found below the broom were still those of the H10 community.

Cladonia lichens were recorded but not identified to species level.

Analysis Methods

A principal component analysis was conducted. The aim was to simplify the large set of variables collected and identify a few components of the gully that shared similar vegetation, incline, aspect and structure.

All variables recorded excluding geographical ones (altitude, latitude, longitude) were run through a PCA in RStudio employing non-metric multidimensional scaling to plot every variable against every other variable and find lines of best fit (Eigenvectors) through the multidimensional space representing the greatest amount of variance. The Eigenvectors were labelled PC1, PC2, PC3 and so on. All Eigenvectors with an Eigenvalue (variance) of <1 were disregarded. The remaining Eigenvectors were ranked in order of the proportion of the variance they accounted for. A table was produced with each column representing a PC and each row a variable. The magnitude of the value of each cell represented the strength of correlation between each Eigenvector and each variable, and its valence (+/-) showed whether this correlation was positive or negative. PC1 was then plotted against PC2, giving a

visual representation of the Eigenvectors and assisting the identification of groups of related variables.

Results

Only PC1-7 had an Eigenvalue of >1. Between them, PC1-5 accounted for just over 75% (75.7%) of the variance. For full and simplified results see appendix 4. A graph of PC1 plotted against PC2 (accounting for 39% of the variance) was useful as a visual aid in identifying associations (appendix 5).
The drop-off in percentage of variance explained was slow across the PC vectors, suggesting that no single one of the variables measured is responsible for the majority of the diversity of the gully. The following associations can be tentatively inferred from this data:

Ling heather/cypress-leaved plait-moss association on north-facing slopes

PC1 and **PC3** both show associations between ling heather and cypress-leaved plait-moss. This supports observations made during the survey that the plait-moss tends to be found hidden under ling heather, growing on sheltered ground and up its woody stems.

The PC1/PC2 plot reveals further associations between these two species and broom fork-moss, heath bedstraw, goldenrod and bare soil.

Less bristly haircap on north-facing slopes

Going in the opposite direction from the ling/plait-moss association above, the PC1/PC2 plot shows associations between southness and bristly haircap cover.

This may be explained by bristly haircap being a coloniser of open and disturbed habitats (Hobbs and Pritchard, 1987, and the relative open-ness of the south-facing slope of the gully compared to the north-facing one.

Grey-cushioned grimmia/bare rock association

PC4 shows a positive correlation with bare rock and grey-cushioned grimmia, while **PC2** shows a negative correlation with both of these variables. This supports observations made during the survey that this moss is only found on bare rockfaces.

The PC1/PC2 plot shows a broader associated group with cladonia, grey-cushioned grimmia, steep incline and high proportion of bare rock.

Steep slopes favour cladonia or broom fork-moss, and lack bell heather and recruiting oak

PC5 shows a positive correlation with incline, cladonia and broom fork-moss, suggesting these two species are more likely to be found on steeper inclines. It shows a negative correlation with bell heather and pedunculate oak, suggesting these two species are less likely to establish on steeper slopes.

Broom/sheep's sorrel/early hairgrass association

The PC1/PC2 plot shows an association between these three species.

Conclusions

NVC

The dominant plant species in terms of cover are broom, ling heather, bell heather, broom fork-moss and bristly haircap, all displaying Braun-Blanquet scores of 3-5 in at least one quadrat. The plant species present sit within the H10 NVC classification. However, *Vaccinium myrtillus* and *Potentilla erecta*, two constant species of H10, are absent.

PCA

An additional cover type to those mentioned above was bare rock and/or steeper inclines with cladonia lichens and/or grey-cushioned grimmia. An important correlation between ling heather and cypress-leaved plait-moss was identified. Broom fork-moss and bristly haircap seemed to occupy largely mutually exclusive spaces, the former predominantly on north-facing slopes, and the latter on south-facing. Two lowland heath species, sheep's sorrel and early hairgrass, seem able to persist under broom.

Recommendations for further work

The conclusions drawn from this survey are meant as guidelines delineating areas for further studies, and as a baseline against which these studies can compare future changes in the reserve.

Several future studies are suggested below. Each should employ a larger sample size of at least 5 quadrats per stand as recommended by Rodwell (2006), and stratified randomness, the placement of quadrats within designated stands is random. They could also measure soil depth, moisture, pH and nitrate levels which were missed by this survey; the management plan mentions variations in the latter affecting vegetation composition elsewhere on site (FOTH, 2020).

