Cyfoeth Naturiol Cymru
Natural Resources Wales

Cwm Idwal Surveillance 2022

Alex Turner
Eryri Ecological Surveys

Report No. 667

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Report series:	Evidence
Report number:	667
Publication date:	January 2024
Contract number:	202205CISU
Contractor:	Alex Turner Eryri Ecological Surveys
Contract Manager:	Philip Oliver
Title:	Cwm Idwal Surveillance Report 2022
Author(s):	**A.J. Turner**
Technical Editor:	P. Oliver
Quality Assurance	Tier 2 Internal Peer Review
Peer Reviewer(s)	Tom Harrison, John Ratcliffe, Paul Williams
Restrictions:	None

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Recommended citation for this volume:

A.J. Turner. 2024 Cwm Idwal Surveillance Report 2022. NRW Evidence Report No: 667, 126pp, Natural Resources Wales, Bangor

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Ymgymerwyd â'r degfed arolwg, yn 2022, o'r effaith ar lystyfiant yn sgil cael gwared â phori ym 1999 dros y rhan fwyaf o Warchodfa Natur Genedlaethol Cwm Idwal. Defnyddiwyd y fethodoleg a ddefnyddiwyd yn y cofnodion arolwg blaenorol yn 2022, ac yn ogystal, cafodd pedwar llain lefel uwch eu hailgofnodi gan ddefnyddio methodoleg 1999-2004 a chymharwyd hyn â'r data cynharach.

Neilltuwyd yr holl ddata cwadrat o 1999, 2004, 2017 a 2022 i'r Dosbarthiad Llystyfiant Cenedlaethol (DLC) a Dosbarthiad Cynefin Cam 1 er mwyn dehongli newidiadau yng nghyfansoddiad llystyfiant. Defnyddiwyd y dull disg gollwng ar gyfer cofnodi uchder y glastir yn 2022 ar gyfer y lleiniau lefel is, ac yn ogystal, mesurwyd uchder uchaf y llystyfiant ym mhob cwadrat ym mhob plot.

Cafodd yr holl leoliadau ffotograffiaeth tirwedd eu hadleoli a chymerwyd ffotograffau ailadroddus yn 2022. Tynnwyd ffotograffau plot a chwadrat ar gyfer pob un o'r 74 cwadrat a gofnodwyd ar y safle.

Ar gyfer y lleiniau lefel is, y prif newidiadau yw:

- Mae amledd celloedd grug (*Calluna vulgaris*) ar gyfartaledd wedi gostwng ers 2017, tra mae wedi cynyddu ar gyfer creiglys (*Empetrum nigrum*), grug y mêl (*Erica cinerea*) a llus (*Vaccinium myrtillus*). Mae'r duedd gyffredinol ar gyfer llystyfiant rhostir sych wedi bod yn gynnydd dros 2006-2022 a 2017-2022.
- Mae'r gostyngiad yn amlder cnwp-fwsogl mawr (*Huperzia selago*) wedi parhau, ond nid yw'r un ar gyfer cnwp-fwsogl alpaidd (*Diphasiastrum alpinum*) yn cael ei ystyried yn arwyddocaol.
- Mae rhywogaethau'r hesgen (*Carex*), glaswellt y gweunydd (*Molinia caerulea*) a'r gawnen ddu (*Nardus stricta*) wedi dangos gostyngiad mewn amlder dros 2006-2022 a 2017-2022.
- Mae'r rhan fwyaf o fforbiau yn dangos gostyngiad parhaus dros y cyfnod hwy ers 2006, ond mae llai yn dangos gostyngiad ers 2017 (gan gynnwys briwydd wen (*Galium saxatile*), llyriad yr ais (*Plantago lanceolata*) ac amlaethai`r waun (*Polygala serpyllifolia*)). Y newidyn Swm Glaswelltir Calchaidd (sy'n cyfuno gorchudd yr holl fforbiau calchgar) yn parhau, fodd bynnag, i ddangos gostyngiad dros 2006-2022 a 2017-2022.
- Mae amlder celloedd *Sphagnum* wedi parhau i ostwng ers 2017, yn rhannol oherwydd cynnydd yn uchder twmpathau *Molinia* a chorlwyni. Mae Mwsoglau Eraill wedi cynyddu'n sylweddol o ran amlder a gorchudd, gan gynnwys mwsoglau plewrocarpaidd sy'n nodweddiadol o weundir.

- Mae'r arwynebedd creigiau noeth wedi parhau i ostwng, ond mae'r cynnydd yn uchder y glastir wedi arafu, a dim ond mewn tri llain yr oedd yn arwyddocaol gyda gostyngiad mewn un arall.
- Roedd nifer y defaid a gofnodwyd yn 2022 yng Nghwm Idwal tua 35% yn is nag yn 2017, ond maent yn dal yn rhy uchel ar gyfer adferiad rhai mathau o lystyfiant. Mae niferoedd geifr wedi cynyddu'n sylweddol ers 2017.
- Mae cwadratau y dynodwyd atynt yn wreiddiol yn laswelltir calchaidd wedi gostwng mewn nifer o 11 i 2 ers 1999, gyda'r mwyafrif o'r rhain yn newid i laswelltir asidig, a nifer fechan i weundir sych. Mae rhai cwadratau glaswelltir asidaidd a oedd wedi newid i weundir sych yn 2017, wedi dychwelyd i laswelltir gyda gostyngiad yn y gorchudd o gorlwyni. Mae un cwadrat a dynodwyn yn lystyfiant perlysiau tal yn 2017, wedi dychwelyd yn laswelltir asidaidd.
- Dangosodd ffotofonitro dro ar ôl tro gynnydd a gostyngiadau lleol yng ngorchudd rhostir sych *Calluna*, gydag ardaloedd o *Calluna* marw i'w gweld sy'n cael eu priodoli i bla o chwilen y grug (*Lochmaea suturalis*).
- Mae cyflwr cynefinoedd gwarchodedig Atodiad 1 *Rhostir sych Ewropeaidd* a *Rhostir gwlyb Gogledd yr Iwerydd gydag Erica tetralix*, wedi gwella tra bod cyflwr *Glaswelltiroedd Nardus llawn-rhywogaethau ar swbstradau silicaidd mewn ardaloedd mynyddig* yn wael ac yn annhebygol o gyrraedd targedau dangosyddion perfformiad Monitro Safonau Cyffredin.

Cafodd pedair llain lefel uwch eu hadleoli a'u cofnodi yn 2022 am y tro cyntaf ers 2004. Cyfyngwyd y newidiadau i ychydig o gynnydd yn y gorchudd o gorlwyni, a gostyngiad mewn arwynebedd greigiau noeth sy'n bresennol. Mae tri o'r lleiniau hyn yn gynefinoedd gwarchodedig Atodiad 1, ond maent i gyd mewn cyflwr gwael.

Ystyrir bod y newidiadau yng ngorchudd *Calluna* a welwyd yn y lleiniau lefel is oherwydd cyfuniad o bwysau pori gafr a difrod Chwilen y Grug. Credir hefyd bod pori gafr yn lleihau gorchudd gweiriau bras a rhai perlysiau. Er bod y dystiolaeth yn anecdotaidd, mae anallu eginblanhigion coed a glasbrennau byr i ddatblygu'n goed yn debygol oherwydd pori gafr.

Credir bod y gostyngiad cyffredinol mewn fforbiau o ganlyniad i gyfuniad o gynnydd yn uchder y borfa a hen deiliach ynghyd â dyddodiad N-atmosfferig.

Y casgliad yw bod y diffyg newid cymharol yn y lleiniau lefel uwch oherwydd diffyg newid sylweddol yn nifer y defaid o ddaliadau cyfagos.

Canfuwyd gwall bach mewn fformiwla sy'n cyfrifo gwerthoedd critigol ar gyfer prawf rheng arwydd Wilcoxon sy'n ymddangos yn nhabl 5 yn yr adroddiad

blaenorol (Turner, 2018). Mae fersiwn wedi'i chywiro o'r tabl wedi'i gynnwys ar ddiwedd yr adroddiad.

2. Executive Summary

The tenth surveillance was undertaken, in 2022, of the impact on vegetation of the removal of grazing in 1999 over the majority of Cwm Idwal National Nature Reserve. The methodology used in the previous surveillance recordings was used in 2022, and additionally four higher-level plots were rerecorded using the 1999-2004 methodology and a comparison was made with the earlier data.

All quadrat data from 1999, 2004, 2017 and 2022 was assigned to the National Vegetation Classification (NVC) and the Phase 1 Habitat classification in order to interpret changes in vegetation composition. The drop-disc method for sward height recording was used in 2022 for the lower-level plots, and additionally, the maximum vegetation height was measured in all quadrats in all plots.

All the landscape photography locations were relocated and repeat photographs were taken in 2022. Plot and quadrat photographs were taken for all the 74 quadrats recorded on the site.

For the lower level-plots, the principal changes are:

- The average cell frequency for Heather (*Calluna vulgaris*) has decreased since 2017, whereas it has increased for Crowberry (*Empetrum nigrum*), Bell Heather (*Erica cinerea*) and Bilberry (*Vaccinium myrtillus*). The overall trend for dry heath vegetation has been an increase over both 2006-2022 and 2017-2022.
- The decrease in the frequency of Fir Clubmoss (*Huperzia selago*) has continued, but that for Alpine Clubmoss (*Diphasiastrum alpinum*) is not regarded as significant.
- Sedge (*Carex*) species, Purple Moor-grass (*Molinia caerulea*) and Mat-grass (*Nardus stricta*) have shown decreases in frequency over both 2006-2022 and 2017-2022.
- Most forbs show a continuing decrease over the longer period since 2006, but fewer show a decrease since 2017 (including Heath Bedstraw (*Galium saxatile*), Ribwort Plantain (*Plantago lanceolata*) and Heath Milkwort (*Polygala serpyllifolia*)). The Calcareous Grassland Sum variable (which combines the cover of all calcicole forbs) continues, however, to show a decrease over both 2006-2022 and 2017-2022.
- Cell frequencies of *Sphagnum* have continued to decrease since 2017, in part due to the increased height of *Molinia* tussocks and dwarf shrubs. Other Bryophytes have increased significantly in frequency and cover, including pleurocarpous mosses typical of heathland.
- The decrease in Bare Rock has continued, but the increase in sward height has slowed and was only significant in three plots with a decrease in another.

- Sheep numbers recorded in 2022 in Cwm Idwal were c35% lower than in 2017, but are still too high for the recovery of some vegetation types. Goat numbers have increased considerably since 2017.
- Quadrats originally referable to calcareous grassland have decreased in number from 11 to 2 since 1999, with the majority of these changing to acid grassland, and a small number to dry heath. Some acid grassland quadrats which had changed to dry heath in 2017, have reverted to grassland with a reduction in the cover of dwarf shrubs. A single quadrat which was referred as to tall-herb vegetation in 2017, has reverted to acid grassland.
- Repeat photomonitoring showed local increases and decreases in the cover of dry *Calluna* heath, with areas of dead *Calluna* visible which is ascribed to infestations of Heather Beetle (*Lochmaea suturalis*).
- The condition of the Annex 1 protected habitats *European dry heath* and *North Atlantic wet heath with Erica tetralix*, has improved while that for *Species-rich Nardus grasslands on siliceous substrates in mountain areas* is poor and unlikely to pass Common Standards Monitoring performance indicator targets.

Four of the original higher level-plots were relocated and re-recorded in 2022 for the first time since 2004. The changes were limited to a slight increase in the cover of dwarf-shrubs, and a decrease in the amount of Bare Rock present. Three of these plots are Annex 1 protected habitats, but all are in poor condition.

The changes in *Calluna* cover observed in the lower-level plots are deemed to be due to a combination of goat grazing pressure and Heather Beetle damage. Goat grazing is also thought to be reducing the cover of coarse grasses and some herbs. Although evidence is anecdotal, the inability of tree seedlings and short saplings to develop into trees is likely due to goat grazing.

The general decrease in forbs is thought to be due to a combination of increased sward height and litter combined with atmospheric N-deposition.

The relative lack of change in the higher-level plots is concluded to be due to a lack of significant change in sheep numbers from adjoining holdings.

A small error was detected in a formula calculating critical values for the Wilcoxon signed-rank test appearing in Table 5 in the previous report (Turner, 2018). A corrected version of the table is included at the end of the report.

3. Introduction

This is the tenth surveillance undertaken to report on the effect of stock exclusion since 1999 in the Cwm Idwal National Nature Reserve (NNR). This surveillance is the second undertaken over a five-yearly recording interval, and the fifth since the recording methodology was changed in 2006. During this surveillance round, both the revised methodology and some elements of the original methodology were used enabling comparison back to 1999 and interpretation of the changes to date in terms of the National Vegetation Classification (NVC). In addition, some higher altitude plots within the site were re-recorded for the first time since 2004.

3.1. Background

Cwm Idwal was designated as a National Nature Reserve (NNR) in 1954 and is managed by Natural Resources Wales under a 99-year tenancy agreement with the landowner, The National Trust. The NNR lies within the Eryri Special Area of Conservation (SAC) and the Eryri Site of Special Scientific Interest (SSSI). It contains the following Annex I habitats for which the SAC was originally selected:

- 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
- 6150 Siliceous alpine and boreal grasslands
- 6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
- 8110 Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*)
- 8210 Calcareous rocky slopes with chasmophytic vegetation
- 8220 Siliceous rocky slopes with chasmophytic vegetation

It also contains the following Annex 1 habitats present as qualifying features, but which were not a primary reason for the selection of the SAC:

- 4010 Northern Atlantic wet heaths with *Erica tetralix*
- 4030 European dry heaths
- 4060 Alpine and Boreal heaths
- 6170 Alpine and subalpine calcareous grasslands
- 6230 Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas
- 7130 Blanket bogs
- 7230 Alkaline fens
- 7240 Alpine pioneer formations of the *Caricion bicoloris-atrofuscae*

Amongst the biological features of interest for which Eryri SSSI is designated, the following occur in Cwm Idwal (CCW, 2003) :

- Upland and montane heath
- Blanket bogs, fen, flushes and springs
- Calcareous grassland
- Inland cliffs and rock exposures with ledge, scree and crevice vegetation
- Mountain lakes and water bodies
- Rare Arctic-alpine plants, rock and cliff ledge and crevice plant assemblage
- Aquatic and marginal plant assemblage
- Montane grassland plant assemblage
- Assemblage of mosses and liverworts
- Lichen assemblage
- Chough
- Upland moorland and grassland breeding bird assemblage
- Rainbow leaf beetle
- Montane invertebrate assemblage

Sheep grazing was removed from Cwm Idwal National Nature Reserve (NNR) in 1998 with a view to the long-term exclusion of sheep in order to enable the previously heavily grazed vegetation communities to recover (Radford, 1999).

In 1998-1999, 30 plots were established around the NNR using stratified random sampling to monitor the response of the vegetation to the relaxation of grazing pressure (Radford, 1999).

Between 2000 and 2003 varying numbers of plots were resampled, with all thirty being re-sampled in 2004. In addition to vegetation composition, assessments of vegetation structure, spatial patterning and grazing pressure were also made (Radford, 1999-2005). Although the hefted stock had been removed in 1998, stray sheep from adjacent holdings continued to trespass onto the NNR and graze throughout this period, despite regular shepherding contracts. A significant decline in numbers and impact, however, was recorded, leading to a general increase in sward height across the sampled plots. Mean dwarf shrub height also increased, along with grass and graminoid cover (Radford, 2005).

In 2006 eleven of the original plots were selected for long-term surveillance monitoring. The same plot and quadrat locations were used, but the recording methodology was modified and therefore the 2006 sampling was adopted as the new baseline from which to assess future changes in vegetation composition (Crowther & Groome 2007). Initially the resurveys were on a 3-year repeat

period, but from 2012 this period was extended to 5 years. The 2022 sampling represents the fifth resurvey of the eleven plots since the change in methodology in 2006.

In addition to vegetation composition and structural analyses, Radford recorded a number of fixed-point photographs across the NNR. In 2006 several of the stations established in preceding years to record gross landscape changes in vegetation were re-photographed. Several new photographic vantage points were also established. Photographs were also taken of all sampled quadrats and plots.

The eleven plots selected for surveillance monitoring all occur at relatively low levels within the reserve with the highest being at 680m. The higher-level plots originally established by Radford had not been re-recorded since 2004. Five of these were selected for recording in 2022.

3.2. Recording Objectives in 2022

The objectives for the 2022 surveillance were:

- Repeat the vegetation surveys undertaken in 2017 to gather repeat data for the same 11 plots and quadrats, plus rerecording at 5 additional (higher-level) plots from the original 30 plots, as recommended in the 2017 surveillance report.
- Repeat plot and quadrat photography undertaken in the previous surveys.
- Repeat fixed point landscape photography undertaken in the previous surveys.
- Undertake statistical analysis as conducted in 2017 to allow comparison of the gathered data with previous survey data to establish what/if statistically significant differences and trends, now including vegetation height, are occurring.
- Present the results of the surveillance in a report in a form comparable/equivalent to that produced in 2017.
- Provide field data in a suitable, digital format for future reference, re-use or analysis.
- Provide photographs including fixed point photographs, in RAW and JPEG formats to add to the photographic catalogue and allow future image processing.

In more detail, the 2017 methodology (Turner, 2018) included:

- Recording the frequency of species, selected species groups and other variables (bare ground, exposed peat, bare rock, litter, and sheep/goat droppings) from the five ‘fixed’ quadrats within each of the eleven

surveillance plots covered by the 2006 baseline, using the prescribed methodology given by Crowther & Groome (2007).

- Identifying changes in the frequency of species, species groups and other variables between 2006 and 2017.
- Re-photographing the suite of images recorded in 2006 and to analyse any changes observed.
- Remeasuring plot vegetation heights using the protocol established by Gritten in 2012, and assessing height changes over the period 2012-2017
- Assessing the overall changes in vegetation composition between 2006 and 2012.
- Recording the percentage cover of vascular plants, bryophytes, macrolichens, bare rock, bare ground, exposed peat within each quadrat (as had been done by Radford 2000-2005).
- Recording maximum vegetation height in centimetres within each of the quadrats.
- Assigning each quadrat to the National Vegetation Classification (NVC).

3.3. Personnel

The work was entirely undertaken by Alex Turner.

3.4. Nomenclature

Species names used in this report are taken from Stace (2019) for higher plants apart from *Empetrum nigrum* subsp. *hermaphroditum* and *E. nigrum* subsp. *nigrum* which are referred to as *Empetrum hermaphroditum* and *E. nigrum* respectively. Names of bryophytes are from Blockeel *et al.* (2021), and lichens from Smith *et al.* (2009). Species names in NVC communities are taken from Rodwell *et al.,* (1991, 1992). Phase 1 Habitat names are from JNCC (2010). Names of Annex 1 habitats are taken from European Union (2013).

In some of the plot descriptions, the DAFOR scale (D = Dominant, A = Abundant, F = Frequent, O = Occasional, R = Rare; L = Locally) is used to describe cover and abundance.

The names of all vascular plants used in the report are listed with the Scientific name, English name and Welsh name in Appendix 8, Table 33.

4. Methodology

4.1. Plot, quadrat and sample cell recording

The relocation and recording of plots, quadrats, and sample cells followed the methodology given by Crowther & Groome (2007).

4.1.1. Relocation and establishment of plots

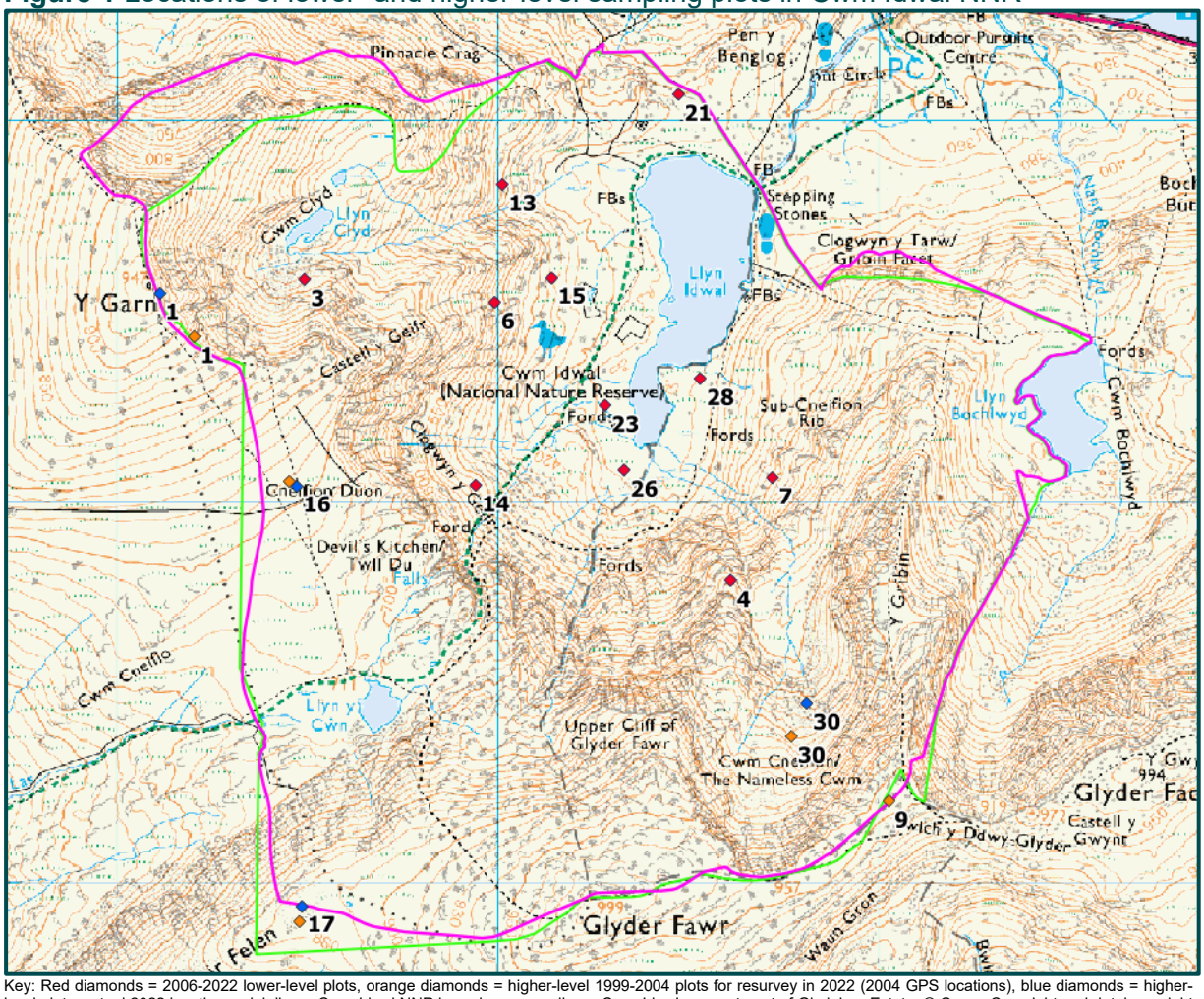
The sampling plots are square in shape and vary from 15m x 15m to 30m x 30m in size. One edge (Axis 1) of each plot is marked with two buried markers (P1 and P2) at either end, and the positions of the 5 quadrats located within the plot are fixed using distances from the marker points. Summary details of the plots are included in Table 1 below, and the distribution of the plots within Cwm Idwal is shown in Figure 1. Details of the relocation, and brief descriptions of the plots are given in Appendix 1.

Table 1 Summary details of the surveillance plots selected for re-recording in 2022 in relation to the altitude and relief classes used by Radford (2000).

Plot	Lower-level plots Location and original 1999 vegetation	Plot size	Altitude Class	Relief Class
3	Grassland; on lower N-facing slope of Cwm Clyd	30m x 30m	Moderate	High
4	Dwarf shrub heath / grassland; above Idwal Slabs	15m x 15m	Moderate	High
6	Dwarf shrub heath; E-facing slope above Llyn Idwal	30m x 30m	Low	High
7	Dwarf shrub heath; NW-facing slope above Llyn Idwal	30m x 30m	Low	High
13	Grassland; on the E-facing slope below Cwm Clyd	25m x 25m	Low	Moderate
14	East-facing slope near boulder scree below Twll Du	25m x 25m	Low	Moderate
15	East-facing calcareous grassland on the slopes above Llyn Idwal	25m x 25m	Low	Moderate
21	Grassland (acid); above Blaen-y-Nant, Nant Ffrancon	30m x 30m	Low	Low
23	Grassland (*Nardus*); near the south-western shore of Llyn Idwal	30m x 30m	Low	Low
26	Grassland (calcareous); near the head of Llyn Idwal	25m x 25m	Low	Not specif
28	Area of severe peat erosion beside eastern shore of Llyn Idwal	30m x 30m	Low	Not specif
Plot	**Higher-level plots Location and original 1999 vegetation**	**Plot size**	**Altitude Class**	**Relief Class**
1	Grassland; near summit of Y Garn	20m x 20m	High	High
9	Grassland; on gently sloping edge of Plateau (above Y Gribin)	30m x 30m	High	Moderate
16	Grassland; on gently-sloping S slope of Y Garn	30m x 30m	High	Low
17	Dwarf-shrub heath; on almost flat ridge-top on Esgair Felen	30m x 30m	High	Low
30	Bryophyte-dominated; steep stream line in Cwm Cneifion	20m, linear	Moderate	Not specified

Key: Altitude classes (centre of 100m x 100m cell): Low, <550m, Moderate, 550m-750m; relief classes (per 100mx100m cell): Low, <5 5m contours, Moderate 5-7 5m contours, High, > 7 5m contours.

Figure 1 Locations of lower- and higher-level sampling plots in Cwm Idwal NNR



Key: Red diamonds = 2006-2022 lower-level plots, orange diamonds = higher-level 1999-2004 plots for resurvey in 2022 (2004 GPS locations), blue diamonds = higher-level plots, actual 2022 locations, pink line = Cwm Idwal NNR boundary, green line = Cwm Idwal compartment of Glydeirau Estate.

Each of the lower-level plots has a series of photographs taken from fixed-points in 2006, 2009, 2012, and 2017. Further for each plot, there is a sketch map, initially provided by Crowther and Groome (2007), but subsequently annotated and updated by Gritten (2012), and Turner (2018), which shows the orientation of the plot, the orientation of fixed-point photographs, and for some plots details of vegetation and significant boulders. GPS-derived grid-references were also available for the two end-points of Axis 1 for all plots from the 2017 re-recording. The buried pegs at the ends of Axis 1 were relocated using a Viking metal detector.

Reference to all these materials, but particularly to the photographs enabled the recovery of all the marker points. As in 2017, further photos were taken of each location from different directions.

The notes of Crowther and Groome (2007) made for each quadrat were found to have become less useful with time because many of the rocks shown have become overgrown with vegetation, particularly bryophytes. The notes were not, therefore, updated in 2022.

For the higher-level plots, relocation photographs had been mislaid, but some negatives of print film were available which showed selected views of the plots in 1999. These were scanned, inverted and colour balanced for use in the field. There were also a set of GPS coordinates for each of the higher-level plots, as well as information on plot size, orientation and distances from marker pegs.