- As a natural step following the delineation of dominant vegetation types, randomly placed quadrats across the gully should be used to determine their relative frequency.

- The association between ling heather and cypress-leaved plait-moss should be studied to see if it is constant across the site.

- Broom fork-moss and bristly haircap distribution should be studied further to gain insight into the largely mutually exclusive spaces occupied by these two species, and whether the aspect-based distribution is borne out by a larger sample size.

- Broom is mentioned in the management plan as an encroaching threat (FOTH, 2020) to the heathland, but the results showed an association between this species, sheep's sorrel and early hairgrass. The edge and centre of patches of broom should be compared to see whether these two heathland species (and others) can persist if broom continues to advance.

References

Friends of Troopers Hill and Wessex Ecological Consultancy (2020) *Troopers Hill Local Nature Reserve Management Plan* [online]. Bristol, Friends of Troopers Hill. Available from: http://www.troopers-hill.org.uk/plan/ManPlan2019.pdf [Accessed 21 July 2023].

Greiser, C., Ehrlén, J., Luoto, M., Meineri, E., Merinero, S., Willman, B. and Hylander, K. (2021) Warm range margin of boreal bryophytes and lichens not directly limited by temperatures. *Journal of Ecology*. [online]. 109 (10), pp.3724–3736. Available from: https://onlinelibrary.wiley.com/doi/10.1111/1365-2745.13750 [Accessed 21 July 2023].

Hobbs, V.J. and Pritchard, N.M. (1987) Population Dynamics of the Moss Polytrichum Piliferum in North-East Scotland. *The Journal of Ecology*. [online]. 75 (1), p.177. Available from: https://www.jstor.org/stable/2260543?origin=crossref [Accessed 18 July 2023].

Maclean, N. (2010) *Silent Summer: the state of wildlife in Britain and Ireland.* Cambridge, Cambridge University Press.

Mallen-Cooper, M., Rodríguez-Caballero, E., Eldridge, D.J., Weber, B., Büdel, B., Höhne, H. and Cornwell, W.K. (2023) Towards an understanding of future range shifts in lichens and mosses under climate change. *Journal of Biogeography*. [online]. 50 (2), pp.406–417. Available from: https://onlinelibrary.wiley.com/doi/10.1111/jbi.14542 [Accessed 18 July 2023].

Rodríguez-Caballero, E., Castro, A.J., Chamizo, S., Quintas-Soriano, C., Garcia-Llorente, M., Cantón, Y. and Weber, B. (2018) Ecosystem services provided by biocrusts: From ecosystem functions to social values. *Journal of Arid Environments*. [online]. 159, pp.45–53. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0140196317301696 [Accessed 22 July 2023].

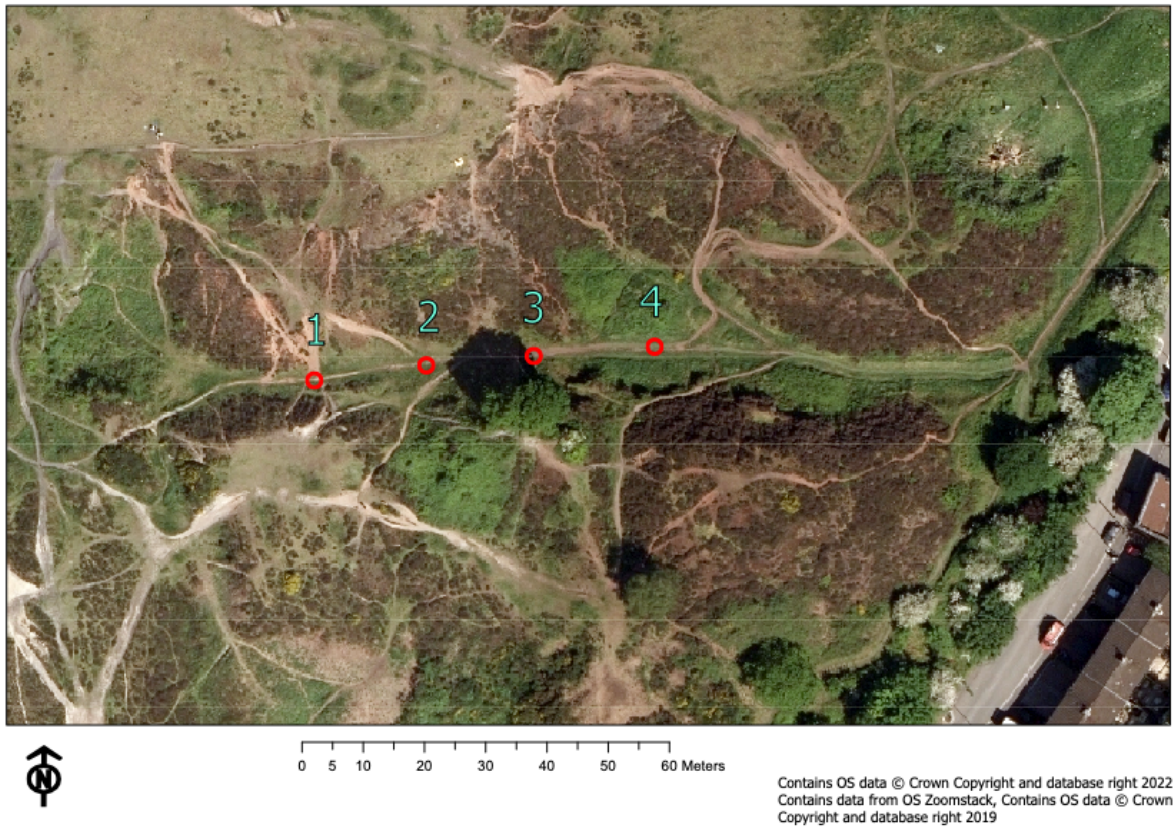
Rodwell, J.S. (ed.) (1992) *British Plant Communities: Volume 2: Mires and Heaths*British Plant Communities [online]. 2, Cambridge, Cambridge University Press. Available from: https://www.cambridge.org/core/books/british-plant-communities/FD7C94395144ADDD5F36B78C83BDDA27 [Accessed 18 July 2023].
Rodwell, J.S. (2006) *National Vegetation Classification: User's Handbook* [online]. JNCC. Available from: https://data.jncc.gov.uk/data/a407ebfc-2859-49cf-9710-1bde9c8e28c7/JNCC-NVC-UsersHandbook-2006.pdf [Accessed 10 July 2023].

Suggitt, A.J. *et al.* (2018) Extinction risk from climate change is reduced by microclimatic buffering. *Nature Climate Change*. [online]. 8 (8), pp.713–717. Available from: https://www.nature.com/articles/s41558-018-0231-9 [Accessed 21 July 2023].

Tretiach, M. *et al.* (2007) Lichen and moss bags as monitoring devices in urban areas. Part I: Influence of exposure on sample vitality. *Environmental Pollution*. [online]. 146 (2), pp.380–391. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0269749106002260 [Accessed 22 July 2023].

Turetsky, M.R., Bond-Lamberty, B., Euskirchen, E., Talbot, J., Frolking, S., McGuire, A.D. and Tuittila, E. (2012) The resilience and functional role of moss in boreal and arctic ecosystems. *New Phytologist*. [online]. 196 (1), pp.49–67. Available from: https://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04254.x [Accessed 22 July 2023].

Appendix 1: transect route



Appendix 2: the Braun-Blanquet scale of vegetative cover

Cover	Score
76-100%	5
51-75%	4
26-50%	3
6-25%	2
1-5%	1
<1%	+

Appendix 3: table of results from NVC survey

a. Topography and structure

plot no.	transect point	altitude/m	latitude	longitude	degrees from north	incline	max height/cm	mean height/cm
1	1	57.3	51.4554	-2.5344	11	44	49	16
2	1	58.4	51.4555	-2.5342	17	46	49	6
3	1	63.2	51.4558	-2.5343	154	31	35	1
4	2	57.2	51.4557	-2.5342	156	20	53	16
5	2	57.5	51.4557	-2.5342	172	27	90	62
6	2	62.8	51.4557	-2.5341	133	25	23	1
7	2	64.7	51.4557	-2.5341	155	46	23	1
8	3	57.7	51.4556	-2.5338	112	35	48	22
9	3	62	51.4558	-2.5339	159	35	10	2
10	3	62.2	51.4558	-2.5338	75	44	14	0
11	3	61.2	51.4558	-2.5339	167	35	1	0
12	4	62.5	51.4555	-2.5335	17	41	23	4
13	4	62.2	51.4554	-2.5335	51	30	58	41
14	4	63.9	51.4559	-2.5338	140	87	27	6
15	4	60.8	51.4558	-2.5337	178	28	40	13
16	4	62.6	51.4558	-2.5338	169	23	12	2