Using the given GPS co-ordinates, however, it soon became clear that there were very large errors present, and instead reliance was placed mainly on the photographs, backed up with a metal detector where necessary. Four of the five plots (Plots 01, 16, 17, and 30) were successfully relocated, but the fifth, Plot 09, was not relocated as the photographs appeared to be from another location.

For each of the high-level plots, photographs were taken of the two marker points, along Axis 1 in both directions, of each of the quadrats, and of the plot in general. The locations of pegs and quadrats were recorded (GPSMAP 66s), and the average difference between the 2004 and 2022 coordinates for the four plots was found to be 77m, with a maximum of 147m.

4.1.2. Relocation and establishment of quadrats

Following the relocation of Axis 1 for each plot, quadrat locations were refound using the measurements given. As noted in Turner (2018), this method is extremely error prone because of (a) measuring tape stretch, (b) the increased height of vegetation since the exclusion experiment started, and (c) the wind which when strong can make accurate measurements of position almost impossible to attain.

To increase the accuracy, where there were relocatable rocks or boulders, the 2017 photographs were used to position the quadrat more accurately than the tape measures suggested. Only where there was no other information available about position was the tape-measured position used uncritically.

In line with previous surveillance recordings, an additional quadrat, F4ii was recorded in Plot 3 where the original quadrat F4i overlaps quadrat F1.

4.1.3. Quadrat cell sampling

Quadrat cell sampling was undertaken in 2022 for the 11 lower-level plots. This method had been used for these plots in 2006, 2009, 2012, and 2017. The higher-level plots were not sampled using this method.

For quadrats in the lower-level sampled plots, a 1m x 1m square frame with 25 square 20cm x 20cm cells was used to sample the vegetation. The presence of

species in each cell, from Table 2 below, rooted in the quadrat was recorded as in previous surveillance recordings but with a few additional species. *Empetrum hermaphroditum* was noted in Plot 4 and in all likelihood was previously overlooked. *Alchemilla* and *Dactylorhiza* species were identified to species-level. Lichen presence was interpreted as referring only to macrolichens.

Each quadrat was positioned so that the left-hand side was oriented North-South. The cells were recorded sequentially starting at the SE corner and progressing according to Table 3.

The higher-level sampled plots had never been recorded using the 25-cell division of the quadrats, and hence this method was not used and the quadrats were recorded using the 1999-2004 methodology (% cover).

Table 2 Species and variables presence/absence recorded in each quadrat cell

Dwarf-shrubs	**Forbs (continued)**	**Forbs (continued)**
Calluna vulgaris	*Campanula rotundifolia*	*Ranunculus acris*
Empetrum hermaphroditum	*Cardamine pratensis*	*Ranunculus bulbosus*
Empetrum nigrum	*Cerastium fontanum*	*Rumex acetosa*
Erica cinerea	*Cirsium palustre*	*Scorzoneroides autumnalis*
Erica tetralix	*Dactylorhiza sp.*	*Sedum anglicum*
Vaccinium myrtillus	*Drosera rotundifolia*	*Solidago virgaurea*
Clubmosses	*Epilobium brunnescens*	*Taraxacum officinale* agg.
Diphasiastrum alpinum	*Euphrasia* sp.	*Thymus drucei*
Huperzia selago	*Filipendula ulmaria*	*Trifolium repens*
Lycopodium clavatum	*Galium saxatile*	*Viola palustris*
Selaginella selaginoides	*Hieracium* sp.	*Viola riviniana*
Sedges, rushes etc	*Hypericum pulchrum*	**Other**
Carex sp.	*Hypochoeris radicata*	*Sphagnum* sp.
Eriophorum vaginatum	*Lysimachia nemorum*	Ferns
Eriophorum angustifolium	*Narthecium ossifragum*	Other Graminoids
Juncus sp.	*Oxalis acetosella*	Other bryophytes
Trichophorum germanicum	*Pedicularis sylvatica*	Lichens
Grasses	*Pinguicula vulgaris*	**Abiotic**
Molinia caerulea	*Plantago lanceolata*	Bare ground
Nardus stricta	*Polygala serpyllifolia*	Exposed peat
Forbs	*Potentilla erecta*	Rock
Achillea millefolium	*Potentilla sterilis*	Litter
Alchemilla glabra	*Prunella vulgaris*	Droppings

Table 3 Recording sequence for 20cm x 20cm quadrat cells

25	16	15	6	5
24	17	14	7	4
23	18	13	8	3
22	19	12	9	2
21	20	11	10	1

SE corner

4.1.4. Quadrat percentage cover recording

For the 11 lower-level plots, in addition to the cell recording, an estimate was made of the percentage cover of all vascular plants, bryophytes, and macrolichens in the quadrat. Species which couldn't be definitively identified in the field were collected from outside the quadrat and taken for later microscopic examination and identification.

For the higher-level plots, percentage cover was the only recording method employed in 2022.

Each quadrat was also assigned in the field to an NVC community based on fitting the species present in the quadrat to the various constants and dominants of the upland heath, mire, grassland, or montane communities in Rodwell *et al.*, (1991,1992). These referrals made in the field were mainly based on the contractor's experience of upland NVC survey over 30 years.

4.1.5. Vegetation height recording

Vegetation height was recorded in a similar way to that used in 2017, the only difference being that the height was rounded down to the nearest centimetre. The drop "disc" used was square rather than circular, as used in 2012, but the area and weight of the "disc" were identical. The drop disc method was only used for the lower-level plots, as it was found to be inaccurate for the higher-level plots due to the low height of the vegetation and the frequency of upstanding rocks and boulders which did not allow an accurate measurement to be taken.

Vegetation height for all quadrats (low-level and high-level) was additionally estimated (a) at the centre of each quadrat, and (b) as the maximum vegetation height within the quadrat.

As with the 2012 and 2017 surveillance exercises, measurements were taken following a series of W-walks across each plot, and 50 measurements were taken including Plot 28 which was not measured in 2012 and 2017. For Plot 21, as in 2012 and 2017, the area with tall rushes was excluded.

4.1.6. Sheep number recording

Numbers of sheep in different parts of the site were recorded during site visits while undertaking landscape photography, and during periods of collection of vegetation data, between March and October 2022. The main counting areas were the West side of the cwm (from Nant Clyd to the unnamed stream below Clogwyn y Geifr), from the unnamed stream to Nant Ifan, and on the East side of the cwm from Nant Ifan to the boundary wall. Sporadic counts were made in Cwm Clyd and Cneifion when present for landscape photography purposes or quadrat recording. Counts of goats within the cwm were made at intervals between March and July before the start of the contract.

4.2. Landscape photography

Figure 2 shows the locations where landscape photographs were taken in 2022.

The methodology used was the same as utilised in 2017. Sheets of images from previous surveillances (from Turner, 2018) were pre-printed, together with information on plot location, GPS reading, bearing, and lens size. A handheld Garmin GPSMAP 66S (average error ±3m) was used to find the position of the photo location, and then detail in the 2017 photos was used to fine-tune this until all features in the photo matched (e.g., boulders in the foreground lined up with more distant objects, etc.). The photos were taken with a Nikon D7200 camera using a Tamron AF 18-250mm lens and a tripod.

The focal length was adjusted until the image in the through-the-lens optical viewfinder matched the reference photo, sometimes slightly larger. Focal lengths and bearings of the photos were not measured in 2022. For each photograph, the exposure was bracketed to give a range of lighting and the most suitable image was subsequently selected.

The location of the tripod was photographed for each of the landscape photos, sometimes using more than one direction.

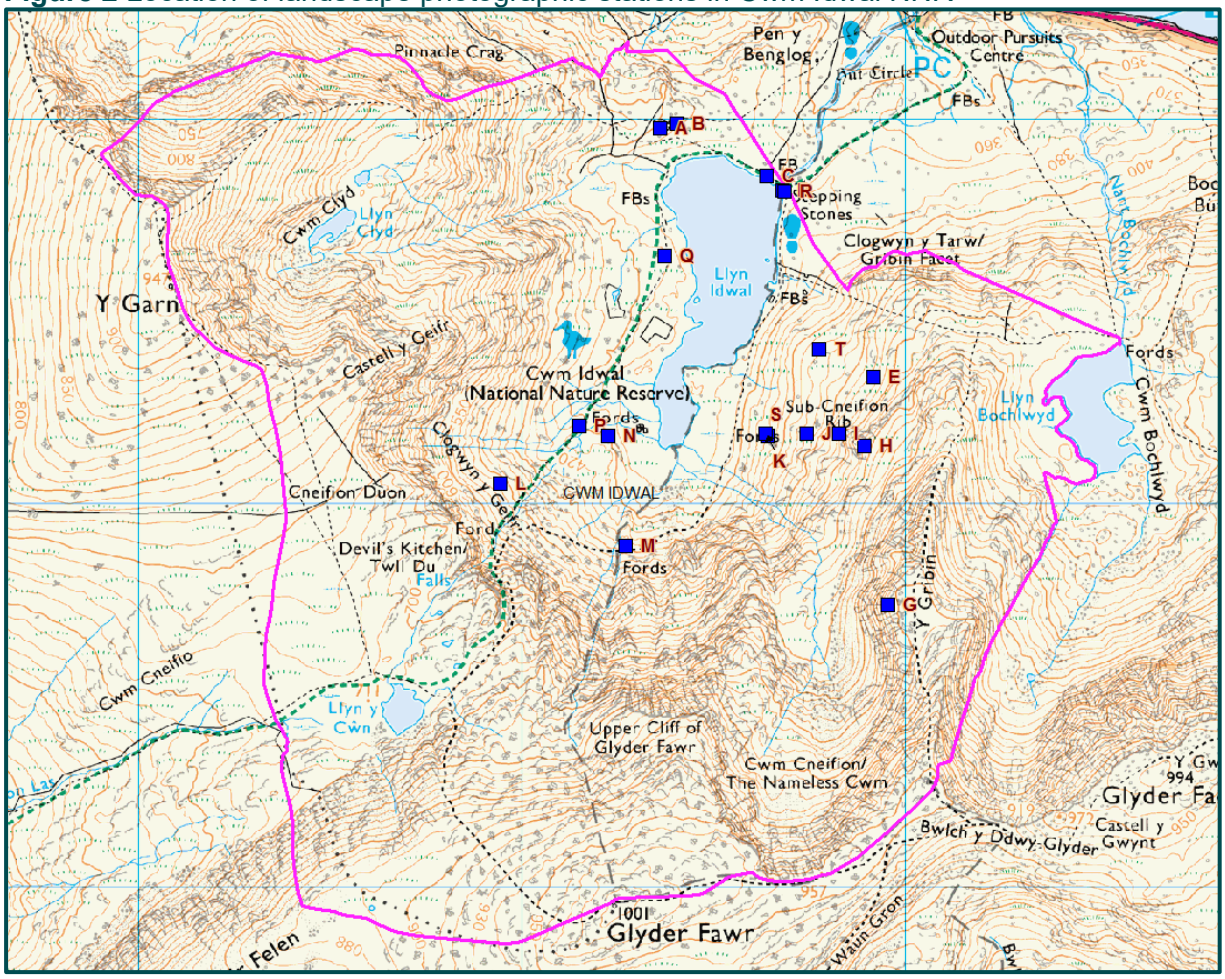
4.3. Plot and quadrat photography

The methodology used for plot and quadrat photography was similar to that used in 2017. Quadrat photos were taken on a Samsung Galaxy XCover Pro using the directions from Gritten (2013) and Turner (2018). A wider-angle photograph

was taken in most cases in order to show more background detail and for several quadrats, photographs were taken in additional directions, to aid future relocation.

Plot photographs were taken using the locations and bearings indicated in the annotated Plot/Quadrat Sketch Plans from earlier surveillances.

Figure 2 Location of landscape photographic stations in Cwm Idwal NNR



5. Assessment of 1999-2022 changes

5.1. Analysis of sample cell, quadrat, and plot frequencies (2006-2022)

Following the completion of field recording, all the 2022 frequency data recorded was entered into two Excel 2016 workbooks together with the field data from the earlier 2006, 2009, 2012, and 2017 recordings.

Comparisons were made at the cell, quadrat, plot, and site level over the periods 2006-2022, and 2017-2022. The significance of changes for all the recorded species at the quadrat and plot data level was assessed using McNemar's test, and at the site level for mean cell occupancy using Wilcoxon's signed rank test for paired means.

Additional variables were generated from the data for cell sums of dwarf shrubs (for the Heathland species variable), Graminoids, and Calcareous grassland forbs. Further, the occurrence of any heathland species in a cell was noted. The significance of changes in these variables at the quadrat and plot level was assessed in a similar manner as above.

5.2. Analysis of quadrat cover (1999-2022)

Species cover data was entered into a single Excel 2016 workbook together with data from 1999, 2004, and 2017. All quadrat referrals to the NVC made in the field were checked and in one or two cases amended. Assignments were made by matching the main species present in each quadrat to the constants and dominants of the various upland communities (in Rodwell *et al.*, 1991, 1992) using between-community comparison tables to identify important differential "indicator" species which aid in community placement. Quadrat assignments for the 1999, 2004, and 2017 data were taken from Turner (2018).

Each 2022 quadrat was further assigned to the relevant Phase 1 habitat category to which the NVC community is referable, in order to summarize broader habitat changes.

In order to assess the overall pattern of changes in vegetation composition across the site, samples were grouped according to their NVC community in 1999, 2004, 2017, and 2022. A similar procedure was carried out for Phase 1 habitats. Transitions between different NVC communities over the periods 1999-2017 and 2017-2022 were summarized.

5.3. Analysis of vegetation height data (2012-2022)

Vegetation height data was recorded for 11 plots in 2022 and was entered into a single Excel 2016 workbook together with the data from the 2012 and 2017 recordings. The earlier data was retrospectively standardised by rounding down the height readings to the nearest centimetre.

The data for each plot was assessed for normality (using the w/s test) and as at many of the plots the distribution was non-normal, a non-parametric approach (Mann-Whitney U-test) was used.

5.4. Analysis of landscape photographs (2006-2022)

Because photographs from different years were taken under different light and weather conditions, and in some cases from slightly different locations, making direct comparisons difficult, the analysis was undertaken solely by looking for gross differences in dwarf-shrub or graminoid cover.

5.5. Analysis of sheep and goat count data

Sheep numbers for the different parts of the site were averaged over the separate areas for August, and a final average count for the lower part of the site was obtained by summing these averages. The recording period in 2022 was longer than in 2017, including several counts in the spring, and the results of these were given as maximum numbers in each area.

5.6. Analysis using Ellenberg indicator values

In order to interpret some of the changes, weighted average Ellenberg indicator values (EIV) calibrated for British plants (Hill *et al*., 1999) were used. These indicator values are ordinal variables which subjectively indicate where the optimal realized ecological niche exists on a scale of 1 to 9 (or 1 to 12 for moisture) for the variables light (L), moisture (F, from German Feuchtigkeit), reaction (R, soil pH or water pH), nitrogen (N, soil fertility) and salt (S). For each quadrat, the average indicator value was calculated using the indicator values of all the species weighted according to percentage cover. All the vascular plants and bryophytes could be used, and separate assessments made for the two levels. The cell frequency data wasn't used for this assessment as there are fewer species recorded, and the period of recording only covers 2006-2022, whereas for percentage cover it is 1999-2022.

6. Results

6.1. Results: Quadrat cell frequency recording (lower-level plots only)

Table 5 is a summary of average cell count per plot for rerecordings between 2006 and 2022, and the trends and significance of the differences (2006-2017, 2006-2022, and 2017-2022) using McNemar's test for matched samples and the Wilcoxon signed-rank test for paired means. Table 4 is a summary of various heathland and grassland variables.

Table 6 shows significant changes at individual lower-level plots (2006 v 2022, 2017 v 2022) using McNemar's test alone.

McNemar's test was used in all the previous surveillance recordings in Cwm Idwal, and in it, the number of cell changes from present to absent, are compared with the number from absent to present, and the statistic calculates differences between these two indicating whether a trend is significant or not.

The Wilcoxon signed-rank test for paired means was used by Gritten (2013) and Turner (2018) and is a non-parametric test which examines whether the population mean ranks differ significantly. Given a reasonable level of homogeneity in the vegetation around the quadrat, this method is probably less prone to positional error in this situation than McNemar's test.

Species have been grouped according to their structure for discussion purposes, from dwarf shrubs, club-mosses, sedges and rushes, grasses, forbs, and then ferns, mosses, and lichens followed by abiotic variables.

Significance values for each species were calculated using both methods for each species. As multiple comparisons have been made, significance values of only $p < 0.05$ have in general been ignored unless supported by a higher-level significance using the other test. McNemar's test appears to be more sensitive to change than the Wilcoxon test.

For dwarf shrubs, the significant increases in frequency for *Calluna vulgaris* over the period 2006-2017, are reproduced over the period 2006-2022, but over the period 2017-2022, the trend shows a significant decrease, which is mainly the result of a significant decrease at Plot 28. For *Vaccinium myrtillus*, the significant increase over all plots is also replicated, but at the individual plot level Plots 4, 6, and 7 (all dry heath/acid grassland) show significant decreasing trends, and this is also true for Plots 4 and 6 over the period 2017-2022. Over the longer period, both *Erica cinerea* and *E. tetralix* show strong increasing trends, which is mainly driven by increases in Plots 4 (dry heath) and 28 (blanket bog/wet heath) respectively over 2017-2022.

No tree species were recorded in any of the quadrats.

For clubmosses, there are no significant changes in the significance of trends over the two longer periods.

Sedges (*Carex* sp.) continue to show a significant decline in 2022, both in relation to 2006 and 2017, particularly in plots which were dry heath, or dry heath/acid grassland in 2022. Of the other non-grass graminoids, only *Trichophorum germanicum* showed a significant trend with a decline in 2022 mainly due to changes in Plot 21 in which wet heath has changed to marshy grassland.

Both the grass species specifically monitored (*Molinia caerulea*, *Nardus stricta*) showed significant trends. *Nardus* has reproduced in 2022 the downward trend seen in 2017 and also has shown a significant decrease since 2017. The pattern of change across the different plots is similar to 2017, but in addition, significant declines in Plots 4 (dry heath) and 26 (acid/calcareous grassland) were noted. For *Molinia* the long-term direction of change has reversed from positive (over 2006-2017) to negative (over 2006-2022) due mainly to changes on Plots 21 (marshy grassland/acid flush) and 28 (blanket bog/wet heath). The trend for Other graminoids remains broadly the same in significance and direction

As in 2017, the responses of forbs have been mixed. Species typical of upland acid grassland (*Galium saxatile, Potentilla erecta, Polygala serpyllifolia*) continue to show significant downward trends. Amongst the calcicolous herbs the decreasing trend seen from 2006-2017, has continued for *Thymus drucei, Prunella vulgaris,* and *Viola riviniana.* Other herbs such as *Achillea millefolium, Euphrasia* sp., and *Campanula rotundifolia* also show a decline over the longer period.

At the individual plot level in 2022, *G. saxatile* now shows a significant downward trend in Plots 4 (dry heath), 13 (dry heath/acid grassland), and 21 (marshy grassland/acid flush). The calcicolous forbs *Thymus drucei* and *Viola riviniana* continue to show a downward trend, particularly in Plot 26 (acid/calcareous grassland in 2022). Less calcicolous herbs such as *Achillea millefolium* and *Campanula rotundifolia* show a similar pattern in Plot 26. Forbs showing an increase are limited to *Narthecium ossifragum* (mainly at Plot 28 (blanket bog/wet heath)), and *Hypericum pulchrum* at Plot 6 (dry heath/acid grassland with calcareous flushing).

Ferns showed a significant increase since 2006, but individual species weren't recorded in cells.

Sphagnum species combined continue to show a significant downward trend over the period 2006-2022, due mainly to downward trends at Plots 3 (dry heath), 7 (dry heath/acid grassland) and 21 (marshy grassland/acid flush). Also, the upward trend for *Sphagnum* sp. cell frequency in Plot 28 (blanket bog/wet heath) in 2017 was not replicated in 2022. The pattern for Other bryophytes is mixed with a significant decrease over the period 2006-2022 contrasting with a significant increase since 2017. Macrolichens show a similar significant decline in 2022 compared to 2017, mainly from Plots 3, 4, 6, 14 and 15.

The abiotic variables Bare Ground, Exposed Peat, and Rock show varying responses over all time periods. There is no significant trend in Bare ground over all periods, although, over the period 2017-2022, Plot 6 (dry heat/acid grassland) showed a significant decrease, while Plot 26 (acid/calcareous grassland) showed an increase. The significant decrease in the cell frequency for Exposed Peat in 2017 was not replicated in 2022, possibly due to a weakly significant increase at Plot 28 (blanket bog/wet/heath).

In 2022, a significant decrease in both Litter and Sheep Droppings was seen.

The Heathland variable is the average cell frequency per quadrat in which 1 or more dwarf-shrub species occurs. The Heathland Sum variable is the additive sum of occurrences of all dwarf-shrub species occurring in each cell. Similarly, the Graminoid Sum variable is the sum of all graminoid occurrences.

As in Turner (2018), the Calcareous Grassland variable was modified from the version used by Gritten (2012), with species having an Ellenberg Reaction (R) value greater than or equal to 5 being removed.

Table 4 Summary of average cell count per plot (2006-2022), and the significance of changes for heathland and grassland variables for all lower-level plots between 2006, 2017, and 2022.

Variable	Average cell count/plot					Differences of means		Wilcoxon signed rank test trend and significance			McNemar's test trend and significance		
	2006	2009	2012	2017	2022	2022 - 2006	2022 - 2017	2006 - 2017	2006 - 2022	2017 - 2022	2006 - 2017	2006 - 2022	2017 - 2022
HEATH	10.22	10.75	11.98	12.65	14.07	3.85	1.42	+, *	.	+, **	+, ***	+, ***	+, ***
HEATH SUM	16.02	16.11	18.29	19.89	21.36	5.35	1.47	+, *	.	+, **	+, ***	+, ***	+, ***
GRAMINOID SUM	46.65	43.55	43.47	41.80	35.15	-11.51	-6.65	-, **	.	.	-, ***	-, ***	-, ***
CALC GRASS SUM	12.09	10.69	6.60	7.22	6.91	-5.18	-0.31	-, *	.	-, ***	-, ***	-, ***	-, *

Significance abbreviations: ·₌ not significant, * = significant at p < 0.05, ** = significant at p < 0.01, *** = significant at p < 0.001.

In 2022, the Heathland and Heathland Sum variables both replicated the highly significant increases seen over 2006-2017. In addition, both showed a highly significant increase over 2017-2022. The Graminoid Sum variable shows a significant decrease over all periods using McNemar's test but not by the

Wilcoxon test. Significant decreases were seen in 2022 for Plots 4, 6, 7, 13, 15, and 26, and an increase at Plot 3. The Calcareous Grassland Sum variable showed a significant decrease over the periods 2006-2022 and 2017-2022. At the individual plot level, this was seen mainly in Plots 21, 23, and 26, with a suggestion also at Plots 3 and 15.

6.2. Results: Quadrat percentage cover changes (lower-level plots)

Percentage cover data for all 55 quadrats from the 11 plots are presented in Appendix 2 together with the percentage cover of bare soil and bare rock. Each of the quadrats was assigned to the NVC, and also to the Phase 1 habitat classification (Table 8). Mean cover was calculated for each species for each plot and is shown in Table 7.

Over all the lower-level plots, the average number of species per quadrat has shown highly significant rises ($p < 0.001$, using t-test) from 14.4 in 1999 to 18.3 in 2017, and to 16.9 in 2022. The decrease between 2017 and 2022 is also significant but less so ($p < 0.05$). Whether this reflects an observer difference or is a real effect is not determinable, apart from between 2017 and 2022.

Changes up to 2017 were outlined in Turner (2018), and are not repeated here in detail, except to note that by 2017, several original Calcareous Grassland (CG) plots had changed to Acid Grassland (AG), and some original AG plots had changed to dry heath (DH). The latter change was part of a general increase in cover of heathland species over the time period 1999-2017.

Changes in species percentage cover up to 2022 broadly agree with changes in cell frequency, but with additional information on individual species which are grouped in the cell frequency recording e.g., Carices, Other Graminoids, bryophytes, etc.

Only the more ecologically significant changes are mentioned below.

Between 2017 and 2022, the progressive increase in *Calluna* cover seen from 1999 has been halted, and in some plots there has been a reduction in cover, but with commensurate increases in the cover of *Vaccinium myrtillus* and *Empetrum nigrum*. Although not noted in Table 7, there were more records of dead *Calluna* in 2022 than in previous years, and elsewhere in the reserve there were several areas of dieback, possibly due to Heather Beetle (*Lochmaea suturalis*) in either 2020 or 2021. The reduction in *Calluna* cover is responsible for a number of changes from dry heath back to acid grassland seen in Table 8.

Table 5 Summary of mean cell frequency values (2006-2022), and the (non-parametric) significance of changes between 2006, 2017, and 2022.