Squares highlighted red in the “degrees from north” column indicate quadrats on north-facing slopes (ie. between East, North and West). Squares highlighted green indicate south-facing slopes (ie. between West, South and East).

b. Braun-Blanquet score by species (blank space indicaces >1% or absent)

plot number	bare soil	bare rock	pedunculate oak	broom	ling heather	bell heather	mouse-ear hawkweed	common cat's ear	sheep's sorrel	heath bedstraw	goldenrod	early hairgrass	wavy hairgrass	grey-cushioned grimmia	cypress-leaved plait-moss	broom fork-moss	bristly haircap	cladonia spp.
1	3	1				3				1	1		1			3		
2	4								1			1	2			2	2	
3								2	1			1	2				5	
4	4				5										3			
5	2	2		4			2		2			2					2	
6	1	2				3	1		1				1				3	
7		3															4	2
8		1			5										5		1	
9	4				1	1											3	2
10		3				1	1	1				1					4	1
11		5					1							2			1	1
12	2				2											5		1
13	1				5										4	2		
14		4			3		1		1									2
15		2	2		5										2			
16	3	2				2											3	

c. Additional observations

plot number	max height due to	notes on plot	outside plot
a	Rank grass and heather	Moss below clumps of heather	Heather mid-age to mature and leggy, thick patches of ling heather to the west, oak saplings recruiting; clear soil paths with easily-disloged loose rocks and reddish soil; goldenrod showing 2-10mm holes in leaves due to insect predation.
b	Rank grass	In places bank approaches vertical. Max height from rank grass/heather	Exposed roots protruding from soil. Cladonia
c	Rank grass		Wider landscape is a mosaic of five components: heather, moss with grass tussocks, bare rock and bare soil. This plot represents a homogeneous moss stand. Grass to moss ratio varies, but on slope general small isolated tussocks on a carpet of moss; gives way to grass completely where top of slope flattens out abruptly. Stope incline varies and in places is vertical or even an overhang. Substantial areas of bare flat rock at least as large as quadrat (50x50cm). Punctuated by paths with reddish soil and loose rock fragments. Patches of young bell heather may be colonising.
g	Heather	Day of survey was intermittently rainy. Space under ling heather was noticeably wetter than the dry top. Stems of heather were thickly bunched but underneath cover between bare soil and moss could be seen	Shares a border with mature leggy broom. Few/no young broom plants visible within *ling* heather. On southfacing slope outside plot, *bell* heather *is* interspersed with young broom. Possibly thicker ling doesn't allow it through?
h	Broom	Very layered with diverse understory. Broom mature and leggy but with lime green living shoot tips. Seeded (black pea pods). Fist sized loose rocks under broom.	

i	Rank grass and heather		Patches of bare rock on this slope; some exceed size of quadrat (50x50cm)
j	Moss		
k	Heather		Full range of Ling from dead to young, but mainly mid age. Goldenrod present. Occasional dry rank wavy hairgrass and vigorous young establishing broom.
l	Heather	Haircap is a sparse carpet here	Full range of Ling from dead to young, but mainly mid age. Goldenrod present. Occasional dry rank wavy hairgrass and vigorous young establishing broom.
m	Heather	Thick carpet of haircap. Varied incline with near vertical smooth straight rock faces (90 degree angle between top and face). Moss establishes from these flat shelves.	
n	Moss	Grey cushioned grimmia establishing where there are shallow crevices in the rock	Bell heather, common cat's ear and wavy hairgrass sparsely present
o	Heather	Thick carpet of fruiting Broom Fork-Moss with overhanging Ling Heather (none growing from in quadrat)	Minimal bell heather beneath dominant Ling, but Bell heather reaches through Ling canopy occasionally. In open patches (most of which are smaller than the quadrat) broom fork moss forms a carpet, but it also found underneath Ling where it is mixed with Creeping Fingerwort. Frequent mature goldenrod in open patches.
p	Heather	Ling heather is reasonably old and leggy. Creeping fingerwort found both on soil beneath heather and growing up woody heather stems.	
q	Heather		
r	Heather, saplings	Large loose rocks, some approaching size of bricks. Recruiting oak saplings	Ling also broken by recruiting holm oak saplings and goldenrod
s	Heather	Sparse carpet of haircap	