Species/variable	Average cell count/plot					Differences of means		Wilcoxon signed rank test trend and significance			McNemar's test trend and significance		
	2006	2009	2012	2017	2022	2022 - 2006	2022 - 2017	2006 - 2017	2006 - 2022	2017 - 2022	2006 - 2017	2006 - 2022	2017 - 2022
Calluna vulgaris	2.93	2.91	5.22	6.02	5.55	2.62	-0.47	+, *	.	-, ***	+, ***	+, ***	-, *
Empetrum hermaphroditum	0.00	0.00	0.00	0.05	0.09	0.09	0.04	.	.	.	.	.	.
Empetrum nigrum	3.18	3.02	2.33	2.58	3.02	-0.16	0.44	.	.	.	-, ***	.	+, *
Erica cinerea	0.80	0.58	1.07	1.00	1.53	0.73	0.53	.	.	.	.	+, ***	+, **
Erica tetralix	0.73	0.76	1.02	0.85	1.07	0.35	0.22	.	.	.	.	+, ***	+, *
Vaccinium myrtillus	8.38	8.84	8.65	9.38	10.11	1.73	0.73	+, ***	+, **	+, ***	+, ***	+, ***	+, **
Diphasiastrum alpinum	0.45	0.53	0.40	0.44	0.27	-0.18	-0.16	.	.	.	.	.	.
Huperzia selago	0.49	0.18	0.15	0.04	0.02	-0.47	-0.02	-, **	.	.	-, ***	-, ***	.
Lycopodium clavatum	0.07	0.00	0.04	0.05	0.02	-0.05	-0.04	.	.	.	.	.	.
Selaginella selaginoides	0.16	0.16	0.05	0.05	0.05	-0.11	0.00	.	.	.	.	.	
Carex sp.	0.00	5.96	5.25	6.04	3.69	3.69	-2.35	-, ***	-, *	-, *	-, ***	-, ***	-, ***
Eriophorum angustifolium	1.71	1.53	1.80	1.78	1.62	-0.09	-0.16	.	.	.	.	.	.
Eriophorum vaginatum	0.00	0.00	0.02	0.02	0.00	0.00	-0.02	.	.	.	.		.
Juncus sp.	1.00	0.85	1.20	0.89	0.73	-0.27	-0.16	.	.	.	.	-, *	.
Trichophorum cespitosum	1.35	1.38	0.75	1.00	0.76	-0.58	-0.24	.	.	.	.	-, **	.
Molinia caerulea	2.69	4.62	2.20	3.07	2.35	-0.35	-0.73	+, *	.	.	+, ***	-, **	-, ***
Nardus stricta	10.78	7.96	11.22	8.55	6.13	-4.65	-2.42	-, **	.	-, *	-, ***	-, ***	-, ***
Achillea millefolium	1.05	0.82	0.51	0.36	0.40	-0.65	0.04	.	.	.	-, ***	-, ***	.
Alchemilla sp.	0.31	0.20	0.00	0.13	0.15	-0.16	0.02	.	.	.	-, **	-, *	.
Campanula rotundifolia	1.62	1.18	0.67	1.00	1.02	-0.60	0.02	.	.	.	-, ***	-, ***	.
Cardamine pratensis	0.09	0.09	0.20	0.13	0.00	-0.09	-0.13	.	.	.	.	.	-, *
Cerastium fontanum	0.15	0.04	0.09	0.15	0.11	-0.04	-0.04	.	.	.		.	.
Cirsium palustre	0.53	0.22	0.33	0.47	0.67	0.15	0.20	.	.	.	.	.	.
Dactylorhiza sp.	0.05	0.04	0.02	0.02	0.02	-0.04	0.00	.	.	.	.	.	
Drosera rotundifolia	0.35	0.27	0.27	0.29	0.40	0.05	0.11	.	.	.	.	.	.
Epilobium brunnescens	0.07	0.00	0.00	0.02	0.00	-0.07	-0.02	.	.	.	.	.	.
Euphrasia sp.	0.73	0.13	0.27	0.44	0.36	-0.36	-0.07	.	.	.	-, *	-, **	.
Filipendula ulmaria	0.02	1.82	0.04	0.00	0.00	-0.02	0.00	.	.	.	.	.	
Galium saxatile	15.89	13.87	13.53	14.69	13.44	-2.45	-1.25	-, ***	-, **	-, ***	-, ***	-, ***	-, ***
Hieracium sp.	0.04	0.02	0.02	0.00	0.00	-0.04	0.00	.	.	.	.	.	
Hypericum pulchrum	0.04	0.05	0.05	0.11	0.22	0.18	0.11	.	.	.	.	+, **	.
Hypochoeris radicata	0.00	0.00	0.02	0.00	0.00	0.00	0.00	.	.	.			
Lysimachia nemorum	0.25	0.20	0.15	0.22	0.36	0.11	0.15	.	.	.	.	.	.
Narthecium ossifragum	1.35	1.49	1.65	1.87	1.96	0.62	0.09	.	.	.	+, ***	+, ***	.
Oxalis acetosella	0.31	0.45	0.24	0.36	0.31	0.00	-0.05	.	.	.	.		.
Pedicularis sylvatica	0.00	0.00	0.05	0.00	0.00	0.00	0.00	.	.	.			
Pinguicula vulgaris	0.07	0.05	0.00	0.02	0.00	-0.07	-0.02	.	.	.	.	.	.
Plantago lanceolata	1.53	1.00	0.69	0.87	0.45	-1.07	-0.42	-, ***	.	.	-, ***	-, ***	-, ***
Polygala serpyllifolia	1.16	0.60	0.53	0.73	0.36	-0.80	-0.36	.	-, ***	.	-, *	-, ***	-, **
Potentilla erecta	5.69	4.29	4.53	5.00	4.53	-1.16	-0.47	.	-, ***	-, ***	-, **	-, ***	.
Potentilla sterilis	0.02	0.00	0.00	0.00	0.02	0.00	0.02	.	.	.	.	.	.
Prunella vulgaris	0.51	0.38	0.31	0.36	0.24	-0.27	-0.13	.	.	.	.	-, **	.
Ranunculus acris	0.38	0.45	0.20	0.33	0.55	0.16	0.22	.	.	.	.	.	+, *
Ranunculus bulbosus	0.00	0.04	0.13	0.00	0.00	0.00	0.00	.	.	.			
Rumex acetosa	0.02	0.07	0.07	0.04	0.00	-0.02	-0.04	.	.	.	.	.	.
Scorzoneroides autumnalis	0.07	0.22	0.04	0.15	0.11	0.04	-0.04	.	.	.	.	.	.
Sedum anglicum	0.40	0.25	0.44	0.31	0.13	-0.27	-0.18	.	.	.	.	-, **	-, *
Solidago virgaurea	0.04	0.05	0.02	0.11	0.02	-0.02	-0.09	.	.	.	.	.	.
Taraxacum officinale agg.	0.04	0.02	0.02	0.00	0.00	-0.04	0.00	.	.	.	.	.	
Thymus drucei	2.13	1.56	1.00	1.00	1.22	-0.91	0.22	.	.	.	-, ***	-, ***	.
Trifolium repens	0.40	0.29	0.38	0.16	0.31	-0.09	0.15	.	.	.	-, **	.	.
Viola palustris	0.02	0.00	0.00	0.00	0.00	-0.02	0.00	.	.	.	.	.	
Viola riviniana	1.02	1.29	0.84	0.58	0.36	-0.65	-0.22	.	.	.	-, **	-, ***	.
Sphagnum sp.	4.71	4.82	3.36	4.09	2.15	-2.56	-1.95	-, ***	-, ***	-, **	-, **	-, ***	-, ***
Ferns	0.51	0.51	0.89	0.62	0.69	0.18	0.07	.	+, ***	.	.	.	.
Other graminoids	21.45	21.24	21.04	20.45	19.87	-1.58	-0.58	-, ***	-, ***	-, ***	-, ***	-, ***	-, *
Other bryophytes	22.29	22.78	21.55	21.60	21.95	-0.35	0.35	-, ***	-, ***	+, ***	-, **	.	.
Lichens	3.85	4.05	4.11	0.80	0.62	-3.24	-0.18	.	.	-, ***	-, ***	-, ***	.
Bare ground	0.35	0.40	0.80	0.55	0.40	0.05	-0.15	.	.	.	.	.	.
Exposed peat	1.65	1.65	1.87	1.45	1.58	-0.07	0.13	.	.	.	-, *	.	.
Rock	5.22	4.87	4.00	3.49	3.02	-2.20	-0.47	.	-, *	-, ***	-, ***	-, ***	-, *
Litter	23.09	24.58	21.65	23.51	7.69	-15.40	-15.82	+, ***	.	.	.	-, ***	-, ***
Sheep Droppings	1.91	1.53	1.09	0.80	0.53	-1.38	-0.27	-, **	-, *	-, ***	-, ***	-, ***	.

Mean frequency values have been calculated for all quadrats in all plots for the years 2006, 2009, 2012, and 2017. Significance abbreviations: · = not significant, * = significant at $p < 0.05$, ** = significant at $p < 0.01$, *** = significant at $p < 0.001$.

Table 6 Summary of trends and significance of mean cell frequency values for lower-level plots (2006 v 2022, 2017 v 2022)

	Trend and significance of changes in cell counts (2006 to 2022)											Trend and significance of changes in cell counts (2017 to 2022)										
Plot no	**3**	**4**	**6**	**7**	**13**	**14**	**15**	**21**	**23**	**26**	**28**	**3**	**4**	**6**	**7**	**13**	**14**	**15**	**21**	**23**	**26**	**28**
Phase 1 (2006)	AG	DH	DH	DH	CG/ AG	CG/ AG	AG	AF/ WH	AG	CG	BB/ WH											
Phase 1 (2017)												AG/ DH	DH	DH	DH	DH/ AG	AG/ CG	AG	AF/ WH	DH/ AG	AG/ CG	BB/ WH
Phase 1 (2022)	DH	DH	DH/ AG	DH/ AG	DH/ AG	AG/ CG	DH/ AG	MG/ AF	AG	AG/C G	BB/ WH	DH	DH	DH/ AG	DH/ AG	DH/ AG	AG/ CG	DH/ AG	MG/ AF	AG	AG/ CG	BB/ WH
Species																						
Calluna vulgaris	.	.	+, ***	+, ***	+, ***	.			+, ***	.	.	.	.		.	.	.		.	.		-, ***
Empetrum hermaphroditum		.											.									
Empetrum nigrum	+, ***	.		-, ***							+, *	+, **	.		.							.
Erica cinerea		+, ***	.	.	+, **								+, ***	.	.	.						.
Erica tetralix											+, ***											+, *
Vaccinium myrtillus	.	-, ***	-, **	-, **	+, ***	+, ***	+, ***		+, ***	.	.	.	-, ***	-, ***	.	.	+, **	+, **		+, ***	.	.
Diphasiastrum alpinum	-, ***	+, **										.	.									
Huperzia selago	-, ***			.		.					.						.					
Lycopodium clavatum									.											.		
Selaginella selaginoides			.																			
Carex sp.	.	.	-, ***		-, ***	.	-, ***	-, ***	.	-, ***	.	.	.	-, **	.	-, **	.	.	-, ***	-, *	.	.
Eriophorum angustifolium								-, ***			+, ***								-, *			.
Eriophorum vaginatum																			.			
Juncus sp.	.	.						.			-, *		.						-, *	.		.
Trichophorum cespitosum								-, ***		.	.								-, *		.	
Molinia caerulea			.					-, ***		.	.			.					-, ***		.	-, **
Nardus stricta	+, **	-, ***	-, **	-, ***	-, ***	.	-, **	-, ***	-, *	-, ***	-, *	.	-, ***	.	-, ***	-, ***	.	.	.	.	.	
Achillea millefolium					.		.			-, ***											.	
Alchemilla sp.						.				.							.				.	
Campanula rotundifolia	.				.	.				-, ***				.		.	.				.	
Cardamine pratensis						.											-, *					
Cerastium fontanum						.	.														.	
Cirsium palustre			+, *			.	.			.				.			+, **	.			.	
Dactylorhiza sp.								.														
Drosera rotundifolia											.											.
Epilobium brunnescens						.											.					
Euphrasia sp.	-, *		.			-, **	.			.							.				.	
Filipendula ulmaria						.																
Galium saxatile	.	-, ***	.	-, *	-, ***	.	.	-, ***	.	-, ***	.	.	.	-, ***	-, ***	.	-, *	.	.	-, **	+, ***	-, **	
Hieracium sp.			.																			
Hypericum pulchrum			+, **											.								
Hypochoeris radicata																						
Lysimachia nemorum			.			+, *								.			.					
Narthecium ossifragum								.			+, ***								.			.
Oxalis acetosella			.	.		.								.	.		.					
Pedicularis sylvatica																						
Pinguicula vulgaris			.											.								
Plantago lanceolata										-, ***											-, ***	
Polygala serpyllifolia			.	.	.		.	-, ***	-, **					.		-, *		.	.	.		.
Potentilla erecta			+, *	.	-, **	.	.	-, ***	.	+, *	.			+, **	.	-, *	.	.	-, ***	.	.	.
Potentilla sterilis			.			.								.								
Prunella vulgaris						.				-, ***				-, *			.					
Ranunculus acris						+, *				.							.					
Ranunculus bulbosus																						
Rumex acetosa						.											.					
Scorzoneroides autumnalis										.											.	
Sedum anglicum					.	-, *											-, *					
Solidago virgaurea	.											.		.								
Taraxacum officinale agg.						.				.												
Thymus drucei	.		.		.					-, ***		+, *		.			.				.	
Trifolium repens						.				.							.				.	
Viola palustris										.												
Viola riviniana			.		.	-, **				-, ***							.				-, ***	
Sphagnum sp.	-, ***	.	.	-, ***		.		-, ***		.	.	-, *	.	.	-, ***	.	.		-, ***			-, ***
Ferns	+, *		.	.	.	.			.			+, *			.		.			.		
Other graminoids		.	-, ***	-, **	-, ***	.	.	.	.		.		.	.	-, **	-, **	.	.	.			.
Other bryophytes		.	.	.	-, *	.	.	+, **	.	-, ***	+, *		.	.	.	.	+, *	.	+, **	.	.	.
Lichens	-, ***	-, ***	-, ***	.	-, *	-, ***	-, ***				.	-, *	.	.	.	.	.	+, *				.
Variable																						
Bare ground			-, ***							+, ***		-, *									.	
Exposed peat		.									.			.								+, *
Rock	-, ***	-, ***	-, ***	-, ***	.	-, ***				.	.		-, *	-, **	-, **	.	.	.			.	.
Litter	-, ***	-, ***	-, ***	.	-, ***	-, ***	-, ***		-, ***	-, ***	-, ***	-, ***	-, ***	-, ***	-, ***	-, ***	-, ***	-, ***		-, ***	-, ***	-, ***
Sheep Droppings	.	-, ***	.	.		-, ***	.	.	.	-, ***		.	-, **	.	+, *			.	.		.	
HEATH	.	.	+, **	.	+, ***	+, ***	+, ***		+, ***	.	+, ***	.	.		.	+, **	+, **	+, **	.	+, **	.	
HEATH SUM	+, **	.	.	.	+, ***	+, ***	+, ***		+, ***	.	+, ***	+, **	.	.	.	+, **	+, **	+, **	.	+, ***	.	-, **
GRAMINOID SUM	+, *	-, ***	-, ***	-, ***	-, ***	.	-, ***	.	.	-, ***	.	.	-, **	.	-, **	-, **		-, *	-, *	-, *	-, *	.
CALC GRASS SUM	-, *			.	.	.	-, *	-, ***	-, **	-, ***		+, *		.		.	.	.	.	.	-, *	.

Significance tested using McNemar's Test, abbreviations: ·: not significant, * : significant at p < 0.05, ** : significant at p < 0.01, *** : significant at p < 0.001. Phase 1 abbreviations: AF - acid flush, AG - acid grassland. BB - blanket bog, CG - calcareous grassland, DH - dry heath, MG - marshy grassland, WH - wet heath.

As noted above, no tree species were recorded in any quadrats.

Changes in the cover of ferns and clubmosses were not significant.

As in the cell frequency results, *Carex* species have decreased in cover, over both 1999-2022 and 2017-2022. *C. pilulifera* showed a significant decline over both periods, and over the latter period, *C. panicea* also show a significant decrease.

Various grass species have exhibited a reduction in cover since 2017, but the actual changes are mostly small. *Nardus stricta* shows weak evidence for a continuing decline ($p < 0.05$).

Amongst the forb species recorded, most show no significant change over both periods except, *Potentilla erecta* (significant increases over both periods), *Galium saxatile* (increase over 1999-2022, decrease over 2017-2022), *Polygala serpyllifolia* (increase over 1999-2022, no significant change over 2017-2022) and *Narthecium ossifragum* (weakly significant increase over 1999-2022, no significant change over 2017-2022). Overall, forbs as a group (represented in the table by the Forb Sum), show a significant decrease, over both 1999-2022 and 2017-2022.

Amongst the non-*Sphagnum* bryophytes over 2017-2022, some of the more typical heathland species (e.g., *Hypnum jutlandicum*, *Pleurozium schreberi, Rhytidiadelphus loreus, R. squarrosus*, and *Thuidium tamariscinum*) have shown small but significant increases in cover since 2017. A very small decrease in cover for *Racomitrium* lanuginosum, over the same period is flagged up as highly significant.

Amongst the Sphagna, none of the species taken individually shows a significant change over either period, but taken together (as the variable Sphagnum Sum) there has been a decrease.

Liverwort and most microlichen species show no significant change over both periods, except for *Cladonia coccifera* which shows a significant decrease over 1999-2022.

Bare Rock shows a significant decrease since 2017. Bare ground and Exposed Peat show no significant change over both periods.

Table 7 Mean percentage cover values for all lower-level plots combined for 1999, 2004, 2017, and 2022, and significance trends for 1999-2022 and 2017-2022.

Species	1999		2004		2017		2022		Trend, significance	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	1999-2022	2017-2022
Sorbus aucuparia (sd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Calluna vulgaris	2.7	1.5	4.0	1.5	14.3	3.5	13.9	3.8	+, *	-, ***
Empetrum hermaphroditum	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	.	.
Empetrum nigrum	3.9	1.1	3.9	1.2	1.9	0.6	3.4	1.0	-, ***	+, **
Erica cinerea	0.9	0.7	1.0	0.8	0.7	0.3	1.3	0.5	.	.
Erica tetralix	1.1	0.8	1.7	1.1	0.5	0.3	0.3	0.2	.	.
Vaccinium myrtillus	7.8	1.7	8.5	1.9	9.0	1.7	12.4	2.3	+, *	+, *
Vaccinium vitis-idaea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Asplenium adiantum-nigrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Blechnum spicant	0.8	0.3	0.6	0.3	0.5	0.3	0.7	0.4	.	.
Cryptogramma crispa	0.2	0.1	0.3	0.2	0.1	0.0	0.1	0.0	.	.
Diphasiastrum alpinum	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	.	.
Dryopteris dilatata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Dryopteris oreades	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Huperzia selago	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	.	.
Hymenophyllum wilsonii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Lycopodium clavatum	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	.	.
Oreopteris limbosperma	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	.	.
Selaginella selaginoides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Carex binervis	0.2	0.1	0.5	0.4	0.1	0.1	0.2	0.1	.	.
Carex caryophyllea	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	.	.
Carex canescens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Carex demissa	0.7	0.3	0.4	0.1	0.3	0.1	0.2	0.1	.	.
Carex echinata	0.0	0.0	0.3	0.1	0.1	0.1	0.0	0.0	.	.
Carex nigra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Carex panicea	2.0	0.6	0.9	0.3	1.0	0.4	0.4	0.2	.	-, **
Carex pilulifera	1.6	0.5	1.6	0.4	0.9	0.3	0.6	0.2	-, ***	-, ***
Carex pulicaris	0.4	0.3	0.1	0.1	0.3	0.2	0.4	0.3	.	.
Eriophorum angustifolium	0.8	0.3	2.5	1.6	2.9	1.6	1.2	0.6	.	.
Eriophorum vaginatum	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Juncus bulbosus	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	.	.
Juncus effusus	0.3	0.3	0.8	0.8	1.6	1.6	1.5	1.5	.	.
Juncus squarrosus	2.1	0.8	0.9	0.4	0.2	0.1	0.2	0.1	-, **	.
Luzula campestris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Luzula multiflora	1.1	0.4	0.5	0.2	0.2	0.1	0.2	0.1	-, ***	.
Trichophorum germanicum	1.5	0.6	1.5	0.6	0.8	0.4	0.5	0.2	.	.
Agrostis canina	0.0	0.0	0.0	0.0	0.6	0.2	0.8	0.6	.	.
Agrostis capillaris	7.9	1.4	12.5	1.8	12.1	2.6	12.1	2.4	+, ***	-, ***
Agrostis stolonifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Agrostis vinealis	2.0	0.4	4.3	0.7	4.3	0.8	3.7	0.5	+, **	-, ***
Anthoxanthum odoratum	3.6	0.6	3.2	0.6	3.4	0.7	4.5	1.1	+, ***	+, ***
Avenella flexuosa	1.5	0.5	2.8	0.7	3.9	0.9	3.2	0.7	+, *	-, ***
Cynosurus cristatus	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	.	.
Danthonia decumbens	0.1	0.1	0.4	0.2	0.4	0.1	0.2	0.1	.	.
Deschampsia cespitosa	0.0	0.0	0.3	0.2	0.8	0.7	0.1	0.0	.	.
Festuca ovina	11.1	1.1	12.0	1.3	7.7	1.2	5.7	0.9	.	-, ***
Festuca rubra	1.0	0.5	0.5	0.2	0.9	0.6	0.6	0.3	.	.
Festuca vivipara	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1	.	.
Holcus lanatus	0.9	0.4	0.7	0.3	0.7	0.4	1.1	0.6	.	.
Holcus mollis	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	.	.
Molinia caerulea	0.7	0.3	1.1	0.5	6.7	2.9	7.1	3.0	.	.
Nardus stricta	10.6	1.8	8.3	1.2	8.8	2.1	5.6	1.4	-, *	-, *
Poa annua	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Achillea millefolium	0.5	0.2	0.1	0.1	0.1	0.0	0.2	0.2	.	.
Alchemilla glabra	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	.	.
Campanula rotundifolia	0.3	0.1	0.6	0.3	0.3	0.1	0.4	0.2	.	.
Cardamine pratensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cerastium fontanum	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	.	.
Cirsium palustre	0.4	0.2	0.5	0.4	0.3	0.1	0.5	0.3	.	.
Dactylorhiza maculata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Drosera rotundifolia	0.2	0.1	0.0	0.0	0.2	0.1	0.1	0.1	.	.
Epilobium brunnescens	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Euphrasia agg.	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.1	.	.

Significance testing using Wilcoxon signed-rank test on paired samples. Abbreviations: : • : not significant, * : significant at p <0.05, ** : significant at p < 0.01, *** : significant at p < 0.001.

Table 7 (continued) Mean percentage cover values for all lower-level plots combined for 1999, 2004, 2017 and 2022, and significance trends for 1999-2022 and 2017-2022.

Species	1999		2004		2017		2022		Trend, significance	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	1999-2022	2017-2022
Galium saxatile	6.1	0.8	5.9	0.6	9.4	1.1	7.1	1.0	+, ***	-, **
Hypericum pulchrum	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	.	.
Lysimachia nemorum	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	.	.
Lysimachia nummularia	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	.	.
Micranthes stellaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Narthecium ossifragum	0.4	0.2	0.6	0.4	1.9	1.0	1.5	0.7	+, *	.
Oxalis acetosella	0.1	0.0	0.1	0.0	0.2	0.1	0.1	0.1	.	.
Pinguicula vulgaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Plantago lanceolata	1.0	0.5	0.6	0.3	0.2	0.1	0.3	0.2	.	.
Polygala serpyllifolia	0.7	0.2	0.4	0.1	0.4	0.2	0.2	0.1	-, ***	.
Potentilla erecta	1.8	0.5	1.9	0.4	2.0	0.5	2.1	0.5	+, ***	+, ***
Potentilla sterilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Prunella vulgaris	0.7	0.3	0.1	0.1	0.1	0.1	0.1	0.1	.	.
Ranunculus acris	0.0	0.0	0.1	0.1	0.2	0.1	0.2	0.1	.	.
Rumex acetosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Rumex acetosella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Sagina procumbens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Scorzoneroides autumnalis	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	.	.
Sedum anglicum	0.5	0.3	0.1	0.0	0.1	0.1	0.1	0.0	.	.
Solidago virgaurea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Succisa pratensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Taraxacum officinale	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Thymus drucei	1.4	0.6	0.8	0.3	0.5	0.3	0.7	0.4	.	.
Trifolium repens	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	.	.
Tussilago farfara	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Viola riviniana	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	.	.
Amphidium mougeotii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Andreaea rothii	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	.	.
Andreaea rupestris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Anoectangium aestivum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Atrichum undulatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Aulacomnium palustre	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Blindia acuta	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	.	.
Brachythecium rutabulum	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Breutelia chrysocoma	0.9	0.5	0.4	0.1	1.1	0.5	0.7	0.3	.	.
Bryum pseudotriquetrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Calliergonella cuspidata	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	.	.
Campylopus atrovirens	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	.	.
Campylopus flexuosus	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.1	.	.
Campylopus introflexus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Ctenidium molluscum	1.9	0.9	1.0	0.6	0.0	0.0	0.0	0.0	.	.
Dichodontium palustre	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	.	.
Dicranella heteromalla	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Dicranum scoparium	0.7	0.2	0.5	0.2	0.2	0.1	0.2	0.1	-, ***	.
Drepanocladus revolvens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Hylocomium splendens	2.2	0.6	1.7	0.5	6.7	1.3	8.7	1.5	.	+, ***
Hypnum cupressiforme	5.7	1.4	5.5	1.1	0.3	0.1	0.0	0.0	.	.
Hypnum jutlandicum	0.0	0.0	0.0	0.0	2.5	0.5	3.8	0.6	.	+, ***
Kindbergia praelonga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Mnium hornum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Plagiomnium undulatum	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Plagiothecium undulatum	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.2	.	.
Pleurozium schreberi	2.3	0.6	5.0	1.0	0.7	0.4	0.8	0.2	-, ***	+, ***
Pogonatum urnigerum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Polytrichum commune	4.9	1.5	3.4	1.0	7.3	2.1	3.8	1.0	-, ***	-, *
Polytrichum formosum	0.5	0.2	0.5	0.2	0.0	0.0	0.0	0.0	-, **	.
Polytrichum juniperinum	1.4	0.7	0.9	0.4	0.1	0.1	0.1	0.1	.	.
Polytrichum piliferum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Polytrichum strictum	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	.	.
Polytrichastrum alpinum	0.0	0.0	0.0	0.0	0.3	0.2	0.4	0.3	.	.
Pseudoscleropodium purum	0.1	0.1	0.5	0.2	0.8	0.3	0.8	0.2	.	.
Racomitrium ellipticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Racomitrium fasciculare	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.1	.	.

Significance testing using Wilcoxon signed-rank test on paired samples. Abbreviations: : • : not significant, * : significant at p <0.05, ** : significant at p < 0.01, *** : significant at p < 0.001.

Table 7 (continued) Mean percentage cover values for all lower-level plots combined for 1999, 2004, 2017 and 2022, and significance trends for 1999-2022 and 2017-2022.

Species	1999		2004		2017		2022		Trend, significance	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	1999-2022	2017-2022
Racomitrium lanuginosum	2.6	0.7	1.6	0.5	1.7	0.5	1.7	0.7	-, ***	-, ***
Racomitrium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Racomitrium sudeticum	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.1	+, **	.
Rhizomnium punctatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Rhytidiadelphus loreus	2.9	0.7	2.9	0.6	3.4	0.7	4.2	0.9	+, ***	+, ***
Rhytidiadelphus squarrosus	4.8	1.0	7.0	0.9	2.2	0.5	2.3	0.5	-, ***	+, ***
Sphagnum capillifolium	2.6	1.2	1.7	0.8	1.1	0.4	1.6	0.8	.	.
Sphagnum compactum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Sphagnum cuspidatum	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	.	.
Sphagnum denticulatum	0.9	0.6	0.4	0.3	0.1	0.1	0.0	0.0	.	.
Sphagnum fallax	0.4	0.3	0.2	0.2	0.5	0.3	0.3	0.2	.	.
Sphagnum inundatum	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	.	.
Sphagnum palustre	0.6	0.3	2.0	1.4	0.7	0.3	0.1	0.1	.	.
Sphagnum papillosum	1.1	0.8	1.0	1.0	0.3	0.3	0.4	0.3	.	.
Sphagnum quinquefarium	0.0	0.0	0.0	0.0	1.5	0.9	1.1	0.6	.	.
Sphagnum squarrosum	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Sphagnum subnitens	0.1	0.1	0.0	0.0	0.1	0.1	0.4	0.3	.	.
Sphagnum tenellum	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	.	.
Thuidium tamariscinum	1.2	0.3	3.4	0.6	1.6	0.5	1.9	0.5	+, ***	+, ***
Aneura pinguis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Anthelia julacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Barbilophozia floerkii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Calypogeia fissa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Calypogeia muelleriana	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cephaloziella sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Diplophyllum albicans	0.3	0.1	0.0	0.0	0.2	0.1	0.1	0.1	.	.
Jungermannia exsertifolia ssp. cordifo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Lophozia ventricosa	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	.	.
Marsupella emarginata	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	.	.
Mylia taylorii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Nardia compressa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Pellia epiphylla	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Plagiochila asplenioides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Ptilidium ciliare	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Scapania gracilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Scapania sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Scapania undulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cetraria aculeata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cladonia arbuscula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cladonia bellidiflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cladonia coccifera	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-, **	.
Cladonia coniocraea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cladonia furcata	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	.	.
Cladonia portentosa	0.3	0.1	0.2	0.1	0.1	0.0	0.1	0.0	.	.
Cladonia pyxidata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Cladonia subcervicornis	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1	.	.
Cladonia uncialis	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	.	.
Hypogymnia physodes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Parmelia saxatilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Peltigera cf canina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Stereocaulon vesuvianum	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	.	.
alga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.
Variables										
Bare ground (%)	0.5	0.2	0.3	0.1	0.1	0.1	0.4	0.3	.	.
Bare peat (%)	3.9	2.2	3.5	2.0	2.6	1.6	3.0	1.8	.	.
Bare rock (%)	**13.3**	2.8	**11.6**	2.7	4.9	1.4	3.7	1.1	.	-, ***
Grass Sum (%)	**39.3**	3.1	**46.1**	3.4	**50.6**	4.8	**44.9**	4.4	+, **	-, *
Forb Sum (%)	**14.6**	2.1	**12.6**	1.4	**16.8**	1.6	**14.3**	1.7	-, ***	-, **
Bryophyte Sum (%)	**33.0**	2.8	**34.8**	2.8	**30.8**	2.8	**30.8**	2.6	-, **	.
Dwarf shrub sum (%)	**16.3**	3.5	**19.2**	4.0	**26.5**	4.6	**31.4**	**5.4**	.	+, **
Sphagnum Sum (%)	**6.3**	2.0	**5.4**	1.9	**5.1**	1.5	4.1	1.5	-, ***	-, ***
Max height (cm)	**18.7**	1.8	**25.3**	2.1	**26.6**	2.3	**30.2**	2.7	.	+, *
Spp number	**14.4**	0.7	**14.6**	0.7	**18.3**	0.8	**16.9**	0.7	+, *	-, **
Calluna vulgaris (dead)					0.2	0.2	0.7	0.3		.

Significance testing using Wilcoxon signed-rank test on paired samples. Abbreviations: : • : not significant, * : significant at p <0.05, ** : significant at p < 0.01, *** : significant at p < 0.001.

6.3. Results: Changes in Phase 1 and NVC communities (lower-level plots)

From Table 8, it can be seen that between 2017 and 2022 there have been a number of changes, some of which are in a different direction to those which happened prior to 2017, perhaps indicating a change in grazing intensity or grazer.

Many of the acid grassland and dry heath quadrats remained the same, but seven **U4** *Festuca-Agrostis-Galium* or **U5** *Nardus-Galium* grassland quadrats had, by 2022, become transformed into heathland (five **H18** *Vaccinium-Deschampsia* heath, one **H10** *Calluna-Erica* heath, and one **H12** *Calluna-Vaccinium* heath). In the opposite direction, three dry heath quadrats (one **H10** and two **H12**) changed to acid grassland (**U4** or **U5**). It might be coincidental, but all of these quadrats are on the W side of the reserve, relatively close together.

Other changes are more subtle, these include several former wet heath quadrats (**M15** *Scirpus-Erica* wet heath) in Plot 21, which are now perhaps best assigned to **M25** *Molinia-Potentilla* grassland. This is due to several of the characteristic species disappearing, and *Molinia* being more prominent, and having taller tussocks in 2022.

Among the Blanket Bog quadrats, one which was referred to **M1** *Sphagnum auriculatum* bog-pool was referred to **M2** *Sphagnum cuspidatum/recurvum* bog-pool in 2022. The distinction is slight and of little significance. More significant is the transformation of a quadrat of very species-poor **M3** *Eriophorum angustifolium* to a slightly less species-poor quadrat of **M1** in 2022 with the appearance of *Sphagnum denticulatum*.

The final change is from a single quadrat in Plot 26, assigned to **U13** *Deschampsia-Galium* grassland in 2017, which has lost virtually all of its *Deschampsia cespitosa* and is now closer to **U4**.

Table 8 Changes in Phase 1 habitats and NVC community for the 55 lower-level Cwm Idwal quadrats between 1999, 2004, 2017, and 2022.

		Phase 1 habitat				NVC community				NVC comm change?		
Plot	Quadrat	1999	2004	2017	2022	1999	2004	2017	2022	1999-2004	2004-2017	2017-2022
3	F1	AG	AG	AG	DH	U4	U4	U4	H18			Y
3	F2	AG	AG	DH	DH	U4	U4	H18	H18		Y	
3	F3	AG	AG	AG	DH	U4	U4	U5	H18		Y	Y
3	F4i	AG	AG	AG	DH	U4	U4	U4	H18			Y
3	F5	AG	AG	AG	DH	U4	U4	U4	H18			Y
4	F1	DH	DH	DH	DH	H18	H18	H20	H18		Y	*
4	F2	DH	DH	DH	DH	H18	H18	H18	H18			
4	F3	DH	DH	DH	DH	H18	H18	H20	H18		Y	*
4	F4	DH	DH	DH	DH	H18	H18	H18	H18			
4	F5	DH	DH	DH	DH	H18	H18	H18	H18			
6	F1	DH	DH	DH	DH	H12	H12	H10/H12	H10		Y	
6	F2	CG	CG	DH	DH	CG10	CG10/H1C	H10	H10	Y	Y	
6	F3	CG	DH	DH	AG	CG10	H10	H10	U5	Y		Y
6	F4	IR	IR	DH	DH	BG	BG	H10	H10		Y	
6	F5	DH	DH	DH	DH	H10	H10	H10	H10			
7	F1	DH	DH	AG	AG	H18	H18	U4	U4		Y	
7	F2	DH	DH	DH	DH	H18	H18	H21	H21		Y	
7	F3	DH	DH	DH	DH	H18	H18	H21	H21		Y	
7	F4	DH	DH	DH	DH	H18	H18	H21	H21		Y	
7	F5	DH	DH	DH	DH	H18	H18	H21	H21		Y	
13	F1	CG	CG	DH	AG	CG10	CG10	H12	U4		Y	Y
13	F2	AG	AG	AG	DH	U4	U4	U5	H12		Y	Y
13	F3	CG	CG	AG	DH	CG10	CG10	U4	H12		Y	Y
13	F4	AG	AG	DH	DH	U4	U4	H12	H12		Y	
13	F5	AG	AG	AG	AG	U5	U4	U5	U5	Y	Y	
14	F1	AG	AG	AG	AG	U4	U4	U4	U4			
14	F2	AG	AG	AG	AG	U4	U4	U4	U4			
14	F3	AG	CG	AG	AG	U4	CG10	U4	U4	Y	Y	
14	F4	CG	CG	AG	AG	CG10	CG10	U4	U4		Y	
14	F5	AG	AG	CG	CG	CG10	U4	CG10	CG10	Y	Y	
15	F1	AG	AG	AG	AG	U4	U4	U4	U4			
15	F2	AG	AG	AG	AG	U4	U4	U4	U4			
15	F3	AG	AG	AG	AG	U4	U4	U4	U4			
15	F4	AG	AG	AG	DH	U4	U4	U4	H18			Y
15	F5	AG	AG	AG	AG	U4	U4	U4	U4			
21	F1	F&S	F&S	F&S	F&S	M6	M6	M6	M6			
21	F2	WH	WH	WH	MG	M15	M15	M15	M25			Y
21	F3	AG	WH	WH	MG	U5	M15	M15	M25	Y		Y
21	F4	WH	WH	WH	MG	M15	M15	M15	M25			Y
21	F5	WH	WH	WH	MG	M15	M15	M15	M25			Y
23	F1	AG	AG	AG	AG	U5	U5	U5	U5			
23	F2	AG	AG	DH	AG	U5	U5	H12	U5		Y	
23	F3	AG	AG	AG	AG	U5	U4/U5	U5	U5	Y	Y	
23	F4	AG	AG	AG	AG	U5	U5	U5	U5			
23	F5	AG	AG	AG	AG	U5	U5	U5	U5			
26	F1	CG	CG	AG	AG	CG10	CG10	U5	U4		Y	
26	F2	CG	CG	TH	AG	CG10	CG10	U13	U4		Y	Y
26	F3	CG	CG	AG	AG	CG10	CG10	U4	U4		Y	
26	F4	CG	CG	AG	AG	CG10	CG10	U4	U4		Y	
26	F5	CG	CG	CG	CG	CG10	CG10	CG10	CG10			
28	F1	WH	WH	WH	WH	M15	M15	M15	M15			
28	F2	BB	BB	BB	BB	M3	M1	M1	M2	Y		
28	F3	BB	BB	BB	BB	M1	M3	M3	M3	Y		
28	F4	BB	BB	WH	WH	M3	M3	M15	M15		Y	
28	F5	WH	WH	WH	WH	M15	M15	M15	M15			

Phase 1 habitats: AG Acid Grassland, BB Blanket Bog, BG Bare Ground, CG Calcareous Grassland, DH Dry Heath, F&S Flush and Spring, IR Inland Rock, MG Marshy Grassland, TH Tall herb and fern, WH Wet Heath. For NVC community codes and names see Appendix 2.

Table 9 Summary of changes in Phase 1 habitats and NVC community for lower-level quadrats between 2017 and 2022.

Phase 1 transitions			NVC transitions		
2017	**2022**	**No**	**2017**	**2022**	**No**
AG	**AG**	17	**U4/U5**	**U4/U5**	17
AG	**DH**	7	**U4/U5**	**H18**	5
			U4/U5	**H10/12**	2
CG	**CG**	2	**CG10**	**CG10**	2
DH	**DH**	15	**H18** (+**H20**)	**H18** (+**H20**)	6
			H10/12	**H10/12**	5
			H21	**H21**	4
DH	**AG**	3	**H10/12**	**U4/U5**	3
TH	**AG**	1	**U13**	**U4**	1
F&S	**F&S**	1	**M6**	**M6**	1
BB	**BB**	2	**M1**	**M2**	1
			M3	**M3**	1
WH	**MG**	4	**M15**	**M25**	4
WH	**WH**	3	**M15**	**M15**	3
Total nos		55			55

Phase 1 habitats: AG Acid Grassland, BB Blanket Bog, BG Bare Ground, CG Calcareous Grassland, DH Dry Heath, F&S Flush and Spring, IR Inland Rock, MG Marshy Grassland, TH Tall herb and fern, WH Wet Heath. For NVC community codes and names see Appendix 2.

6.4. Results: Quadrat percentage cover changes (higher-level plots)

18 quadrats from 4 higher-level plots were recorded using percentage data alone, and individual plot summaries for 1999, 2004, and 2022 are shown in Table 10. There are too few samples to make a meaningful summary for all plots combined or to calculate statistics.

Plot 01, a high-altitude (936m OD) steeply sloping grassy site near the summit of Y Garn, can be assigned to **U4** *Festuca-Agrostis-Galium* grassland in both 1999 and 2022, although the vegetation in 2022 is closer to the **U4d** *Luzula-Rhytidiadelphus* sub-community. The main differences between the two dates are a decrease in the cover of *Vaccinium myrtillus, Galium saxatile* and the grasses *Festuca ovina* and *Agrostic capillaris*, while there has been an increase in cover of various pleurocarpous mosses such as *Hylocomium splendens, Pleurozium schreberi, Rhytidiadelphus loreus,* and *R. squarrosus*. The increase in these bryophytes is reflected in the Bryophyte Sum variable which has increased almost three-fold in value. The apparent large change in the cover of *Polytrichastrum alpinum* is probably partly an artefact of differences in the identification of *Polytrichum* s.l. species. Cover of Bare Rock and Bare ground has decreased considerably since 1999, and the maximum height of vegetation has increased (but see caveats about measurement methodology in 7.6 below).

Plot 16, a moderately sloping plot on the south-east slopes of Y Garn at 778m OD), is referable to **U5** *Nardus-Galium grassland* in both 1999 and 2022. There has been some increase in dwarf-shrub cover, principally *Empetrum nigrum,* but not quite enough to classify it as dry heath. The clubmoss *Diphasiastrum alpinum* has shown some increase in cover, but conversely, *Huperzia selago* has declined. Sedges have increased in cover overall, with the increase mainly from *Carex panicea.* Grasses have declined in cover, with a large decrease in *Nardus stricta* and a smaller decrease in *Festuca ovina* cover. Forb cover has slightly decreased mainly due to changes in the cover of *Galium saxatile.* There has been some increase in bryophyte cover, mainly due to an increase in *Racomitrium lanuginosum*. There has been no real change in maximum vegetation height. Overall, the vegetation in 2022 is similar to that recorded in 1999.

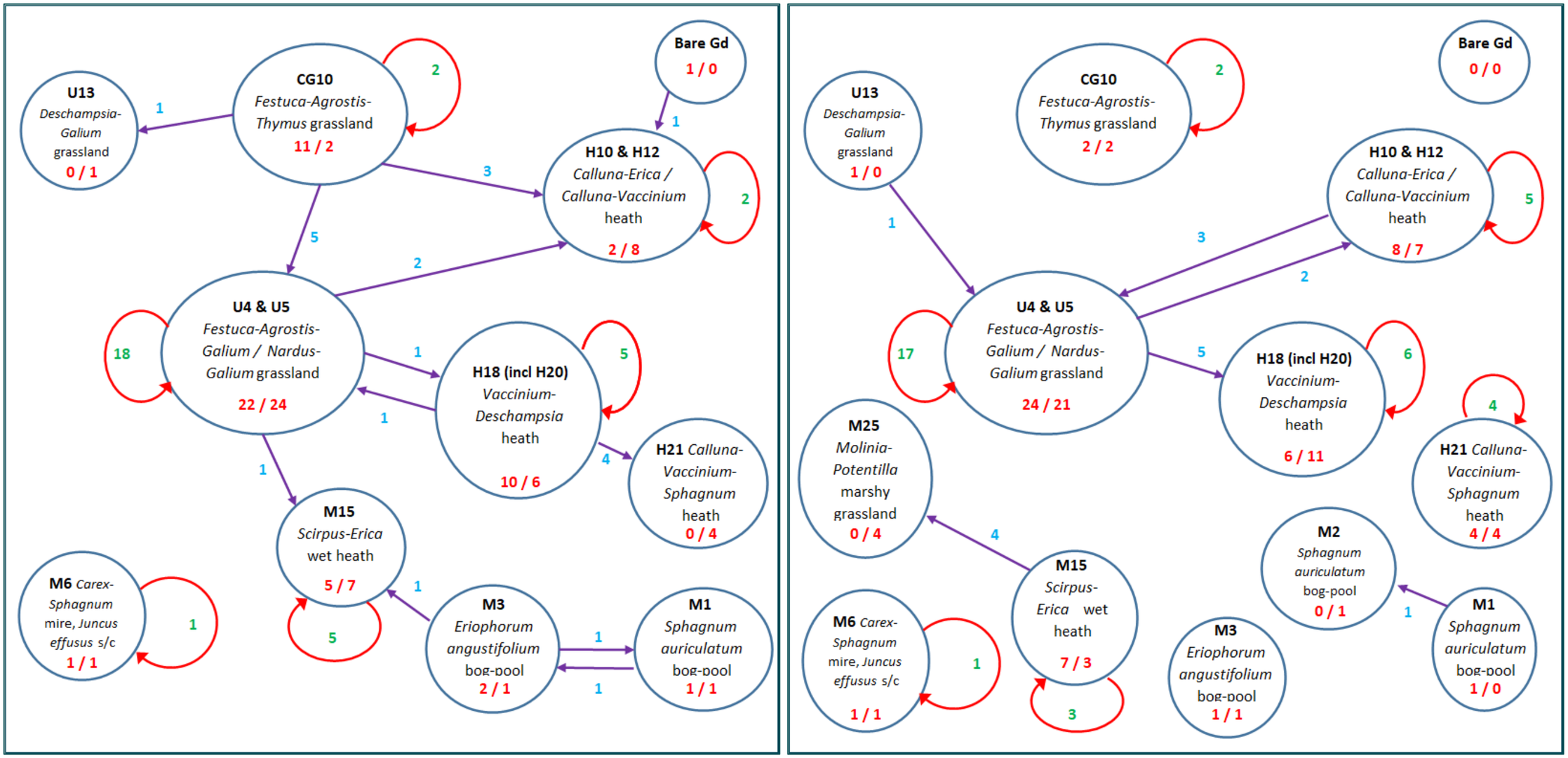
Plot 17 is located on the upper flat-topped part of the Esgair Felen ridge at 889m OD. It has very open short and sparse vegetation which could be described as Fell-field, and is difficult to assign to the NVC but is closest to **H18** *Vaccinium-Deschampsia* dry heath in both periods. The dwarf-shrub component, which is small, is comprised of *Vaccinium myrtillus* and *V. vitis-idaea*, and this has shown a decrease in cover since 1999. Grasses (*Festuca* spp.) have slightly increased, and *Galium saxatile* was recorded for the first time in 2022. There has been some decrease in the cover of *Racomitrium lanuginosum*, while *Polytrichastrum alpinum* has increased (even allowing for differences in ID). The macrolichen component has slightly increased in cover, and is more diverse than in 1999, with species such as *Cetraria aculeata* present in 2022. The cover of Bare Rock (including flat scree) remains unchanged between 1999 and 2022. The vegetation is very similar in 2022 to that in 1999, and there has been no change in maximum height.

Plot 30 is a linear plot with three quadrats along a steeply sloping bryophyte-dominated rocky streamline in the upper part of Cwm Cneifion at 725m OD. The average species number has considerably increased since 1999. There are some species from 1999 which are questionable for such a wet environment subject to fast water flow e.g., *Atrichum undulatum* and *Mylia taylorii*. Otherwise, there has been little change in overall bryophyte cover, but with increases in species such as *Anthelia julacea* and *Scapania undulata*, and decreases in *Jungermannia exsertifolia* ssp. *cordifolia*. Algae comprised 10% of cover in 2022, but it is not clear whether it was recorded or not in 1999. Among the higher plants, graminoids have increased slightly, with some calcicolous forbs being recorded for the first time in 2022 (e.g., *Thymus drucei*, *Viola riviniana*). The vegetation is assigned to a form of **M31** *Anthelia-Sphagnum* spring vegetation in both 1999 and 2022.

Figure 3 Transitions between quadrat NVC communities in Cwm Idwal

(a) 1999–2017

(b) 2017-2022



—— : Same state, —— : Change of state: **1,2,3,…** Number of quadrats in 1999 / 2017 or 2017 / 2022; **1,2,3…** Number of quadrats remaining the same; **1,2,3,…** Number of quadrats changing.

Table 10 Percentage cover values for upper surveillance plots (quadrats combined) for 1999, 2004 and 2022.

NVC community	Plot 01			Plot 16			Plot 17			Plot 30		
Species	U4e 1999	U4e R 2004	U4d 2022	U5a/e 1999	U5a/e 2004	U5e 2022	FF 1999	FF 2004	FF 2022	M31 1999	M31 2004	M31R 2022
Empetrum nigrum	0.0	0.0	0.0	**6.2**	**7.4**	**13.6**	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium myrtillus	**5.6**	3.4	1.4	**6.0**	**8.8**	**9.4**	**8.0**	2.8	2.8	0.0	0.0	0.0
Vaccinium vitis-idaea	0.0	0.0	0.0	0.0	0.0	0.0	**5.0**	2.8	3.2	0.0	0.0	0.0
Diphasiastrum alpinum	0.2	0.0	0.0	1.0	4.6	**5.0**	0.0	0.0	0.0	0.0	0.0	0.0
Huperzia selago	0.4	0.6	0.0	1.4	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Carex binervis	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex panicea	0.0	0.0	0.0	3.4	**8.4**	**9.4**	0.0	0.0	0.0	0.0	0.0	0.0
Carex pilulifera	0.0	0.0	0.0	**12.0**	**19.0**	**10.0**	0.0	0.0	0.0	0.0	0.0	0.0
Juncus squarrosus	0.0	0.0	0.0	1.0	3.0	4.0	0.0	0.0	0.0	0.0	0.0	2.0
Luzula multiflora	0.2	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agrostis capillaris	**13.0**	**11.0**	**9.0**	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Agrostis vinealis	3.0	2.0	2.8	2.6	**9.0**	**5.6**	0.0	0.0	0.0	1.0	1.7	0.0
Avenella flexuosa	4.6	**6.0**	2.8	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Festuca ovina	**28.0**	**52.0**	**13.0**	**7.4**	**8.0**	3.0	0.0	0.4	3.4	**7.7**	**8.0**	0.0
Festuca vivipara	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	**9.0**
Molinia caerulea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Nardus stricta	0.0	0.0	0.0	**67.0**	**42.0**	**25.4**	0.0	0.0	0.0	2.3	1.7	**5.7**
Campanula rotundifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3
Galium saxatile	**15.0**	**7.4**	**5.8**	**11.0**	1.8	**7.8**	0.0	0.0	0.6	0.0	0.0	0.0
Micranthes stellaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0
Narthecium ossifragum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Pinguicula vulgaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Potentilla erecta	0.0	0.0	0.0	0.4	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Sedum anglicum	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thymus polytrichus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Viola riviniana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Amphidium mougeotii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	1.0	0.0
Anoectangium aestivum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Atrichum undulatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**6.7**	3.7	0.0
Blindia acuta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Bryum pseudotriquetrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3
Campylopus paradoxus	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ctenidium molluscum	**5.0**	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dicranella palustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.3
Dicranum scoparium	0.0	0.0	0.0	1.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Hylocomium splendens	0.0	0.0	**5.6**	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0
Hypnum cupressiforme	2.0	2.6	0.0	**11.0**	**7.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hypnum jutlandicum	0.0	0.0	0.4	0.0	0.0	**9.8**	0.0	0.0	0.0	0.0	0.0	0.0
Pleurozium schreberi	0.0	1.0	**12.0**	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Polytrichum commune	2.0	1.4	0.0	1.0	0.6	1.0	0.0	0.0	0.0	0.0	0.0	0.3
Polytrichum formosum	2.0	**5.4**	0.0	0.0	0.6	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Polytrichum juniperinum	3.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polytrichastrum alpinum	0.0	0.0	**18.4**	0.0	0.0	0.2	0.0	0.0	**5.2**	0.0	0.0	0.0
Pseudoscleropodium purum	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Racomitrium ellipticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Racomitrium fasciculare	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Racomitrium lanuginosum	3.6	**15.0**	3.0	**7.0**	**6.0**	**13.0**	**16.0**	**12.8**	**7.4**	0.0	0.0	1.3
Racomitrium sudeticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Rhytidiadelphus loreus	2.0	**5.4**	**15.0**	0.0	0.0	4.4	0.0	0.0	0.2	0.0	0.0	0.0
Rhytidiadelphus squarrosus	2.6	**6.0**	**17.0**	4.0	2.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Sphagnum denticulatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.3	1.3
Sphagnum palustre	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Aneura pinguis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Anthelia julacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**6.7**	3.0	**38.3**
Diplophyllum albicans	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jungermannia exsertifolia ssp. cordifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**31.7**	**28.3**	**6.7**
Marsupella emarginata	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Mylia taylorii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**5.0**	**5.0**	0.0
Nardia compressa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.0	0.0
Scapania undulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**8.0**
Cetraria aculeata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Cladonia arbuscula	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Cladonia coccifera	0.2	0.2	0.0	0.0	0.0	0.0	0.6	1.0	0.2	0.0	0.0	0.0
Cladonia furcata	0.0	0.8	0.2	0.0	0.0	0.2	0.0	0.0	0.6	0.0	0.0	0.3
Cladonia portentosa	0.6	1.6	0.0	0.2	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Cladonia subcervicornis	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	1.4	0.0	0.0	0.0
Cladonia uncialis	1.0	0.4	0.0	0.0	0.0	0.4	0.4	0.0	0.4	0.0	0.0	0.0
Stereocaulon vesuvianum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
alga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**10.0**
Bare ground (%)	3.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare rock (%)	**6.4**	**5.0**	1.8	0.6	0.0	0.0	**74.0**	**80.4**	**74.0**	**33.3**	**34.7**	**22.7**
Grass Sum (%)	**48.6**	**71.0**	**27.6**	**77.0**	**61.0**	**34.4**	0.0	0.4	**5.4**	**11.0**	**12.3**	**17.3**
Forb Sum(%)	**16.0**	**7.4**	**5.8**	**11.4**	2.8	**8.8**	0.0	0.0	0.8	0.7	0.0	2.0
Bryophyte Sum (%)	**23.0**	**43.4**	**72.4**	**24.8**	**16.6**	**33.2**	**16.0**	**13.4**	**13.0**	**55.3**	**44.7**	**58.0**
Dwarf shrub sum (%)	**5.6**	3.4	1.4	**12.2**	**16.2**	**23.0**	**13.0**	**5.6**	**6.0**	0.0	0.0	0.0
Sphagnum Sum (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.3	1.7
Avg max height (cm)	3.4	**7.0**	**8.6**	**16.0**	**19.0**	**17.6**	1.4	3.0	2.4	**11.7**	**13.3**	
Avg spp number	**11.6**	**13.8**	**12.4**	**10.6**	**11.0**	**16.2**	**3.6**	**4.2**	**9.2**	**8.0**	**7.0**	**14.7**

6.5. Results: Vegetation height (W-walk)

In Turner (2018), the significance of changes in vegetation height for each of the lower-level plots over the period 2012 to 2017 was tested using both parametric and non-parametric methods (Mann-Whitney U-test). Over this period, all but one of the plots showed highly significant increases in the median height of vegetation using the Mann-Whitney U-test. Not all the plot data was normally distributed, but where parametric significance testing was undertaken, it generally agreed with the non-parametric results. In 2022, as fewer of the plot datasets were normally distributed, only non-parametric comparisons were made.

Table 11 Mean vegetation height of lower-level plots for 2012, 2017 and 2022, and significance of changes.