Appendix 4: PCA analysis results

a. Eigenvalues of PC1-16

```
[1] 4.414375e+00 4.228941e+00 3.758785e+00 2.499682e+00 1.752647e+00 1.408605e+00 1.069431e+00 8.656394e-01
[9] 6.799193e-01 5.948535e-01 2.735282e-01 2.519005e-01 1.191275e-01 4.982257e-02 3.274477e-02 3.252096e-32
```

b. Components ranked by importance (amount of variance explained)

	PC1	PC2	PC3	PC4	PC5
Standard deviation	2.1010	2.0564	1.9388	1.5810	1.32388
Proportion of Variance	0.2006	0.1922	0.1709	0.1136	0.07967
Cumulative Proportion	0.2006	0.3929	0.5637	0.6774	0.75702

c. Correlations of PC1-5 with variables

	PC1	PC2	PC3	PC4	PC5
southness	-0.271734008	-0.126198814	0.2254787763	-0.07429200	-0.34229256
incline	-0.020390923	-0.157217213	-0.0766512950	0.28338506	0.50200364
max.height.cm	-0.016367054	0.459143884	0.0928180140	0.04504349	0.05036948
mean.height.cm	-0.069006811	0.406672696	0.1797813307	0.17325824	-0.02164703
soil	0.161221846	0.175626857	-0.1604761834	-0.02569284	-0.05910759
rock	-0.230776797	-0.261478499	0.0602907424	0.35541024	-0.12570114
pedunculate.oak	0.058591845	-0.007879962	0.2251334569	-0.05331173	-0.21020925
broom	-0.291594126	0.321595027	0.0371153095	0.19684876	-0.04976835
ling.heather	0.220567126	0.079641690	0.4177577512	-0.04848370	0.08573590
bell.heather	0.104841073	-0.025257767	-0.3139421070	0.09887549	-0.43414181
mouse.ear.hawkweed	-0.367122629	0.079770902	0.0001812273	0.31933315	-0.04554650
common.cat.s.ear	-0.160100029	-0.031131960	-0.1669495405	-0.38503417	0.08164835
sheep.s.sorrel	-0.328640602	0.250376020	-0.1067427546	0.03777824	0.13050625
heath.bedstraw	0.232425429	0.103138745	-0.2877347360	0.26360787	-0.19708246
goldenrod	0.232425429	0.103138745	-0.2877347360	0.26360787	-0.19708246
early.hair.grass	-0.326715666	0.276807108	-0.1226656312	-0.06842813	0.11976752
wavy.hair.grass	-0.009518214	0.110827206	-0.3394938538	-0.28416489	0.07136599
grey.cushioned.grimmia	-0.093341900	-0.203604298	0.0494386937	0.21027550	-0.16507621
cypress.leaved.plait.moss	0.201120314	0.137657250	0.3659535681	-0.12481088	-0.03728410
broom.fork.moss	0.286158393	0.120014518	-0.1665295096	0.11934538	0.31555616
bristly.haircap	-0.269558397	-0.119024079	-0.2203615434	-0.33928980	-0.07530530
cladonia.sp.	-0.079749233	-0.322960640	0.0026138241	0.19030028	0.33053502

d. Table of simplified results

Correlations with a magnitude of less than 0.20 have been disregarded, those from 0.20 – 0.39 have been termed “weak” and those from 0.40 – 0.69 “moderate”:

PC	**Percent of variance accounted for**	**Moderate correlations (0.35-0.50)**		**Weak correlations (0.20-0.34)**	
		positive	***negative***	**positive**	***negative***
1	20%		*mouse-ear hawkweed*	broom fork-moss, heath bedstraw, goldenrod, ling heather, cypress-leaved plaitmoss	*sheep's sorrel, early hairgrass, broom, southness, bristly haircap*
2	19%	maximum height, mean height		broom, early hairgrass, sheep's sorrel	*cladonia spp., bare rock, grimmia*
3	17%	ling heather, cypress-leaved plait-moss		southness, pedunculate oak	*wavy hairgrass, bell heather, heath bedstraw, goldenrod, bristly haircap*
4	11%	bare rock	*common cat's-ear*	mouse-ear hawkweed, incline, heath bedstraw, goldenrod, grey-cushion grimmia	*bristly haircap, wavy hairgrass*
5	8%	incline	*bell heather*	cladonia spp., broom fork-moss	*southness, pedunculate oak*

Appendix 5: PC1 plotted against PC2