	Plot number										
	3	**4**	**6**	**7**	**13**	**14**	**15**	**21**	**23**	**26**	**28**
2012											
Mean height	8.3	9.7	27.6	23.3	12.6	7.4	8.2	12.2	13.0	3.8	
Standard deviation	2.9	2.4	9.9	13.4	7.5	2.5	2.4	3.3	6.0	1.7	
Median height	8.5	10.0	28.0	19.5	10.0	7.0	8.0	12.0	11.5	4.0	
n	50	25	50	50	50	50	50	50	50	50	
Max height	15	14	43	50	43	16	13	22	36	7	
Min height	3	5	9	4	5	4	4	6	6	1	
Normally distributed (w/s test)	Y	Y	N	N	Y	Y	N	Y	Y	N	
2017											
Mean height	15.4	16.1	44.6	34.1	24.0	12.6	13.4	17.5	24.1	6.5	
Standard deviation	4.7	3.7	11.9	13.5	13.6	3.4	4.4	6.4	7.0	4.5	
Median height	14.0	17.0	45.0	33.5	20.0	12.0	12.0	16.0	22.0	4.0	
n	50	25	50	50	50	50	50	50	50	50	
Max height	27	22	68	66	68	23	27	44	44	16	
Min height	7	3	14	13	8	6	6	7	14	2	
Normally distributed (w/s test)	Y	N	Y	Y	Y	Y	Y	N	Y	N	
2022											
Mean height	16.9	20.3	40.2	37.2	38.6	9.5	14.2	28.2	22.3	5.9	15.2
Standard deviation	4.7	5.8	15.0	18.2	19.3	3.0	12.2	12.7	8.2	3.8	9.8
Median height	16.0	20.0	42.0	39.5	37.0	9.0	12.0	25.0	20.5	4.0	11.0
n	50	50	50	50	50	50	50	50	50	50	50
Max height	29	34	68	65	88	21	90	70	58	13	39
Min height	6	7	17	0	10	5	5	11	12	1	4
Normally distributed (w/s test)	Y	Y	N	N	Y	Y	N	Y	Y	N	N
Difference of median heights (2017-2012)	5.5	7.0	17.0	14.0	10.0	5.0	4.0	4.0	10.5	0.0	
Difference of median heights (2022-2017)	2.0	3.0	-3.0	6.0	17.0	-3.0	0.0	9.0	-1.5	0.0	
Mann-Whitney U-test (2012 v 2017) p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.025	
Significance	***	***	***	***	***	***	***	***	***	*	
Direction of change	+	+	+	+	+	+	+	+	+		
Mann-Whitney U-test (2017 v 2022) p-value		< 0.01			< 0.001	< 0.001		< 0.001			
Significance	ns	**	ns	ns	***	***	ns	***	ns	ns	
Direction of change		+			+	-		+			

Abbreviations: * : significant at p < 0.05, ** : significant at p < 0.01, *** : significant at p < 0.001, + : Increase, - : Decrease

The median vegetation height of plots 4, and 13 was found to have significantly increased, whereas that for plot 14 had significantly decreased. For all the other plots there was no significant change.

6.6. Results: Maximum vegetation height (Quadrats)

Maximum height was measured in each quadrat using the drop disc method in both 2017 and 2022. Radford (1999, 2005) gives maximum height for various strata within each quadrat but no clear indication of how the measurements were made. Taking the maximum height for all strata gives a value for the whole quadrat, and this was used to make a comparison with the later data from 2017 and 2022.

Table 12 Mean maximum vegetation height (cm) for (top) the 55 lower-level quadrats and (bottom) the 18 upper-level quadrats between 1999, 2004, 2017 and 2022, and net increase 1999-2022.

Level	Plot	No Qs	Average Q max height				Difference
			1999	2004	2017	2022	1999-2022
Lower level	3	5	11	15	14.4	20.3	9.3
	4	5	21	24	22.3	23.8	2.8
	6	5	21.4	26	47.2	48.4	27
	7	5	25	25	44	45.8	20.8
	13	5	25	25		45.8	20.8
	14	5	12	18	23.2	20.3	8.3
	15	5	14	21		18.8	4.8
	21	5	37	48		38.6	1.6
	23	5	21	28	29.2	36.8	15.8
	26	5	2	21	7.2	6.2	4.2
	28	5	19	23	16.8	14.2	-4.8
	All	55	18.7	25.3	26.6	30.2	11.3
Upper level	1	5	3.4	7		8.6	5.2
	16	5	16	19		17.6	1.6
	17	5	1.4	3		2.4	1
	30	3	11.7	13.3			
	All	18	6.9	9.7		9.5	2.6

For all the lower-level quadrat data combined, the increase in maximum vegetation height (11.3cm) over the period 1999-2022 is highly significant ($p < 0.001$).

For the higher-level plots, the increase in vegetation height is very small and is only just significant ($p < 0.05$), and given the caveats above about uncertainty in the original method of measurement, should probably be discounted.

6.7. Results: Sheep and goat counting

Numbers of sheep and goats for different parts of the NNR are shown in Table 13. Sheep and goat numbers were recorded during visits for sampling or photomonitoring between July and October 2022. Counts were focussed on sections of the lower part of the NNR, with incidental records from the higher Cwms Clyd, and Cneifion, and no counts from the summit areas or above Clogwyn y Geifr. Additional limited counts were made on several occasions from March to June, particularly of goat numbers. Shepherding took place in the cwm in 2022, mostly moving sheep towards Pentre holding, but was only observed on three occasions. The effect of individual clearances was observed to be short-lived with sheep very soon returning to the cwm.

Averaged numbers of sheep for August 2022 for the lower part of the reserve are around 65% of those noted during August 2017. In addition, although the count numbers were low, there were fewer sheep noted in Cwm Cneifion.

Table 13 Average and maximum sheep numbers in different parts of Cwm Idwal in summer 2022, with 2017 summary (S = sheep, G = goat).

Month	No of counts	Lower Cwm Idwal						Lower Cwm Idwal totals		Upper Cwm Idwal			
		W side Nant Clyd -> Clogwyn y Geifr stream		Centre Clogwyn y Geifr stream -> Nant Ifan		E side Nant Ifan -> E side wall				Cwm Cneifion		Cwm Clyd	
		Average numbers per month											
		S	G	S	G	S	G	S	G	S	G	S	G
March	2	0	0	0	0	0	19	**0**	**19**				
April	1	0	0	0	0	0	20	**0**	**20**				
May	0												
June	1						41		**41**				
July*	3	11	0	10	2	14	0	**38**	**2**	[10]	[0]		
August	10	12	1	18	0	12	0	**42**	**1**	[3]	[0]	50	15
September	2	9	0	15	0	12	0	**35**	**0**	18	8		
October*	2	18	11	16	0	19	4	**55**	**14**			36	0
2022 count summary													
Average (Aug)	10	12	1	18	0	12	0	**42**	**1**				
Max (Mar-Oct)	21	25	11	27	3	22	41	**55**	**41**	18	8	50	15
2017 count summary from Turner (2018)													
Average (Aug)	7	21	0	23	0	21	0	**67**	**0**	22	0	35	0
Max (Aug-Sep)	8	27	0	27	0	24	1	**56**	**1**	26	0	47	0

* = not all counts of lower Cwm Idwal included all three sections.

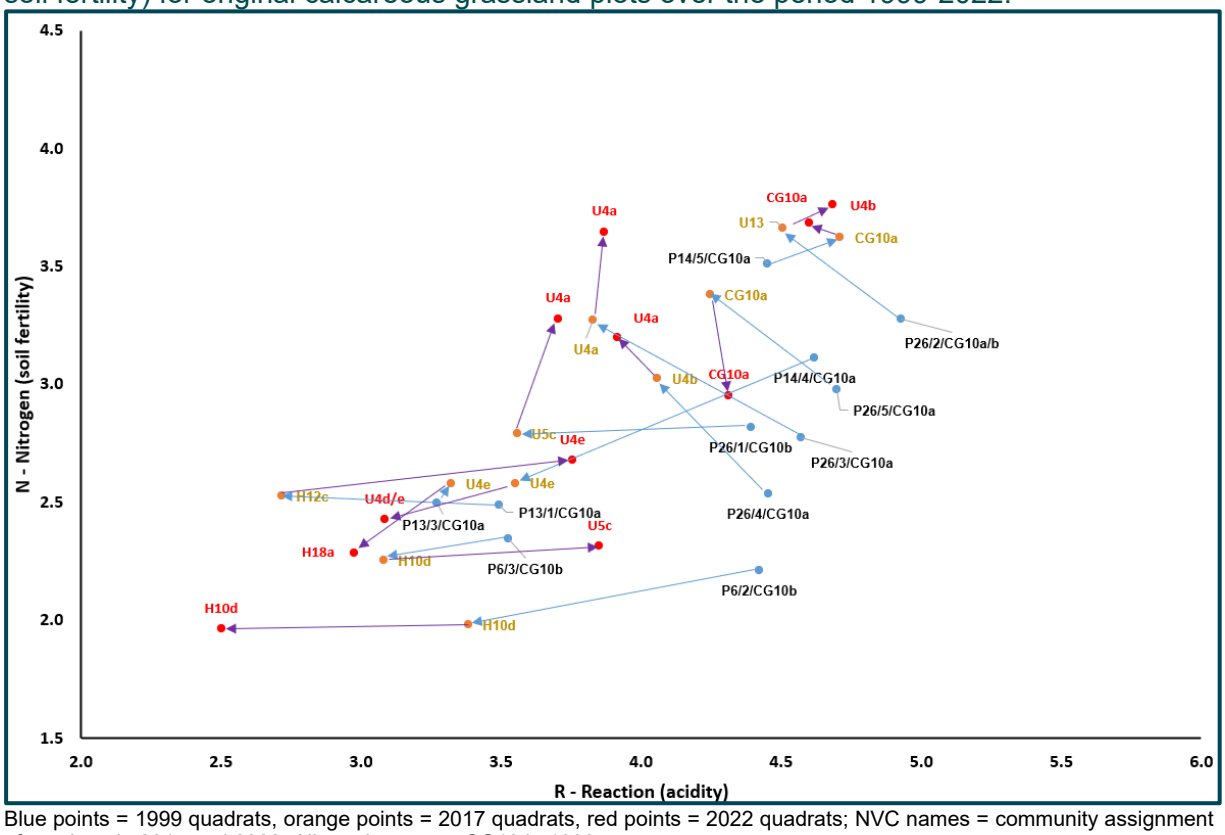
Average goat numbers in the lower part of the reserve during August 2022 were seen to be slightly higher than in 2017. Maximum numbers earlier in 2022, however, were much higher than in 2017, with 41 being recorded in June 2022, and herds of around 20 being seen twice earlier in the year, and 14 recorded in October. This compares with one goat seen in 2017 during all visits.

Further, it should be noted that sheep were not present in the reserve until after April, while numerous goats were frequently seen in the reserve all through the preceding winter and during the spring of 2022

6.8. Results: Ellenberg indicator values (EIVs)

The Ellenberg indicator value (EIV) approach was used to investigate changes for quadrats which were initially referable to calcareous grassland (**CG10** *Festuca-Agrostis-Thymus* grassland) in 1999. For this, EIVs for light (L), moisture (F), acidity (R) and nitrogen (N) were calculated for the 11 quadrats which were originally referable to calcareous grassland (**CG10**) and these are shown in Table 14 below. The quadrats are from Plot 6 (Qs 2 & 3), Plot 13 (Qs 1 & 3), Plot 14 (Qs 4 & 5) and Plot 26 (Qs 1-5).

Figure 4 Changes in the Ellenberg Indicator Values R (reaction or acidity) and N (Nitrogen or soil fertility) for original calcareous grassland plots over the period 1999-2022.



Blue points = 1999 quadrats, orange points = 2017 quadrats, red points = 2022 quadrats; NVC names = community assignment of quadrats in 2017 and 2022. All quadrats were CG10 in 1999.

Using the percentage cover data on the selection of vascular plants monitored, between 1999 and 2022, the main changes seen were (a) an increase in acidity (R, -0.5*) and (b) a decrease in light (L, -0.3). These are consistent with the increase in dwarf-shrub cover, and the decrease in the number of calcicoles noted above. Both the vascular plant and bryophyte layers show a similar response. Over the period 2017 to 2022, there have been few overall changes except a decrease in moisture (F, -0.2) in the bryophyte layer.

* sign negative because the scale runs from extreme acidity (1) to calcareous or highly basic soils (9)

Table 14 Ellenberg values for L (Light), F (Moisture), R (reaction or acidity) and N (Nitrogen/soil fertility) for initial calcareous grassland plots from 1999-2022.

Layer	EbV	1999	2017	2022	1999-2017	2017-2022	1999-2022
ALL	L	6.8	6.6	6.5	-0.2	-0.1	-0.3
	F	5.6	5.7	5.7	0.1	0.0	0.1
	R	4.3	3.7	3.7	-0.5	0.0	-0.5
	N	2.8	2.9	2.9	0.1	0.0	0.1
VASC	L	6.9	6.7	6.6	-0.2	-0.1	-0.3
	F	5.6	5.6	5.7	0.1	0.1	0.1
	R	4.2	3.7	3.7	-0.5	0.0	-0.4
	N	2.9	2.9	3.0	0.1	0.1	0.1
BRYO	L	6.4	6.3	6.2	-0.2	-0.1	-0.3
	F	5.5	5.7	5.6	0.2	-0.2	0.0
	R	4.1	3.6	3.6	-0.5	0.0	-0.5
	N	2.6	2.5	2.4	-0.1	-0.1	-0.1

Figure 4 shows the changes in R and N over the periods 1999-2017 and 2017-2022 for the original 11 calcareous grassland quadrats. For acidity, several quadrats show a strong increase over 1999-2017, but from 2017-2022 the response is more mixed. Quadrats Q2(Plot06) and Q4(Plot16) show a further decrease over 2017-2022, while Q3(Plot06) and Q1(Plot13) both show a reversal in trend over the same period. Interestingly, both of these are quadrats which have reverted from dry heath to acid grassland.

Two quadrats from Plot 26 (Q1 and Q3), adjacent to the 'wild camping' site, both show increases in N over 2017-2022, however Q5 from the same plot shows a decrease in N.

6.9. Results: Repeat photomonitoring

Images are presented in Appendix 5 for all the photomonitoring locations. For each location, the images from 2006, 2009 and 2012 surveillance recordings are shown at a slightly smaller scale above the 2017 and 2022 images. Some of the photos in 2017 were taken later in the season when the *Calluna* was in flower, whereas in 2022 they were taken earlier making some comparisons more difficult.

There are no photomonitoring locations showing the upper parts of the site, but some plot photos taken 1999-2004 which were relocated in 2022 are shown in Appendix 7, and are discussed in section 7.9.2.

6.9.1. Landscape photo stations

The changes in the cwm will be described in an anticlockwise sequence starting with the moraine area at the northern end of the reserve and finishing with the two higher-level cwms (Clyd and Cneifion) at the end.

As noted in Turner (2018), the terminal moraine was originally within the exclusion area of the reserve when the grazing experiment was initiated in 1999, but sometime between 2009 and 2012, the “grazing-free” area was reduced to that contained behind the two dry-stone walls which meet the lake at SH643598 on the West side and SH 646596 on the East side, and the vegetation was grazed by Blaen Nant stock (mainly cattle). In 2022, however, the tenancy of Blaen Nant was vacant, and there was no stock grazing the terminal moraine area. In the 2022 photos A2, B1 and B2 which cover this area, there is little evidence for change from 2017.

Photo A2 shows the prominent rockfall near Nant Clyd which occurred early in 2019 (also seen in photo R2). There appears to be no change in the distribution of *Calluna* or grassland in the photo.

The area of blanket mire just north of the moraines on the west side of the cwm in Photo Q1 shows some reduction in heather cover, and with frequent bushes of dead heather.

The area around the moraines on the west side of Llyn Idwal is covered by Photos N2, N4 and P1. All these photos seem to show a localised increase in *Calluna* cover, and Photo P1 shows scattered bushes of dead *Calluna* as well. Photo P2, looking south along the crest of the highest moraine ridge shows some reduction in *Calluna* cover. Photo T2, taken from mid-height on the flanks of the Gribin, looking to the west side of the lake, appears to show some consolidation of areas of *Calluna* above the moraines, and below the rockier area extending up towards Castell y Geifr.

The area around Clogwyn y Geifr and the Block Scree (boulders) at the back of Cwm Idwal is covered by Photos M1, N1, P2, R3 and S1, although Photos M1, R3 and S1 are very distant and not particularly informative. Of these, most show little or no change in the amounts of grassland and *Calluna* cover, apart from Photo N1 which possibly shows a reduction in heath cover in the area below the boulders.

There are many photos covering the east side of the cwm from the lake up to the top of the Gribin ridge. Several show dead *Calluna* including Photos K1, J1, T2 and particularly K2. Photos I1, I2 and T1 show some increase in *Calluna* cover, and several show decreased prominence of rocks indicating taller grass cover - these include H2, J1 and K1-3.

In Cwm Clyd, Photo F1 appears to show an increase in *Vaccinium* cover and a decrease in the number of rocks visible in the foreground. For Cwm Cneifion, only two very distant views (Photos B2 and C2) are available amongst the areas

covered by the photomonitoring and these are insufficient to detect any changes.

6.9.2. Higher-level plot areas

Photographs of the areas around the four higher-level plots are shown in Appendix 7.

Plot 01, close to the summit of Y Garn shows little change since 1999-2004, with the exception of the disappearance of some of the scattered rocks on the plot.

The two photos of Plot 16, located on the south-eastern slopes of Y Garn above the transverse fence, are of poor quality and taken from a distance and show no obvious signs of change.

Plot 17, located on the flat upper part of the Esgair Felen ridge where it merges into the main mass of Glyder Fawr, is very stony and the vegetation is very open. The 2022 photographs seem to show an increased amount of vegetation compared to 2017 which is comprised of very short dwarf-shrubs (*Vaccinium myrtillus*, *V. vitis-idaea*) and the moss *Polytrichastrum alpinum*.

Plot 30 is a linear plot aligned along a steeply descending rocky stream in the upper part of Cwm Cneifion. The 1999-2004 photos are poor quality but possibly show an increase in dwarf-shrub cover (principally *V. myrtillus*) immediately adjacent to the stream.

Overall, the signs of change seen at the four plots since 1999 include some increase in dwarf-shrub cover (Plots 17, 30), and a reduction in bare rock (Plots 01 and 17).

7. Discussion

The 2022 surveillance in Cwm Idwal shows a rather mixed picture of changes, and some differences in trends from the previous re-recordings. The steady trend of increasing *Calluna* cover in the lower-level plots since the beginning of the grazing exclusion has slowed, there has been a decrease on one plot since 2017 and little or no change in several others. At the same time, there has been an increase in some of the other dwarf-shrub species such as *Vaccinium myrtillus, Erica* spp. and *Empetrum nigrum*, and as a result, the trend of cells with heath species over both 2006-2022 and 2017-2022 is still significantly increasing.

Other changes since 2017 include significant decreases in *Carex* sp., *Molinia, Nardus*, *Galium saxatile* and *Sphagnum* spp. when all plots are considered together. When examined at an individual plot level, however, the picture becomes somewhat messier, with, for example, *Vaccinium myrtillus* increasing significantly in 3 plots, but decreasing significantly in two others. Another example is *Empetrum nigrum* which has only significantly increased in one plot (Plot 04), and whose changes are not significant in all other plots. The trends which are consistent across two or more plots include decreases in *Carex sp., Nardus stricta*, *Sphagnum* spp., Other graminoids (including the Graminoid Sum variable) and Bare Rock.

Tree species were not recorded in any quadrat again in 2022. A seedling of *Sorbus aucuparia* was noted in one quadrat in Plot 06 in 2004 but was not seen in subsequent rerecordings. A short *S. aucuparia* sapling was noted in Plot 06 in 2022, and anecdotally seedlings and short *S. aucuparia* saplings have been seen elsewhere in the NNR for several years, mainly amongst deep *Calluna* elsewhere. Also, *Salix cinerea* seedlings have been seen amongst the Block Scree. Nowhere in the cwm, excluding the exclosures and cliffs, have saplings managed to get more than about 1m high.

Many forbs have continued to show an overall decreased trend since 2006, mainly picked up in the cell frequency recording, but there have been fewer changes since 2017, with only *Galium saxatile, Plantago lanceolata* and *Polygala serpyllifolia* showing a significant decrease. Both the variables Graminoid Sum and Calcareous Grass Sum, however, show a significant decrease over both periods.

Some species changes affect only one plot and do not show up as a significant change as they were lumped together into a group when using the cell counting method. This is the case for *Deschampsia cespitosa* which was at 40% cover in 2017 and only 1% in 2022 in one quadrat in Plot 26.

Recording percentage cover also picked out changes in some of the bryophyte species missed by the cell frequency method. In particular, there were significant increases from 2017-2022 for various pleurocarpous mosses typical of heathland such as *Hylocomium splendens, Hypnum jutlandicum, Pleurozium schreberi, Rhytidiadelphus loreus* and *R. squarrosus.*

The increase in vegetation height has slowed since 2017, with only three plots showing a significant increase (10 in 2017), and one a decrease. Maximum height of the vegetation within the quadrats, measured using the drop disc method in 2017 and 2022, shows a weakly significant increase.

Finally, the investigation of changes in Ellenberg Indicator Values (EIVs) points to a small amount of eutrophication occurring in two of the quadrats immediately adjacent to the large rock by Plot 26, an area used for 'wild camping'.

Factors which need to be examined to understand the likely causes for the changes seen since 2017 include Heather Beetle damage, grazing pressure changes, climatic changes, atmospheric N-deposition effects and recreational impacts.

7.1. Heather Beetle damage

An outbreak of Heather Beetle is considered to be responsible for the patches of dead *Calluna* in the reserve. There were a higher number of cell counts with dead *Calluna* than in previous re-recordings (6 plots in 2022 v 1 plot in 2017). As well as being clearly visible in several of the landscape photos (Section 7.9.1), dead *Calluna* had been noted elsewhere in the cwm both in 2022 and in previous years (Figure 5). Photos taken in 2020 and 2022 indicate a patchy but significant dieback in various places within the reserve, which was almost certainly due to an attack by Heather Beetle over one or more years. This is partly responsible for the change in the trend of *Calluna*.

Figure 5 Dead *Calluna* in Cwm Idwal NNR (L) in July 2020, (R) in March 2022.

7.2. Grazing Pressure Changes

There has been some change in the overall composition of grazing animals present in the cwm. Table 13 indicates a c.35% reduction in the number of sheep in the lower part of the cwm, and although this may be ascribed to the shepherding, in the opinion of the author the shepherding had a very limited effect on numbers. In contrast to sheep, goat numbers appear to have risen dramatically since 2017 when very few were seen. Several groups of 15-20 and one of 40+ were noted in the spring and summer of 2022, as well as later in the season. The numbers dropped during the middle part of the summer in the lower cwm, but larger numbers were present higher up, and they returned in the autumn.

Evidence of large deposits of goat dung in sheltered locations in the block scree since 2019 (Figure 6) confirm their continued presence all year round, whereas the trespassing sheep are generally only present in the cwm from around May to October. Goats have been implicated in damage to some of the arctic-alpine plant interest in the cwm (Turner, 2022).

The increase in goat numbers, and their persistent presence during the winter months is considered, in part, to be responsible for the change in the trend of *Calluna*, and for other changes such as the localised decrease in *Deschampsia cespitosa*. Goat grazing, particularly in winter, is probably also responsible for the apparent inability of tree seedlings and short saplings to develop into taller trees.

Figure 6 Signs of large goat presence in Cwm Idwal - deposited dung in sheltered locations amongst the Block Scree in (L) April 2019 and (R) March 2022.

For the higher-level plots, there has been no control of grazing over the whole period of the grazing experiment and the grazing is mainly sheep-dominated. The only changes in this area are likely to be due to (a) the original removal of

the Cwm Idwal heft in 1998, and (b) changes in numbers of the surrounding holdings likely due to changes in agricultural support rules and for economic reasons. The small increase in dwarf-shrub cover in two of the sampled plots probably reflects a decrease in sheep numbers in these holdings.

7.3. Climate

Generally, climate can affect vegetation in several ways (including through temperature, rainfall, wind, evapotranspiration, snow lie etc.), but the most likely in relation to the changes described above, is through rainfall, or more specifically the lack of it. Drought has been implicated directly in the demise of colonies of arctic-alpine plants in the past in the cwm (Parker, 1982).

There is only a single rain gauge in the cwm, and its monthly data wasn't available in time, so reference has been made to data from the nearby Capel Curig automatic weather station. The rainfall in the NNR is generally high (c3000mm/year, info from Hywel Roberts, ex-NRW warden), and the annual rainfall at Capel Curig is c2700mm (1991-2020), so a reasonable comparison can be made. In recent years there have been some very dry spring months - in particular, May 2020, April 2021 and April 2022 - when there were less than 50% of the normal number of rain days (Daily data extracted from https://www.ogimet.com/gsynres.phtml.en and analysed). Counting up dry spells (defined here as periods with more than 10 days with no rain), during 2020-2022, there have been an average of 2.33 dry spells per year, compared with an average of 0.5 for the period 1999-2019, and during 2020-2022 the dry spells were all in the spring/early summer. The impact of dry spells on the vegetation in the cwm is difficult to quantify, but they clearly stress some species, particularly those found in thin soils. There might be a connection with the occurrence of dead *Calluna* bushes, as Gillingham *et al*. (2016) quote a study from Denmark linking increased grazing by heather beetle to drought episodes. Another effect of drought can be to speed up development processes, so that species set seed earlier and then die back, possibly leading to the species being missed when surveyed later in the season.

Apart from these suggestions, there is little hard evidence to link climate with particular changes which have taken place since 2017.

7.4. Atmospheric N-deposition

The deposition of atmospheric Nitrogen was mentioned in the discussion in Turner (2018) in relation to the decrease in forb cover to 2017, particularly calcicolous forbs. Work by Maskell *et al.* (2010) and Stevens *et al.* (2011) was referenced which had shown a negative effect on several calcicoles under the impact of N-deposition. Work by McGovern *et al.* (2011) on exclusion plots on

Snowdon had, however, shown a reduction in species-richness due to acidification. It was concluded that the changes seen in Cwm Idwal were in part due to increased acidification caused by N-deposition, and in part due to increased sward height due to grazing reduction leading to increased litter and shading. These possible mechanisms continue to be applicable to interpreting the more recent changes.

7.5. Recreational Activities

The final factor to consider is the continuing impact of recreation on the vegetation in the cwm, and in particular on the plots which were sampled. This is likely to be very localised as most plots are relatively distant from the commonly used paths. The two plots where there are some impacts are Plots 4 and 26. The former is near the top of the Idwal Slabs and has a slight climber's path crossing it which is becoming more defined with time. The latter plot overlaps with the 'wild camping' area at the south end of the lake, and here the impact is more obvious with stones moved, burnt patches from fires and probably some degree of eutrophication. Despite these impacts, overall recreational activity is having little effect on the majority of the vegetation in the cwm.

7.6. Summary

Considering all these factors together, it seems likely that the change in the grazing profile from more sheep and virtually no goats in 2017, to fewer sheep and more goats in 2022, together with the impact of Heather Beetle has caused the slowdown in increase in *Calluna* cover. Sheep don't generally graze *Calluna,* except in winter when there is little else available, but they are not present then in Cwm Idwal. Goats will graze *Calluna* throughout the year, and especially during the winter. They also graze some of the tougher grasses and tall-herb vegetation during the Spring-Summer-Autumn period (pers. observ.).

The continued decrease in the cover of forbs in general, and calcicolous forbs in particular, is probably due to a combination of N-deposition, and higher sward-heights swamping species with litter and shading them out, and this is a greater problem for the smaller species.

The continued decrease in *Sphagnum* cover is probably due to a combination of the increase in sward height and cover of heath species. *Molinia*, although not increasing in cover in some plots (e.g., in Plot 21), has tussocks which are growing taller and are shading out *Sphagnum* species.

Drought episodes, possibly in combination with atmospheric N-deposition, may be making *Calluna* more susceptible to Heather Beetle attacks.

The effect of recreation is considered to be relatively minor, with only very local impacts.

As noted in Turner (2018), the series of lower surveillance plots in the cwm fail to cover any of the habitats which were a primary reason for the selection of the Eryri SAC, and instead cover some of the secondary Annex 1 habitats including 4030 European dry heaths, 4010 Northern Atlantic wet heaths with *Erica tetralix* and 6230 Species-rich *Nardus* grasslands. Of these, the first two have improved in condition since 1999, while the third has deteriorated.

Of the higher-level plots, Plot 17 occurs in 4060 Alpine and Boreal heaths, Plot 01 could become some form of 4060 with lower grazing levels, and Plot 16 is probably transitional to 4030 European dry heath. These habitats show a slight increase in dwarf-shrub cover, but are essentially the same as in 1999-2004, and all would be unlikely to pass Common Standards Monitoring performance indicator attributes for good quality habitat (JNCC, 2009).

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9. Appendices

9.1. Appendix 1 Plot recording details in 2022

9.1.1. Lower-level plots

Table 15 Plot recording details for the lower plots, brief descriptions, and comments on relocation problems.

Plot	Date plot laid out	Dates recorded	Description	Other comments
3	29-Aug-22	29-Aug-22	Mainly **H18** *Vaccinium*-heath with some **U4** *Festuca-Agrostis* grassland and very locally *Nardus* grassland. *Diphasiastrum alpinum* occasional and *Blechnum spicant* scattered throughout. In places with occasional patches of *Sphagnum capillifolium.* Occasional boulders.	Quadrats 3 and 5 outside 30m x 30m plot
4	12-Aug-22	12-Aug-22	Mostly *Vaccinium* heath (**H18b**, **H18c** in places tending towards **H20** with local *Empetrum hermaphroditum*), but with an expanding area of **H12b** *Calluna-Vaccinium* heath on E side of plot; *Calluna* pioneer or building but stunted due to exposure. Species not in quadrats are *Potentilla erecta* , *Blechnum spicant* , *Solidago virgaurea* and occasional *Sphagnum capillifolium*	Quadrat 5 outside 15m x 15m plot; Climbers path from top of Idwal Slabs becoming more pronounced across the plot.
6	28-Aug-22	30-Aug-22	Deep *Calluna*- heath (mainly **H10**) and some *Vaccinium*-heath (**H18**) with strips of flushed base-rich scree.	Peg 1 and Peg 2 relocated using photos.
7	19-Aug-22	19-Aug-22	Mostly *Calluna-Vaccinium-Sphagnum* heath (**H21a**) with small amount of *Vaccinium*- heath (**H18b**) and more *Festuca-Agrostis-Galium* grassland (**U4**) in 2022 than in 2017.	Peg 1 and Peg 2 relocated using Photos
13	24-Aug-22 & 25-Aug-22	24-Aug-22 & 25-Aug-22	Some grassy *Calluna*-heath (**H12c**) becoming more *Calluna*- dominated (**H12a**) with building to mature *Calluna* , and also patches of *Vaccinium*-heath (**H18a**), *Festuca-Agrostis-Galium* (**U4e**) and *Nardus-Galium* grassland (**U5d**). Bare rock being covered over with vegetation.	Quadrat 3 outside 25m x 25m plot
14	03-Aug-22	03-Aug-22 & 04-Aug-22	*Mostly Festuca-Agrostis-Galium* (**U4a** and locally **U4b**) with some and *Nardus-Galium* grassland (**U5c**)/ *Festuca-Agrostis-Thymus* grassland (**CG10b**) where flushed. Larger areas of boulders tending towards *Cryptogramma* -scree vegetation (**U21**). Moderately heavy grazing.	Quadrats 2 and 4 outside 25m x 25m plot
15	20-Jul-22	20-Jul-22	*Festuca-Agrostis-Galium* grassland (mainly **U4e**, locally **U4b**) with increasing amounts of *Vaccinium-Deschampsia* heath (**H18b**, locally consolidating as **H18a)**, and with patches of *Calluna-Vaccinium* heath (**H12**). Scattered boulders and small patches of calcareous grassland (**CG10**) with frequent *Thymus drucei* and *Campanula rotundifolia* .	Peg 1 and Peg 2 relocated using Photos
21	05-Aug-22	10-Aug-22 & 11-Aug-22	Heterogenous plot with stands of *Juncus*-dominated acid flush (**M6c**), and *Molinia-Potentilla* marshy grassland (**M25**). Some *Molinia*-dominated wet heath (**M15**) and locally blanket bog (**M17**)and bare rock. Ungrazed at time of survey. Scattered bushes of *Calluna vulgaris* but not in quadrats in any significant amount. Little/no *Erica tetralix* present and *Sphagnum* buried amongst *Molinia* tussocks.	Peg 1 and Peg 2 relocated using Photos
23	04-Aug-22	05-Aug-22	*Nardus-Galium* grassland (**U5a**, **U5d**), with patches of *Vaccinium*-heath (**H18a**) and *Calluna*-*Vaccinium* heath (**H12c**, locally **H12a**) present; Pioneer, building & mature bushes of *Calluna vulgaris* .Canada Goose droppings nearby.	Pegs 1 and 2 both refound
26	02-Sep-22	02-Sep-22	Plot bisected by frequently used round-the-lake footpath. The vegetation on the south side of this path is very short acid grassland (**U4a** and **U4b**), locally calcareous (**CG10a**). Part of the plot is used by campers and locally there are burnt patches due to fires. The formerly taller vegetation on the N side of the path now grazed lower with *Deschampsia cespitosa* much less prominent and now **U4b**.	Quadrat 3 outside 25m x 25m plot
28	23-Aug-22	23-Aug-22	Plot straddling area of former peat cutting with higher area on E side. Upper part has *Scirpus-Erica* wet heath (**M15**) with much building/mature *Calluna* , while the lower area is mainly **M3** *Eriophorum* bog-pool vegetation, locally grading to **M1** or **M2** bog-pool with possibly more *Sphagnum papillosum* hummocks than in 2017.	Peg 1 and Peg 2 relocated using Photos

All the lower-level plots were successfully relocated, and the quadrats were rerecorded between 20th July and 2nd September 2022.

9.1.2. Upper-level plots

Four of the five upper plots were relocated using old photographs. The GPS positions given were found to be very inaccurate with an average error of 77m, and the largest difference, for Plot 01, was 147m. The photograph of the fifth plot (Plot 09) did not match anything within two hundred metres of the grid reference, and hence the plot was not rerecorded.

Table 16 Plot recording details for the upper plots, brief descriptions, and comments on relocation problems.

Plot	Date plot laid out	Dates recorded	Description	Other comments
1	11-Oct-22	11-Oct-22	A relatively even grassland plot on a moderately steep slope overlooking Cwm Clyd. The vegetation is fairly species-poor mossy *Festuca-Agrostis-Galium* grassland (**U4d)**	Both pegs relocated using photos and metal detector
9	-	-	Plot not relocated	-
16	14-Oct-22	14-Oct-22	Plot with abundant *Nardus-Galium* (**U5e**) grassland, grading to *Vaccinium*-heath (**H18c**) in places, with local patches of *Juncus-Festuca* (**U6c**) grassland. At the top edge there is frequent to abundant *Trichophorum germanicum.*	Both pegs relocated using photo and metal detector
17	09-Sep-22	09-Sep-22	Very open and stony vegetation on flat ground (fell field), with frequent *Vaccinium vitis-idaea* and locally abundant *Polytrichastrum alpinum*, perhaps closest to **H18c** *Vaccinium-Deschampsia* heath. In places grading to *Festuca-Agrostis-Galium* grassland (**U4e**)	Peg 1 relocated, Peg 2 missing, position relocated using direction from photo and tape measure
30	13-Sep-22	13-Sep-22	A plot aligned along a steep rocky stream with frequent bryophytes including locally abundant *Anthelia julacea* (rocky form of **M31**). Forbs include *Thymus drucei, Pinguicula vulgaris, Viola riviniana* and *Campanula rotundifolia.*	Linear plot with only 3 quadrats, all relocated from photos; Pegs 1 and 2 not marked

9.2. Appendix 2: Tables of percentage cover for lower-level plots for 1999, 2004, 2017 and 2022

Table 17 Species percentage cover for quadrats in Plot 3 for 1999, 2004, 2017 and 2022

Plot	3					3					3					3				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4i	F5	F1	F2	F3	F4i	F5
NVC community	U4e	U4e P	U4e	U4e	U4e Da	U4e	U4e P	U4e	U4e	U4e Da	U4e P	H18 b	U5e	U4e P	U4e P	H18 b	H18 b	H18c	H18 b Sc	H18 b
Calluna vulgaris										1			2					8		
Empetrum nigrum			5	7	3			4	1	2		1	7	5	3	2		22	9	9
Vaccinium myrtillus	7	15	5	13	15	10	15	10	15	5	18	38	18	18	7	38	42	20	31	23
Blechnum spicant		3		5			4					7				11	10			
Diphasiastrum alpinum					15					15			2					2		
Huperzia selago	1		3		2			3		3	1		1					1		
Oreopteris limbosperma													1							
Carex demissa			5										6					2		
Carex echinata										3										
Carex pilulifera			7		1			15					1		1			1		1
Luzula multiflora												1								
Agrostis capillaris	30	10		20	5	15	20		45	10	7	5	2	3	7	12	10	5	10	3
Agrostis vinealis			7		5			15		15	2	7	8	2	4	5	3	10	3	5
Anthoxanthum odoratum		2										4	3	2		3	2	3		
Avenella flexuosa					5	15	5		5	5	12	8	2	10	10	5	5	5	10	20
Festuca ovina	30	15	10	20	10	25	15	10	20	30	8	10	5	6	7	10	10	15	15	10
Nardus stricta			5	1				5			1		15	4	2	1		8	1	2
Campanula rotundifolia			3																	
Euphrasia agg.	1																			
Galium saxatile	15	10		15	5	10	10	10	10	10	15	22	10	15	7	12	5	7	10	25
Solidago virgaurea													1					1		
Thymus drucei								2										5		
Viola riviniana			1																	
Andreaea rupestris													1							
Breutelia chrysocoma																				1
Ctenidium molluscum	2			3																
Dicranella heteromalla													1							
Dicranum scoparium	2			2							1				1					
Hylocomium splendens		3		3			10	10			3	8	5	2		5	15	20	5	1
Hypnum cupressiforme	3	5	3	10	1	5			5		5									
Hypnum jutlandicum												4	1	3		5	5	5	10	1
Pogonatum urnigerum												1								
Polytrichum commune		10					5				40	18	5	35	80	15	10	5	10	35
Polytrichum formosum						2				2										
Polytrichum juniperinum	3	35	3	5		7	15	3	7											
Racomitrium fasciculare					2			2			1	3		1			1		1	
Racomitrium lanuginosum	3	3	20	2	15	5	5	20	5	10	3		16	5		2		5	1	
Racomitrium sudeticum													1							
Rhytidiadelphus loreus				10	10				5		3	8	5	6	1	10	10	10	10	5
Rhytidiadelphus squarrosus	3	10		5		5	10		10			3	1			1	10			
Sphagnum capillifolium														3					2	
Sphagnum denticulatum	1			1																
Sphagnum inundatum														1						
Sphagnum quinquefarium																			1	
Sphagnum tenellum													2		1					1
Thuidium tamariscinum		3		1			3					3		1		3	2			1
Diplophyllum albicans	5				3						1	1	1	1			1		1	
Marsupella emarginata												1					1			
Pellia epiphylla			1																	
Cladonia bellidiflora											1			1						
Cladonia coccifera	1	2	1	1			1	1	1											
Cladonia portentosa			1		1			2	1	2			2		1			1		
Cladonia subcervicornis											1	1	1	1			1	1		
Cladonia uncialis	1		1		1								3					2		
Stereocaulon vesuvianum																	1			
Bare ground (%)	5	5	0	2	5	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Bare rock (%)	10	25	45	20	0	20	30	25	20	0	7	8	11	0	0	0	5	4	3	0

Table 18 Species percentage cover for quadrats in Plot 4 for 1999, 2004, 2017 and 2022

Plot	4					4					4					4				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	H18b	H18c	H18c	H18a	H18b	H18b	H18c	H18b	H18a	H18b	H18a	H18a	H18a	H18a	H18b	H18a	H18a	H18b	H18a	H18a
Calluna vulgaris		3	1				2	1		1		2	1	1	1		6	1	2	1
Calluna vulgaris (dead)																1				
Empetrum hermaphroditum											3		1			3		2		
Empetrum nigrum	25	15	20	20	15	20	20	35	35	15	16	15	17	7	4	20	24	30	15	20
Vaccinium myrtillus	30	25	30	25	45	35	20	35	25	25	31	33	17	40	42	30	38	25	30	50
Blechnum spicant																		+		
Diphasiastrum alpinum											2		7			1		3		
Huperzia selago			3					1												
Carex binervis			1									3					3			
Carex pilulifera						2		5			2	1	1			2		2		
Juncus squarrosus		3		5	5				10			2		4	4		3		4	4
Luzula multiflora		2										1								
Agrostis capillaris												4			1		2		2	1
Agrostis vinealis	5	5	2		5	5	2		5	5	7	3	4	5	6	5	4	5	5	5
Anthoxanthum odoratum															1					1
Avenella flexuosa	10	15	10	10	5	15	20	15	10	15	12	10	12	18	18	7	20	12	15	15
Festuca ovina	15	10	10	10	5	10	5	5	2		18	7	8	7		5	5		5	
Festuca vivipara											2		1					2		
Nardus stricta	10	10	20	10	10	15	25	15	10	5	4	7	12	7	5	2	2	4	5	3
Galium saxatile	3	5	5	3	3	5	2	5	7	3	17	14	12	10	7	5	12	10	7	3
Campylopus flexuosus				1			1					1	1	1						1
Dicranum scoparium				2	3		3		2	5	1			1						
Hylocomium splendens					5		2			10	2	3	2	12	5	1	5	10	10	5
Hypnum cupressiforme	55	25	35	35	25	20	10	15	10	50										
Hypnum jutlandicum											5	7	3	6		10	3		2	
Plagiomnium undulatum										1										
Plagiothecium undulatum												2		1	2	1	1			2
Pleurozium schreberi	3					7			5				1			1	2	5		
Polytrichum commune					5					5	3	4	3	6	5		1		1	2
Polytrichum formosum	1	5	5	5		1	3	2	1											
Polytrichum juniperinum														1						
Polytrichastrum alpinum											5	6	7	1		15		3	2	
Racomitrium fasciculare											1					1			1	
Racomitrium lanuginosum		10	10		5	3	5				12		3	3		2		2	1	
Rhytidiadelphus loreus	10	10		10	5	15	10	10	7	15	15	6	12	12	15	25		15	10	20
Rhytidiadelphus squarrosus		10					5			15		2		2						
Sphagnum subnitens													1					2		
Sphagnum tenellum																	1			
Thuidium tamariscinum				1						5		1					2		1	
Barbilophozia floerkii																				1
Cephaloziella sp.												1								
Diplophyllum albicans												1	2	1				1		
Lophozia ventricosa												1			1		1			1
Plagiochila asplenioides															2					
Cladonia coccifera		1																		
Cladonia furcata												1		2	1				1	1
Cladonia portentosa	1	2	1	2			1		1					1					1	
Cladonia uncialis													1					1		
Hypogymnia physodes					1															
Bare ground (%)	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare rock (%)	15	20	10	15	10	15	20	10	15	10	16	3	2	13	4	20	1	1	13	5

Table 19 Species percentage cover for quadrats in Plot 6 for 1999, 2004, 2017 and 2022

Plot	6					6					6					6				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	H12c	CG10b	CG10b	BG	H10a	H12c	CG10a/H10d	H10d	BG	H10a	H10a/H12a	H10d	H10d	H10d	H10a	H10a	H10d	U5c/H10d	H10d	H10a/H12a
Sorbus aucuparia										1										
Calluna vulgaris	65		7		50	50	15	25		60	85	38	41	50	95	85	36	5	75	70
Calluna vulgaris (dead)																	3	5		
Erica cinerea	7				40	5	1	5		45	10	3		7	9	15	5		11	20
Erica tetralix						10														
Vaccinium myrtillus	25		15		5	25		20		10	10		3		30	5		2		30
Blechnum spicant												1								
Dryopteris dilatata													1			1		1		
Selaginella selaginoides												1		1			1	1		
Carex demissa		1	5				2	5					4	1				2	1	
Carex panicea			1					3												
Carex pilulifera							2	3			1		15			1				
Carex pulicaris			5									12		1			3	15		
Luzula multiflora			2															1		
Agrostis canina														1			1			
Agrostis capillaris			3			10		15												
Agrostis vinealis	3	1	5		1	5		10		5	3	1	2		1	3		2		2
Anthoxanthum odoratum			5		1			5										1		
Avenella flexuosa	1									2	1			2	1	1	1			
Danthonia decumbens												2	1	1			1			
Festuca ovina	10	12	15	5	7	5	10	5	2	5		1	1	1		1	1	2	1	3
Festuca vivipara												2	1				2	1		
Holcus lanatus																		1		
Molinia caerulea											1	1	1	1			1	1	1	
Nardus stricta	3		10				3	10				3	5	3			1	10	3	
Alchemilla glabra		1	1																	
Campanula rotundifolia												1								
Cirsium palustre												1	3				1	5		
Galium saxatile	5		15		3	2		10			30		5		3	2		1		2
Hypericum pulchrum												1		1			2	1	1	
Lysimachia nemorum													2					3		
Lysimachia nummularia								4												
Oxalis acetosella											2					3				
Pinguicula vulgaris														1					+	
Polygala serpyllifolia			1				1										1			
Potentilla erecta			5		3		1	5		5		2	4				10	7		1
Potentilla sterilis																	1			
Prunella vulgaris			5					1					2							
Solidago virgaurea														1					+	
Thymus drucei		3	5				2	3				17	2	7				10	20	
Tussilago farfara				1					1											
Viola riviniana		1		1				1			1	2	1	1			1	3	1	
Blindia acuta												1						3		
Brachythecium rutabulum					5															
Breutelia chrysocoma			15				1	5					15	4				10	10	
Campylopus atrovirens														2						
Dicranum scoparium					1									1					1	1
Drepanocladus revolvens												1								
Hylocomium splendens	5		5		1	2				5	15		4		46	15		3		55
Hypnum cupressiforme	20				10	10				10										
Hypnum jutlandicum											7	5		15	3	5	5	3	20	15
Plagiothecium undulatum											1				1	10				1
Pleurozium schreberi	10					10		15		15					20	5		1	2	10
Polytrichum commune	15					4				5	2									
Polytrichum piliferum					1															
Pseudoscleropodium purum			3									1				2				3
Racomitrium fasciculare														2					1	
Racomitrium lanuginosum												12		6			10		20	
Rhytidiadelphus loreus			10			5		5							1	2		3		
Rhytidiadelphus squarrosus					2			3		5		1				1			1	1
Sphagnum denticulatum							3													
Sphagnum palustre													5					5		
Sphagnum subnitens													4					15		
Thuidium tamariscinum	10		3			15		7		10	17		3		4	1		3		1
Diplophyllum albicans					2												1			
Cladonia portentosa					2															
Stereocaulon vesuvianum												1								
Bare ground (%)	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare peat (%)	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Bare rock (%)	0	85	10	94	0	0	78	0	98	0	0	43	5	42	0	0	0	6	25	0

Table 20 Species percentage cover for quadrats in Plot 7 for 1999, 2004, 2017 and 2022

Plot	7					7					7					7				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	H18 b	H18 a Sc	H18 a Sc	H18 a Sc	H18 a Sc	H18 b	H18 a Sc	H18 a Sc	H18 a Sc	H18 a Sc	U4e	H21 a	H21 a	H21 a	H21 a	U4e	H21 a	H21 a	H21 a	H21 a
Calluna vulgaris			5	5	3		20	15	7	10	1	55	63	79	61		60	85	95	95
Empetrum nigrum	20	20	15	25	25	3	25	5	20	30		12	4		13	2	15	10		2
Erica cinerea																		1		
Vaccinium myrtillus	35	35	25	30	30	65	35	25	25	45	5	26	22	20	29	9	40	30	25	30
Blechnum spicant	10	7	5	3	7	12	3	4	1	5	14	2	4			16	1	1		
Huperzia selago				1					1											
Lycopodium clavatum				3																
Carex demissa			1																	
Carex echinata							5													
Carex pilulifera														1	1					
Agrostis capillaris						5					4					5				
Agrostis vinealis	2		3	5	2	5	5	5	5	5	7	1	3	2	2	5	1	2	2	3
Anthoxanthum odoratum	10					10														
Avenella flexuosa	5	10			5	3	5		2	10	35	8	5	3	5	20	5	3	2	4
Danthonia decumbens														2					1	
Festuca ovina	5			5	10	10	5	5	5	5	10					5				1
Nardus stricta		10	15	5	5	10	10	15	7	10	5	2	3	6	4	3	1	1	1	+
Galium saxatile	10	5	2	3	5	7	7	5	4	10	9	10	1			10	4	1		
Oxalis acetosella						1					1					1				
Potentilla erecta				2			2		2					2					2	
Campylopus flexuosus									2					1						3
Dicranum scoparium					1										2					2
Hylocomium splendens					10				5	7	6		2	4	3	15		3	5	10
Hypnum cupressiforme				2	3	10			5											
Hypnum jutlandicum														5					5	10
Pleurozium schreberi	15	15	10		10	20		10	15	10	1	1	2	1		2	1	3	1	
Polytrichum commune	1	5	5		1	5	7	15		10	4	8	4	2	6	5	5	10	2	2
Polytrichum formosum			5		2		5		5											
Polytrichum juniperinum	2				2							4					3			
Polytrichum strictum									1				3							
Pseudoscleropodium purum																1				
Racomitrium fasciculare						2														
Racomitrium lanuginosum			10	3	2			3	3											
Racomitrium sp.														1						
Racomitrium sudeticum											1					1				
Rhytidiadelphus loreus	25	10	10		5	5	5	7	10	5	20	10		7	6	10	5	5	5	2
Rhytidiadelphus squarrosus						10														
Sphagnum capillifolium		30	25	20	50		20	25	7	20		18	10	3	12		30	30	1	15
Sphagnum fallax		2											2					10		
Sphagnum inundatum															20					
Sphagnum palustre				2									4							
Sphagnum papillosum		10			2															
Sphagnum quinquefarium											3	20	40	18			20	20	15	5
Sphagnum subnitens		3																		
Thuidium tamariscinum	1		5		1	10				15	15		2		3	15	3	1		15
Calypogeia fissa																		1		
Diplophyllum albicans					1						1			1	1	2				
Lophozia ventricosa															1					
Ptilidium ciliare												1								
Scapania sp.											1			1						
Cladonia coniocraea																1				
Cladonia portentosa				1	2									1						
Cladonia subcervicornis														1						
Bare rock (%)	15	0	5	30	2	10	0	0	40	3	11	0	0	5	2	11	0	0	0	0

Table 21 Species percentage cover for quadrats in Plot 13 for 1999, 2004, 2017 and 2022

Plot	13					13					13					13				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	CG10a	U4b	CG10a	U4eP	U5e	CG10a	U4b	CG10a	U4eP	U4d	H12c	U5b	U4e	H12c	U5d	U4e	H12c	H18a	H12a	U5d
Calluna vulgaris				2		3	1		5		55			52		4	19		67	+
Calluna vulgaris (dead)																10				
Erica cinerea														9					14	4
Vaccinium myrtillus			1	5				2	5		3		20	15		5	2	65	20	2
Blechnum spicant				2					3											
Carex binervis		5			3		3		2	20					2					7
Carex demissa		5				2	2													
Carex panicea		10			3		5			7		20			4		5			4
Carex pilulifera	10	20	10	2	3	5	7	5			1	10	7	1		1	2	2		1
Luzula multiflora			1					1					1							
Agrostis capillaris	15	20	10	15	15	40	30	20	25	20	20	3	25	5	15	15	15	5	10	20
Agrostis vinealis				3	15	5		15	10	5		25	5	10	10		5	3	5	10
Anthoxanthum odoratum	5	10	10	5	10	5	15	15		15	5	3	7	7	7	10	25	10		2
Avenella flexuosa											3			3			2		10	
Danthonia decumbens	3				3	2		3	5	3			3	2	4	1				
Deschampsia cespitosa																				2
Festuca ovina	15	10	15	5	15	15	10	10	10	5		5	10	2		10	5	10		
Nardus stricta	25	15	25	10	20	7	7	10	20	10	1	45	3	1	85	2	4	2		50
Achillea millefolium		5					1					1					1			
Campanula rotundifolia																3				
Galium saxatile	15	5	10	2	10	5	5	3	7	10	15	2	12	5	20	10	7	20	3	5
Polygala serpyllifolia	2	1	2	2	5	1	1	1	3			7	5	1	2	3	1	1	1	
Potentilla erecta	5	15	15	3	15	7	5	15	5	10	6	8	15	10	20	8	7	15	5	7
Thymus drucei	5		3			2		3												
Andreaea rupestris																				1
Aulocomnium palustre					2															
Breutelia chrysocoma	20					3	1			3	1		1		1					
Calliergon cuspidatum		2																		
Dicranum scoparium				1														1		
Hylocomium splendens											5	25	12	15	20	30	25	30	30	10
Hypnum cupressiforme		5	5	5	5	5		5	5	5										
Hypnum jutlandicum											8		2	12				3	10	
Pleurozium schreberi	10	15	10	10	10	20	20	20	20	10	1			2						
Pogonatum urnigerum			1	1					1											
Polytrichum commune	10		3	55					25		1		2	3		1		3	10	
Polytrichum formosum	1					2														
Polytrichum piliferum								1												
Pseudoscleropodium purum							5	5	10	5		15	3	1	10		3	4		4
Racomitrium fasciculare													1							
Racomitrium lanuginosum	5				10			1					1		1					
Racomitrium sudeticum																				1
Rhytidiadelphus loreus			10		15			5	5	15			2					10		
Rhytidiadelphus squarrosus	15	10	5	15	5	10	5	25	15	20	2	15	5	2	5		15			1
Sphagnum fallax															1					1
Sphagnum palustre						2														
Sphagnum subnitens															1					
Thuidium tamariscinum	2		5						2	3			1		3	15		5		2
Lophozia ventricosa													1							
Cladonia coccifera			2	2																
Cladonia subcervicornis													1							
Bare rock (%)	10	0	25	10	20	0	0	20	2	5	0	0		0		1	0	4	0	2

Table 22 Species percentage cover for quadrats in Plot 14 for 1999, 2004, 2017 and 2022

Plot	14					14					14					14				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	U4b	U4a	U4a	CG10a	CG10a	U4b	U4a	CG10a	CG10a	U4b	U4b	U4e	U4eSc	U4e	CG10a	U4e(B)	U4e	U4e	U4d/e	CG10a
Calluna vulgaris																			1	
Vaccinium myrtillus											3	1	4	2		4	6	8	1	
Asplenium adiantum-nigrum							1													
Cryptogramma crispa	2	2		5		10	3		5			2		1			1	1	1	
Dryopteris oreades							1													
Huperzia selago									1					1						
Hymenophyllum wilsonii												1		1			1			
Oreopteris limbosperma												3					1			
Carex demissa															3					1
Carex pilulifera										5										
Carex pulicaris															2					1
Luzula multiflora			5															1		1
Agrostis capillaris	5	5	10	15	25	10	25	20	25	30	4	14	12	7	15	4	5	10	5	25
Agrostis vinealis			5			10		3			5	12	17	10		4	10	15	6	
Anthoxanthum odoratum	3	3	5	10	15	5	5	5	5	5	4	15	15	5	20	1	10	20	2	15
Avenella flexuosa													2				1	2		
Cynosurus cristatus															5					2
Festuca ovina	19	15	10	15		30	20	25	25	5		25	20	20		10	5	10	5	1
Festuca rubra	2	10	10	25				5	10		15				30	10				15
Festuca vivipara															1					
Holcus lanatus	5		10	2	5			7			4		5	2	2	3		2		1
Holcus mollis												3	2	1	1	1	5	3		2
Nardus stricta						7			5			4		3	6			4		4
Poa annua					2															
Alchemilla glabra					3					2					3					3
Campanula rotundifolia	2	5				3	2			1					5					3
Cardamine pratensis															2					
Cerastium fontanum					2										3					2
Cirsium palustre	1		1		10					20					4					14
Epilobium brunnescens					5					2					1					
Euphrasia agg.					1					1					2					2
Galium saxatile	3	15	15	2	5	10	5	5	5	5	12	23	17	17	7	10	20	20	15	4
Lysimachia nemorum															5					2
Oxalis acetosella	2	1				2	1				1	3			2	1	2			1
Polygala serpyllifolia		1																		
Potentilla erecta								3					2		2			1		1
Prunella vulgaris					5					2					5					3
Ranunculus acris															7					4
Rumex acetosa													2							
Rumex acetosella								2												
Sedum anglicum	1	5	10		10	1	1	2	1			1		4	2		1		1	1
Thymus drucei					2			3	3						1					+
Trifolium repens																				1
Viola riviniana					2										3					1
Amphidium mougeotii														1						
Andreaea rothii																1				
Andreaea rupestris											1									
Atrichum undulatum										2										
Breutelia chrysocoma		3			2					1	4	4	4	20	3	5	5	3	3	2
Campylopus atrovirens											2									
Ctenidium molluscum	3		35	25		5		10	3											
Dicranum scoparium				3		5			3								1			
Hylocomium splendens		5					15				5	18	8	8	4	3	25	5	15	2
Hypnum cupressiforme	5					5		15	15											
Hypnum jutlandicum													1	3		2	5	3	1	
Plagiomnium undulatum		2													1					1
Pleurozium schreberi		5					10		10	10						2				
Polytrichum commune	2	2	5	20		10	5	2	7		4	7	12	8	2	2	5	5	2	
Polytrichum formosum	2																			
Polytrichum juniperinum					5					5			2							
Racomitrium fasciculare											2	1		1		2	2			
Racomitrium lanuginosum		2	2	1			3	3				5		2			8		1	
Racomitrium sudeticum											1	1				2	1		1	
Rhytidiadelphus loreus							5		10		3	10	4	15	1	2	10	5	30	1
Rhytidiadelphus squarrosus	3	5	10	10	5	10	15	10	10	15			2	15	2			3	2	1
Sphagnum capillifolium													7					4		
Sphagnum quinquefarium												1	2	1				1		
Sphagnum subnitens		3																		
Thuidium tamariscinum	5	2	5	1	5	5	10	15	2	10	3		7	10		3	5	7	5	
Diplophyllum albicans											1					1				
Marsupella emarginata											2					1				
Cladonia coccifera	1		1	1				1												
Cladonia portentosa						1														
Cladonia subcervicornis											3	1				2				
Peltigera cf *canina*					1															
Stereocaulon vesuvianum											2	2		1		1				
Bare ground (%)	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Bare rock (%)	70	45	15	30	0	65	40	15	30	0	50	6	0	10	2	50	13	2	7	0

Table 23 Species percentage cover for quadrats in Plot 15 for 1999, 2004, 2017 and 2022

Plot	15					15					15					15				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	U4b	U4a	U4a	U4a	U4a	U4a	U4a	U4a	U4e	U4a	U4a	U4a	U4e	U4e	U4e	U4a	U4e	U4e	H18b	U4e
Vaccinium myrtillus				1					2				2	20	1	+	1	3	50	1
Carex pilulifera				3		2			5					3					1	
Luzula multiflora					5					3				3	2		1			2
Agrostis capillaris	15	30	45	25	20	15	40	50	25	35	35	60	75	20	50	30	45	50	5	40
Agrostis vinealis											5	5	5	5	17	10	10	2	5	5
Anthoxanthum odoratum	3		15		5	5		15		10	3	3	7	10	7	2	10	15	2	40
Avenella flexuosa									3					1						
Danthonia decumbens								5	2									1		
Festuca ovina	35	25	15	35	25	40	35	20	20	25	20	20	18	30	20	30	20	15	5	5
Festuca rubra	3		5			5		5	5								1		3	1
Holcus lanatus	15				10	10	2			10	20	2			1	20				1
Nardus stricta				7	10				7	5				8						1
Achillea millefolium					1															
Cirsium palustre					2						2									
Galium saxatile	5	15	10	15	5	10	15	15	20	15	20	25	17	20	20	20	15	15	15	10
Polygala serpyllifolia												1								
Potentilla erecta												1								
Andreaea rothii																	1	1		
Breutelia chrysocoma														1						
Campylopus flexuosus							2									2				
Dicranella heteromalla													1							
Dicranum scoparium	1	10	1	2	3		2			2		1	1			3		1		
Hylocomium splendens											3	5		2	2	5	2	1	1	2
Hypnum cupressiforme	10	10	5	5	10	10	10	5	10	10	5	2	3							
Hypnum jutlandicum														1		10	8	10	5	
Pleurozium schreberi												1				2	2			
Polytrichum commune	3	10			1	2	5			1	10	1		2	2	3	3	1	1	
Polytrichum juniperinum			5	1																
Pseudoscleropodium purum											3	1	2	2	3	10	2	2	2	1
Racomitrium fasciculare											1					1	1	2		
Racomitrium lanuginosum	2					2											1			
Racomitrium sudeticum													1			1	2	1		
Rhytidiadelphus loreus											1			1		1			2	
Rhytidiadelphus squarrosus	25	20	30	20	15	15	20	5	15	5	15	1	10	10	11	10	4	15	7	10
Thuidium tamariscinum	2	5			1	5	5				3	1			1	2	2		1	2
Barbilophozia floerkii													1							
Ptilidium ciliare															1					
Cladonia portentosa			1																	
Cladonia pyxidata																	1			
Cladonia subcervicornis											1		1			1		2		
Parmelia saxatilis																1				
Bare rock (%)	30	20	15	10	5	25	15	15	5	3	17	1	3	2	0	6	8	2	6	0

Table 24 Species percentage cover for quadrats in Plot 21 for 1999, 2004, 2017 and 2022

Plot	21					21					21					21				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	M6 c	M15a/d'	U5 e	M15a/d'	M15a/d'	M6 c	M15b/d'	M15b/d'?	M15a/d'	M15a/d'	M6 c	M15b/d	M15d'	M15a'	M15a'	M6 c	M25a	M25b	M25a/M15d	M25a
Calluna vulgaris												3		1					1	
Calluna vulgaris (dead)																	1			
Dryopteris dilatata																+				
Carex demissa		3	1	5	15				3	2										
Carex echinata								5		2		1		2	3		1			
Carex nigra													2					1		
Carex panicea		15		20	15				5	3		7		5	5		2		1	3
Eriophorum angustifolium		5		5	5		7		2	5				2	1					
Eriophorum vaginatum		5													1					1
Juncus bulbosus									7	1				1	1	1				
Juncus effusus	15					45					90					80				
Juncus squarrosus		10	20	10	10		5	2	5	2										
Trichophorum germanicum		15	5	20	20		20	10	20	15		5	2	3	3		2		1	1
Agrostis canina											8	2	3	2	4	30	4	4	3	2
Agrostis stolonifera																1				
Agrostis vinealis		5	10				15	10	10	5										
Anthoxanthum odoratum			5					2					2					1	1	
Avenella flexuosa			2					5					3					1		
Festuca ovina		5	15	10			10	19	10	3			1					1		
Festuca vivipara															2					1
Molinia caerulea			5	5				20	7	5		60	90	90	85		70	90	85	90
Nardus stricta		20	30	15	20		10	10	10	10		7	8	9	7		4	3	7	3
Dactylorhiza maculata				1										1					1	
Drosera rotundifolia		2		1	5															
Galium saxatile	1		5			10	1	3			15		12			15		1		
Narthecium ossifragum		5		5	10		7		20	5		45		20	20		25		20	15
Polygala serpyllifolia		2		2	5		1	2	2	1		3		1			1			
Potentilla erecta		2	5	2	5		5	7	5			3	2	2	3		1	1	1	1
Aulocomnium palustre														1						
Breutelia chrysocoma		5		2	5		2		3											
Calliergon cuspidatum																1				
Campylopus atrovirens										2										
Hylocomium splendens	10	5				5						1	2	1			1	1	1	1
Hypnum cupressiforme		5	1		5		5			5										
Hypnum jutlandicum												1		7	3		2		5	
Plagiomnium undulatum			5																	
Plagiothecium undulatum													1					1		
Pleurozium schreberi													2				1	1		1
Polytrichum commune	60		10			40		1			70		1			40		1		
Pseudoscleropodium purum														2					3	
Racomitrium lanuginosum										2										
Rhytidiadelphus loreus		2	5	5	3						1	2	4	1	5	1	1	2	5	2
Rhytidiadelphus squarrosus							10	10	15		1		2			3		4	5	2
Sphagnum capillifolium		15	5				20	2												
Sphagnum cuspidatum				10																
Sphagnum denticulatum		20			25		5			15										
Sphagnum fallax	15			3		10					15		1	1	8	6				
Sphagnum inundatum															1					
Sphagnum palustre		5	5		10		10	70				3		12	12					1
Sphagnum papillosum				45					55					1						
Sphagnum squarrosum		3	5		10															
Sphagnum subnitens												2					5			1
Sphagnum tenellum		1		1	1															
Thuidium tamariscinum								5					1		1	1		1		1
Calypogeia fissa												1								
Calypogeia muelleriana		1	2																	
Diplophyllum albicans					2															
Bare ground (%)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 25 Species percentage cover for quadrats in Plot 23 for 1999, 2004, 2017 and 2022

Plot	23					23					23					23				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	U5b	U5b	U5b	U5a	U5b	U5b	U5b	U4e	U5a	U5b	U5b/d	H12c	U5d	U5b	U5a	U5d	U5d/H12c	U5d	U5a	U5a
Calluna vulgaris							5					30	15			2	20	20		
Calluna vulgaris (dead)																	2			
Vaccinium myrtillus	2		2	5				4	7		1	2	6	3	1	2	2	5	6	1
Lycopodium clavatum	2							5			1					1				
Carex binervis									3			2					1			
Carex panicea	5	10	5				10	7		3	4	3	3		4	3	2	1		3
Carex pilulifera	3		10			3		5		3	1		2		1	1		2		
Juncus squarrosus		2	2	30			3		15	3		1								
Luzula multiflora		10	5	10	5	3	5	5		5	1		1			2	1	1		1
Agrostis canina												3	5	7						
Agrostis capillaris		5		5	10	5	30	10	10	15	5	4	5	5	20	20	10	15	15	15
Agrostis stolonifera																10	5	10	10	10
Agrostis vinealis	5			5	5	10	5	5	20	10	15				20			15		15
Anthoxanthum odoratum		10	10		10	5	2	10		5		1	2	4						
Avenella flexuosa				2			3		5	5		2	8	7	2		1	1	5	1
Danthonia decumbens											3		2		1	1	3	3		
Festuca ovina	15	10	15	15	15	15	10	15	10	10	20	12	5	15	15	10		10	10	15
Molinia caerulea				2		3		3		3										
Nardus stricta	65	60	25	30	25	20	10	20	15	55	35	35	40	15	35	40	25	25	20	35
Galium saxatile	10		10	20	20	5		15	5	7	10	1	9	11	15	15	5	8	15	
Polygala serpyllifolia	3		3		5	2				1	1	1					1			
Potentilla erecta	5	3		5		5	3	7		2	4	5	4			5	10	7		
Breutelia chrysocoma								1			1									
Dicranum scoparium	5																			
Hylocomium splendens	2		15	15	15			3	10	5	10	15	8	20	40	15	10	12	15	15
Hypnum cupressiforme	2			2			15	5	5											
Hypnum jutlandicum											3	3		1	1		3	3	5	
Pleurozium schreberi			5					25		20	2	2	3		1					
Polytrichum commune	20	5	10		10	25	5	1		2	20		1	25	1	4			20	5
Polytrichum formosum						5														
Rhytidiadelphus loreus							5					4				1	2		2	
Rhytidiadelphus squarrosus	5			15	5	15		5	10	10	1	1	1	2	2		1	1	3	5
Thuidium tamariscinum							5	5		2		4	1	1			1			
Barbilophozia floerkii	1																			
Bare ground (%)	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 26 Species percentage cover for quadrats in Plot 26 for 1999, 2004, 2017 and 2022

Plot	26					26					26					26				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	CG 10b	CG 10a /b	CG 10a	CG 10a	CG 10a	CG 10a	CG 10a	CG 10a	CG 10a	CG 10b	U5c	U1 3	U4 a	U4 b	CG 10a	U4 a	U4 b	U4 a	U4 a	CG 10a
Calluna vulgaris	1					1														
Empetrum nigrum															1					1
Vaccinium myrtillus				1					1					1					1	
Carex caryophyllea														5	1					1
Carex canescens													1							
Carex demissa						2				3	2	1			2	1	1			3
Carex panicea	3				10															
Carex pilulifera		2		5	10	5	5	2	5	5		1				2		1	13	
Carex pulicaris	15	1								3										1
Luzula campestris														1					1	
Luzula multiflora	10		5	2		2		5				1					1			1
Trichophorum germanicum											3					3				
Agrostis capillaris	15	15	15	15	15	15	20	20	15	15	36	30	62	40	65	70	30	75	60	20
Anthoxanthum odoratum	15	10	10	5	5	5	10	5	7	5		10		25	15		20		1	20
Avenella flexuosa											6					1				
Deschampsia cespitosa							10	5		3		40			2		1			1
Festuca ovina	5	10	5	15	10	5	15	20	10	15	18	2	20	25	10	7	10	5	20	5
Festuca rubra												3			3					1
Holcus lanatus							10					2			1		30			2
Molinia caerulea																1				
Nardus stricta	20	10	10	5	10	20	15	15	10	10	30	4	10	4	2	13	3	6	4	3
Achillea millefolium	3	10	5	2		3	3				1	1		1	1					10
Alchemilla glabra	3	3				2	3	3												
Campanula rotundifolia				2	3	10			5	10	2	2		2	4	1	2		2	10
Cerastium fontanum															1					
Cirsium palustre		5	2		3	1	5					5			1		4			2
Euphrasia agg.		1		1		1	1	2	1	2		1			4					8
Galium saxatile	5		10	10		5	2		5	5	1	8		8	10		7		2	20
Plantago lanceolata	10	20	5		20	10	7	7		7	1	4			5		8		1	7
Polygala serpyllifolia		1			1				5	3										
Potentilla erecta		2			2	2	2	2		5	1	3		1	5	2	7		1	10
Prunella vulgaris	3	15			10	2	2			1										
Ranunculus acris	1				1	2	2	2		1		2			2		5			2
Scorzoneroides autumnalis	1					1				2	1	1			1	2				1
Taraxacum officinale					1															
Thymus drucei	15	15	10	1	20	10	5	5	3	5					2					1
Trifolium repens							3					2					7			
Viola riviniana	2	1			3	1				5		1			3					
Breutelia chrysocoma						1				2					2					
Calliergon cuspidatum										2		1		1	2	1			1	
Campylopus atrovirens				1																
Campylopus flexuosus											1		2			1		2		
Ctenidium molluscum			15	20		1		5	30											
Dicranella heteromalla												1								
Dicranum scoparium			3			3														
Eurhynchium praelongum															1					
Hylocomium splendens			10	10				2	5			2		1	5				2	30
Hypnum cupressiforme					3	5		5			1									
Hypnum jutlandicum													2	1		5		1	1	
Mnium hornum		1																		
Polytrichum commune									2			1		1	1		1			1
Pseudoscleropodium purum												1			1		3			5
Racomitrium lanuginosum	1	2																		
Rhizomnium punctatum			2																	
Rhytidiadelphus squarrosus		10			5	10	5	10	10	15	1	2		2	2		8		2	10
Sphagnum compactum											1					1				
Thuidium tamariscinum		3				5	10	10	10			1	2	1				1	4	
Diplophyllum albicans			2																	
Scapania sp.																1		1		
Bare ground (%)	1	0	1	5	2	0	0	0	0	0	0	2	4	0	0	8	0	12	1	0
Bare rock (%)	3	3	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0	0

Table 27 Species percentage cover for quadrats in Plot 28 for 1999, 2004, 2017 and 2022

Plot	28					28					28					28				
Year	1999					2004					2017					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	M15c	M3	M1	M3	M15c/d	M15c	M1	M3	M3	M15c/d	M15c	M1	M3	M15b	M15b/d	M15c	M2	M3	M15b	M15b/d
Calluna vulgaris	2				3						17			3	38	1			2	2
Calluna vulgaris (dead)																				15
Empetrum nigrum															2					5
Erica cinerea															1					
Erica tetralix	40				20	55				30	8	3		1	13	3			4	12
Vaccinium myrtillus															1	1				
Huperzia selago					1															
Carex echinata												1								
Carex panicea	3				10					5										
Eriophorum angustifolium	5	14	7	5		5	85	10	20	3	7	70	20	54	4	2	25	20	17	1
Juncus squarrosus					20					5					1					
Trichophorum germanicum	10		1		10	10		2		5	15			2	12	5	3		3	7
Agrostis vinealis					7					5										1
Avenella flexuosa										5	1				3					1
Festuca ovina					10	10				10										
Molinia caerulea	15				10	10				10	17	5			15	20				30
Nardus stricta	5				5	5				5				1						
Drosera rotundifolia		1	1		1	1	1				2	4		3		1	4		2	
Galium saxatile										7										
Narthecium ossifragum										1	1	4		5	8	1	1		8	15
Polygala serpyllifolia											1				1	1				
Potentilla erecta	1				3					2					3	1				3
Campylopus atrovirens	1																			
Campylopus flexuosus											1					3				
Campylopus introflexus																			1	
Dicranum scoparium											1			1						
Hylocomium splendens															10					7
Hypnum cupressiforme						10														
Hypnum jutlandicum											18				8	15				7
Pleurozium schreberi										5										
Polytrichum commune															2					
Polytrichum juniperinum					15					15				1					1	
Polytrichum strictum															3					3
Racomitrium fasciculare	5					2														
Racomitrium lanuginosum	20				15	5				15	17			1	7	30			3	5
Rhytidiadelphus loreus					5					10					5					7
Rhytidiadelphus squarrosus															1					
Sphagnum capillifolium															5					6
Sphagnum cuspidatum																	3			
Sphagnum denticulatum			1				1					5								
Sphagnum inundatum												15								
Sphagnum palustre					10					30										
Sphagnum papillosum					5									5	13		2		7	15
Sphagnum tenellum																1				
Thuidium tamariscinum	5					10		1												
Scapania gracilis															1					
Cladonia furcata											1									
Cladonia portentosa					3	1					1					1				
Bare peat (%)	50	60	70	78	20	20	15	89	66	00	100	200	801	300	00	00	451	801	403	00
Bare rock (%)		1	1	7		0	0	1	4	0	0	0	1	0	0	0	1	1	3	0

9.3. Appendix 3: Tables of percentage cover for higher-level plots for 1999, 2004 and 2022

Table 28 Species percentage cover for quadrats in Plot 01 for 1999, 2004 and 2022

Plot	**1**					**1**					**1**				
Year	**1999**					**2004**					**2022**				
Quadrat	**F1**	**F2**	**F3**	**F4**	**F5**	**F1**	**F2**	**F3**	**F4**	**F5**	**F1**	**F2**	**F3**	**F4**	**F5**
NVC community	U4e	U4e	U4e	U4e	U4e	U4e R	U4e R	U4e R	U4e R	U4e R	U4d	U4d	U4d	U4d	U4d
Vaccinium myrtillus	2	5	4	10	7	2	3	2	5	5	1	3	1	1	1
Diphasiastrum alpinum				1											
Huperzia selago			2			1	1	1							
Luzula multiflora			1												
Agrostis capillaris	20	10	10	20	5	10	15	10	10	10	10	5	10	15	5
Agrostis vinealis			10	5				5	5		5	2	2	5	
Avenella flexuosa	10		5	5	3	7	5	3	5	10	5	3	2	2	2
Festuca ovina	25	25	30	25	35	50	40	60	50	60	20	5	15	10	15
Galium saxatile	20	15	15	10	15	7	10	5	5	10	8	2	5	7	7
Sedum anglicum				5											
Breutelia chrysocoma					2										
Campylopus flexuosus												1			
Ctenidium molluscum		10	5		10		3	5		5					
Hylocomium splendens											3	10	5	5	5
Hypnum cupressiforme			5		5	3		5		5					
Hypnum jutlandicum												2			
Pleurozium schreberi						5					20	5	10	15	10
Polytrichum commune			10					7							
Polytrichum formosum		5			5		15	2		10					
Polytrichum juniperinum	7			10		5			10						
Polytrichastrum alpinum											2	30	25	15	20
Pseudoscleropodium purum												1			
Racomitrium lanuginosum	7	2	5	1	3	15	15	15	10	20	5	10			
Rhytidiadelphus loreus		3		2	5	2	5	5	5	10	20	5	15	15	20
Rhytidiadelphus squarrosus		10			3	3	7		5	15	20	5	15	20	25
Barbilophozia floerkii						2		2	1						
Diplophyllum albicans												2			
Marsupella emarginata												1			
Cladonia coccifera		1					1								
Cladonia furcata							2		2			1			
Cladonia portentosa	1				2	3	2	1		2					
Cladonia uncialis	1	2		1	1	1				1					
Bare ground (%)	3	0	5	5	3	2	0	0	0	0	0	0	0	0	0
Bare rock (%)	2	20	5	2	3	2	15	5	0	3	0	8	1	0	0

Table 29 Species percentage cover for quadrats in Plot 16 for 1999, 2004 and 2022

Plot	16					16					16				
Year	1999					2004					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	U5e	U5e/H20	U4e	U5a	U5a	U5e	H18c	U4eDa	U5a	U5a	U5e	H18c	H18c	U6c	U5e
Empetrum nigrum	15	20	10			24	20	15				30	35		3
Vaccinium myrtillus		5	10	5	5		10	10	10	10	10	7	10	10	10
Diphasiastrum alpinum		5					3	20			1	12	12		
Huperzia selago			7				1	2				1			
Carex binervis		5													
Carex panicea	5	2		5	5	15	10		5	12	10	10	2	10	15
Carex pilulifera	10	10	10	15	15	20	15	20	15	25	5	10	5	10	20
Juncus squarrosus				5					15					20	
Luzula multiflora										3					
Agrostis capillaris							10								
Agrostis vinealis	5		3		5	15		10	10	10	5	5	3	10	5
Avenella flexuosa														2	
Festuca ovina	2	10	10	5	10	10	10	10	5	5	2	2	3	3	5
Nardus stricta	80	75	20	80	80	45	35	25	55	50	35	20	17	20	35
Galium saxatile	10	10	15	10	10	2		5		2	10	7	7	5	10
Potentilla erecta	2								5		1			2	2
Breutelia chrysocoma												1			
Dicranum scoparium			5	3				2							1
Hylocomium splendens											5			2	5
Hypnum cupressiforme	10	20		10	15	10	10		5	10					
Hypnum jutlandicum											10	10	7	10	12
Pleurozium schreberi														1	
Polytrichum commune					5					3	1	1		2	1
Polytrichum formosum						1			2						
Polytrichastrum alpinum												1			
Racomitrium lanuginosum	15	10	10			15	10	5			20	15	15	10	5
Rhytidiadelphus loreus											3	1		3	15
Rhytidiadelphus squarrosus					20					10	7			2	
Diplophyllum albicans	1														
Cladonia arbuscula											1				
Cladonia furcata														1	
Cladonia portentosa			1			1					1	1	1	1	
Cladonia uncialis													2		
Bare rock (%)	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0

Table 30 Species percentage cover for quadrats in Plot 17 for 1999, 2004 and 2022

Plot	17					17					17				
Year	1999					2004					2022				
Quadrat	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
NVC community	H18c	H18c	BR	H18c	H18c	H18c	H18c	BR	H18c	H18c	FF (H18c)	FF (U4e R)	FF (H18c)	FF (H18c /U4	FF (H18c)
Vaccinium myrtillus		15		20	5		7		5	2		4		8	2
Vaccinium vitis-idaea	10	5			10	3	8			3	5		7		4
Festuca ovina						1	1					6	2	5	4
Festuca vivipara											3	2	1	2	2
Galium saxatile											2				1
Micranthes stellaris													1		
Polytrichum formosum						1	1	1							
Polytrichastrum alpinum											1	1	1	3	20
Racomitrium lanuginosum	5	25		30	20	2	25		25	12	3	3	2	27	2
Racomitrium sudeticum											1				
Rhytidiadelphus loreus											1				
Cetraria aculeata											1	2	1	2	1
Cladonia coccifera		1		1	1	1	2		1	1				1	
Cladonia furcata												1	1	1	
Cladonia subcervicornis	1	1		1		1			1		1	2	1	2	1
Cladonia uncialis	1	1											1		1
Bare rock (%)	84	53	100	64	69	95	57	99	69	82	85	80	90	50	65

Table 31 Species percentage cover for quadrats in Plot 30 for 1999, 2004 and 2022

Plot	**30**			**30**			**30**		
Year	**1999**			**2004**			**2022**		
Quadrat	**F1**	**F2**	**F3**	**F1**	**F2**	**F3**	**F1**	**F2**	**F3**
NVC community	cf M31 R	cf M31 R	Bryo	cf M31 R	cf M31 R	Bryo	M31R	M31R	M31R
Selaginella selaginoides							1	3	1
Carex demissa								5	
Juncus bulbosus								1	
Juncus squarrosus									6
Agrostis canina								3	3
Agrostis capillaris							1		1
Agrostis vinealis	1	2		5					
Festuca ovina	6	7	10	7	12	5			
Festuca vivipara							7	10	10
Molinia caerulea						3			
Nardus stricta		7			5		10	4	3
Campanula rotundifolia		1						1	
Micranthes stellaris		1							
Narthecium ossifragum							1		
Pinguicula vulgaris								1	
Thymus drucei								1	
Viola riviniana								1	1
Amphidium mougeotii		10			3				
Anoectangium aestivum								3	
Atrichum undulatum	10	5	5	5	1	5			
Blindia acuta							2		
Bryum pseudotriquetrum						2		1	
Dichodontium palustre		1			3				1
Polytrichum commune									1
Racomitrium ellipticum								1	
Racomitrium fasciculare			1						
Racomitrium lanuginosum								4	
Sphagnum denticulatum	1	5			4			1	3
Sphagnum palustre									1
Aneura pinguis								1	
Anthelia julacea	10	10		4	5		40	15	60
Jungermannia exsertifolia ssp. *cordifolia*	15	20	60	10	25	50	10		10
Marsupella emarginata								1	
Mylia taylorii	15			15					
Nardia compressa	2	2		5	1				
Scapania undulata							4	10	10
Cladonia furcata								1	
Stereocaulon vesuvianum								1	
alga							20	10	
Bare rock (%)	35	45	20	35	49	20	20	45	3

9.4. Appendix 4 - Full names of NVC communities mentioned in the text

Calcareous grassland

CG10a *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland, *Trifolium repens-Luzula campestris* sub-community

CG10b *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland, *Carex pulicaris-Carex panicea* sub-community

Acid grassland

U4a *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland, Typical sub-community

U4b *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland, *Holcus lanatus-Trifolium repens* sub-community

U4d *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland, *Luzula multiflora-Rhytidiadelphus loreus* sub-community

U4e *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland, *Vaccinium myrtillus-Deschampsia flexuosa* sub-community

U5a *Nardus stricta-Galium saxatile* grassland, Species-poor sub-community

U5b *Nardus stricta-Galium saxatile* grassland, *Agrostis canina-Polytrichum commune* sub-community

U5c *Nardus stricta-Galium saxatile* grassland, *Carex panicea-Viola riviniana* sub-community

U5d *Nardus stricta-Galium saxatile* grassland, *Calluna vulgaris-Danthonia decumbens* sub-community

U5e *Nardus stricta-Galium saxatile* grassland, *Racomitrium lanuginosum* sub-community

The following informal variants of **U4e** were recognised:

U4e P *Polytrichum* sp. variant

U4e Da *Diphasiastrum alpinum* variant

U4e R *Racomitrium lanuginosum* variant

U4e Sc *Sphagnum capillifolium* variant

Tall herb and fern

U13 *Deschampsia cespitosa-Galium saxatile* grassland

Dry heath

H10a *Calluna vulgaris-Erica cinerea* heath, Typical sub-community

H10d *Calluna vulgaris-Erica cinerea* heath, *Thymus praecox-Carex pulicaris* sub-community

H12c *Calluna vulgaris-Vaccinium myrtillus* heath, *Galium saxatile-Festuca ovina* sub-community

H18a *Vaccinium myrtillus-Deschampsia flexuosa* heath, *Hylocomium splendens-Rhytidiadelphus loreus* sub-community

H18b *Vaccinium myrtillus-Deschampsia flexuosa* heath, *Alchemilla alpina-Carex pilulifera* sub-community

H18c *Vaccinium myrtillus-Deschampsia flexuosa* heath, *Empetrum nigrum-Racomitrium lanuginosum* sub-community

H20 *Vaccinium myrtillus-Racomitrium lanuginosum* heath

H21a *Calluna vulgaris-Vaccinium myrtillus-Sphagnum capillifolium* heath, Typical sub-community

The following informal variant of **H18a** was recognised:
H18a Sc *Sphagnum capillifolium* variant

Wet Heath
M15a *Scirpus cespitosus-Erica tetralix* wet heath, *Carex panicea* sub-community
M15b *Scirpus cespitosus-Erica tetralix* wet heath, Typical sub-community
M15c *Scirpus cespitosus-Erica tetralix* wet heath, *Cladonia* sub-community
M15d *Scirpus cespitosus-Erica tetralix* wet heath, *Vaccinium myrtillus* sub-community

(vegetation intermediate between several of these are labelled in the form **M15b/d** etc. Where annotated with a ‘ , it indicates forms of **M15** with little or no dwarf-shrub component).

Marshy Grassland
M25 *Molinia caerulea-Potentilla erecta* marshy grassland
M25a *Molinia caerulea-Potentilla erecta* marshy grassland, *Erica tetralix* sub-community

Blanket Bog
M1 *Sphagnum auriculatum* bog pool
M2 *Sphagnum cuspidatum/recurvum* bog-pool
M3 *Eriophorum angustifolium* bog pool

Mountain spring
M31 *Anthelia julacea-Sphagnum auriculatum* spring

For further details on communities, refer to Rodwell *et al.* (1991, 1992).

9.5. Appendix 5 – Landscape photographs for 2006, 2009, 2012, 2017 and 2022

Figure 7 Landscape photo location A1

2006

2009

2012

2017

2022

Figure 8 Landscape photo location A2

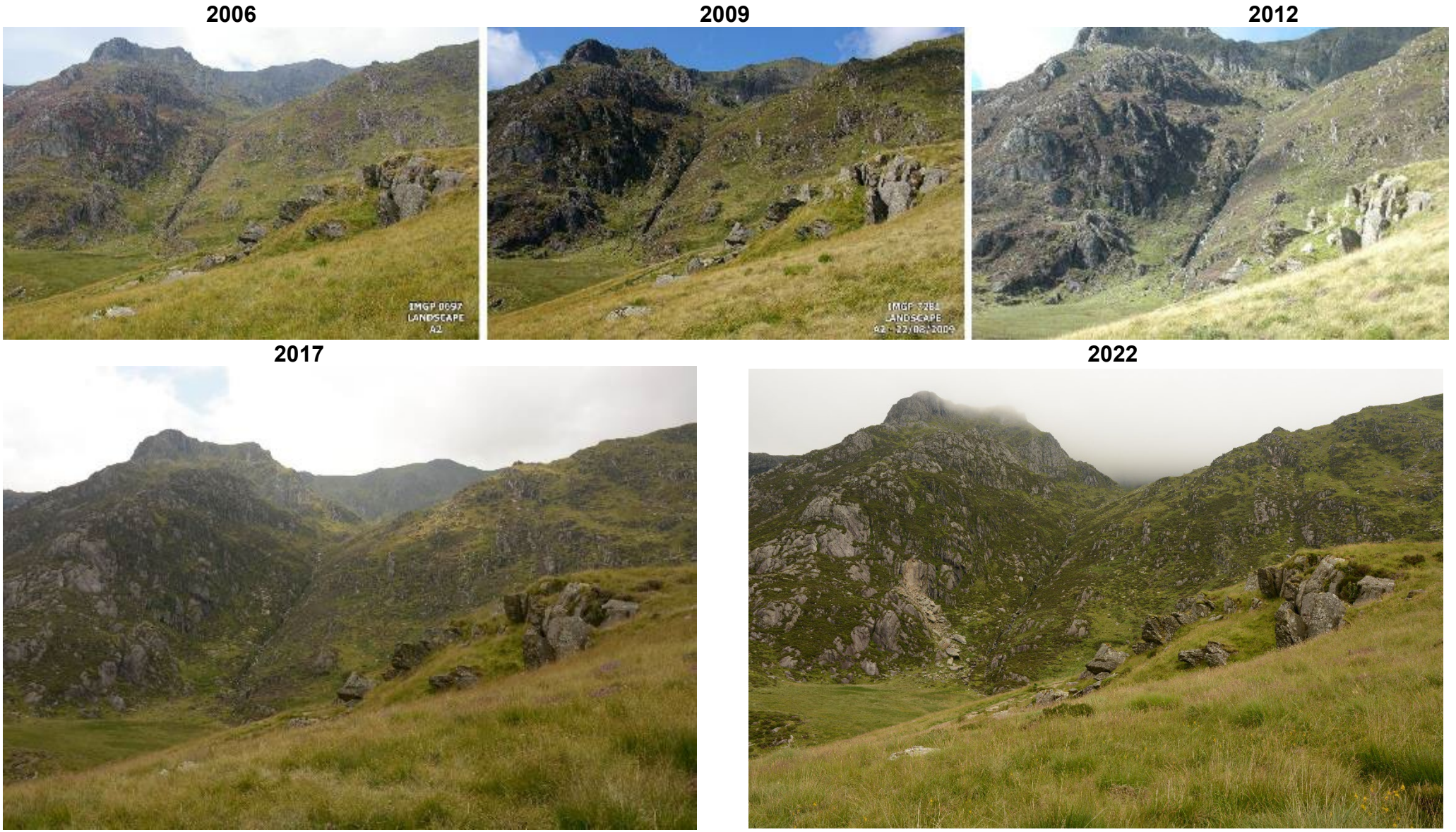


Figure 9 Landscape photo location B1

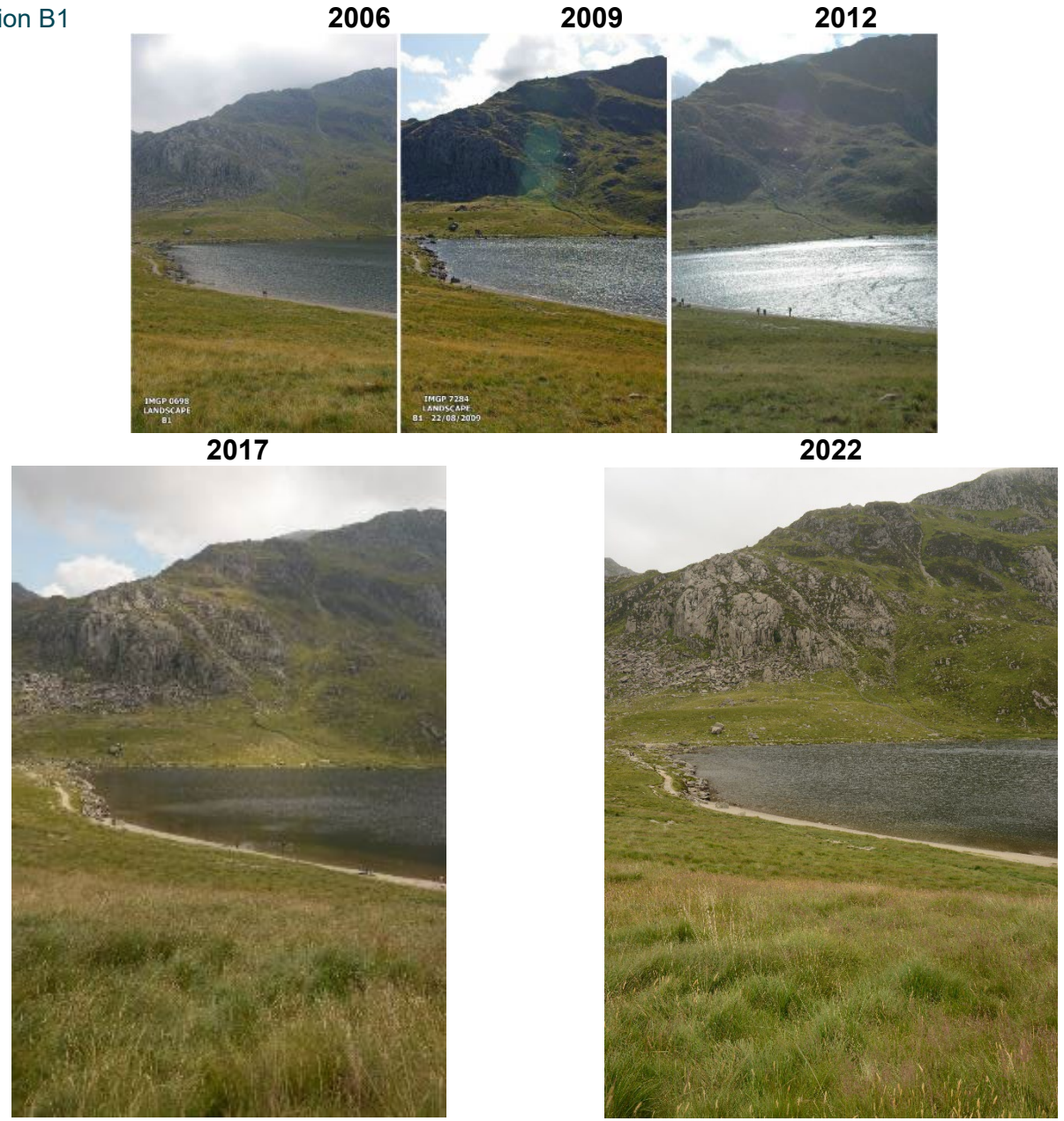


Figure 10 Landscape photo location B2

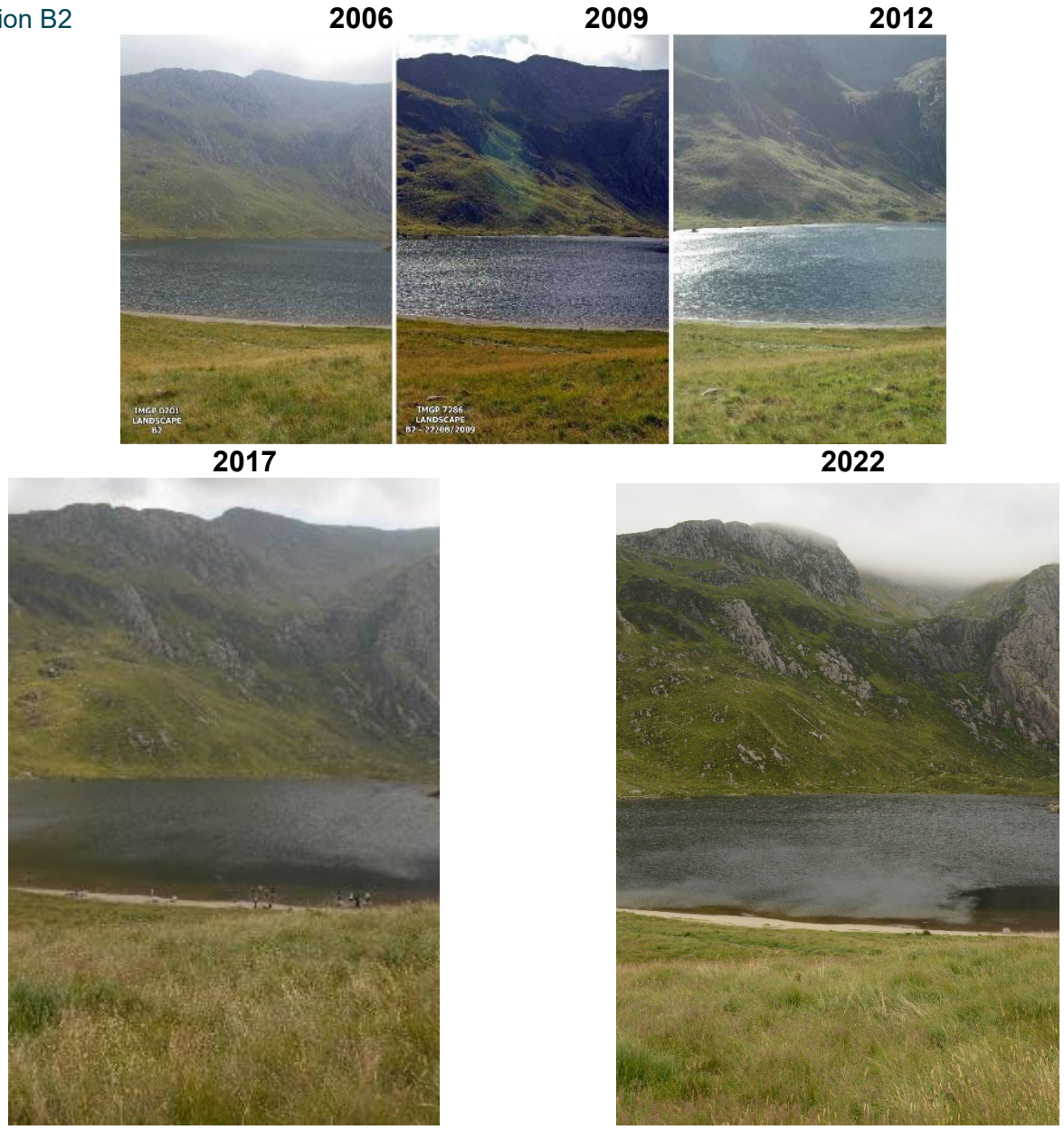


Figure 11 Landscape photo location C1

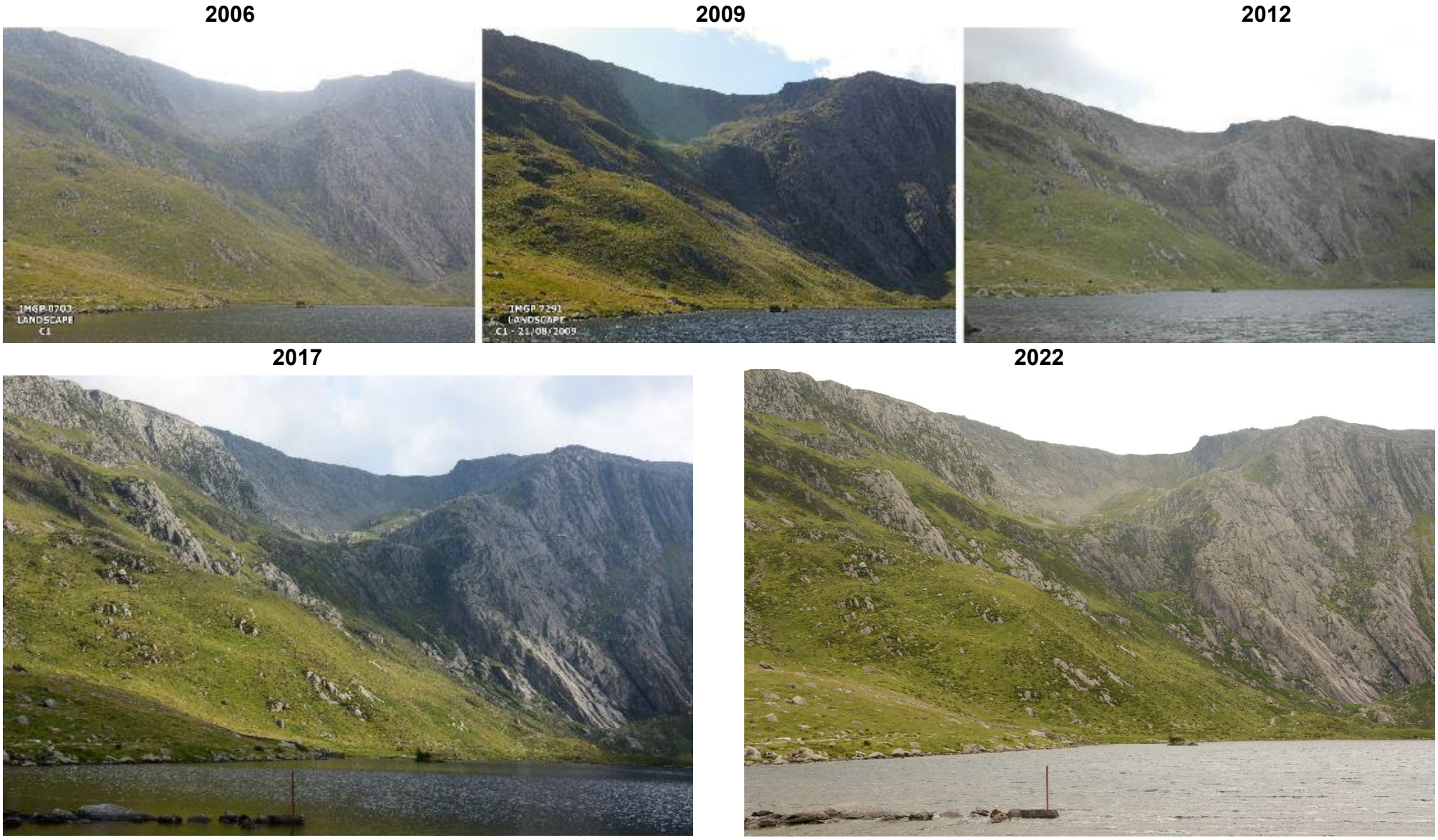


Figure 12 Landscape photo location D1

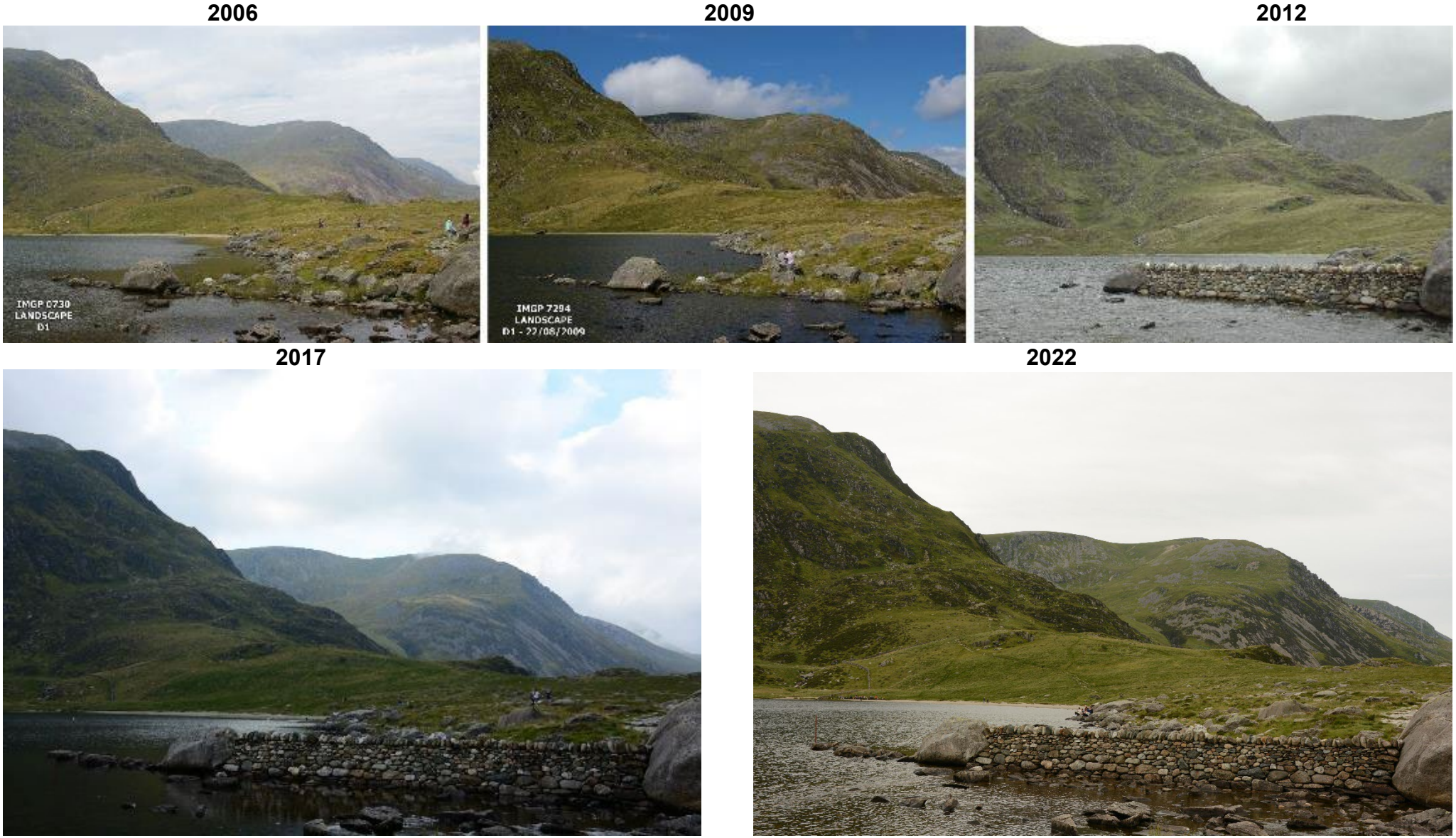


Figure 13 Landscape photo location D2

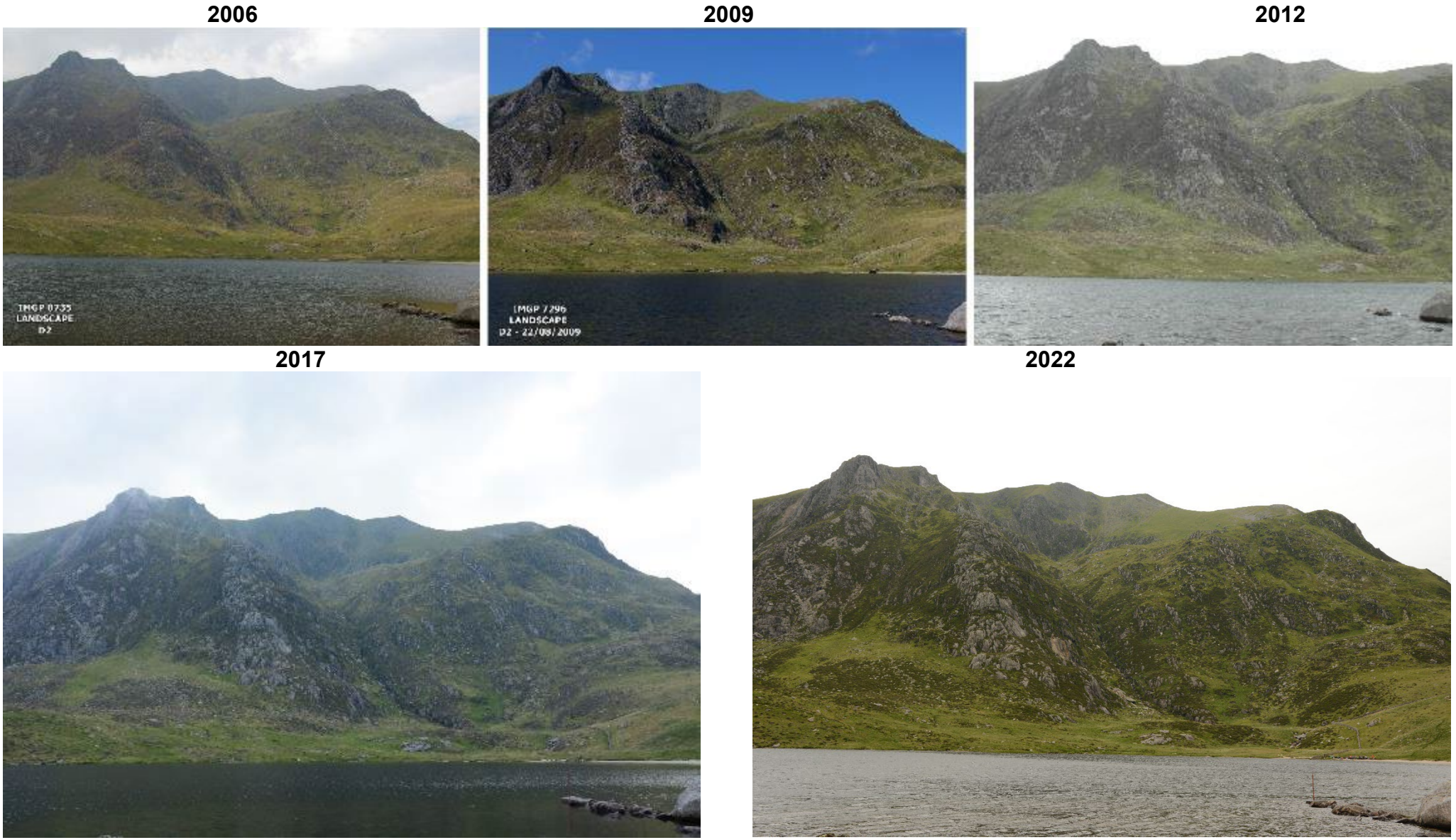


Figure 14 Landscape photo location E1

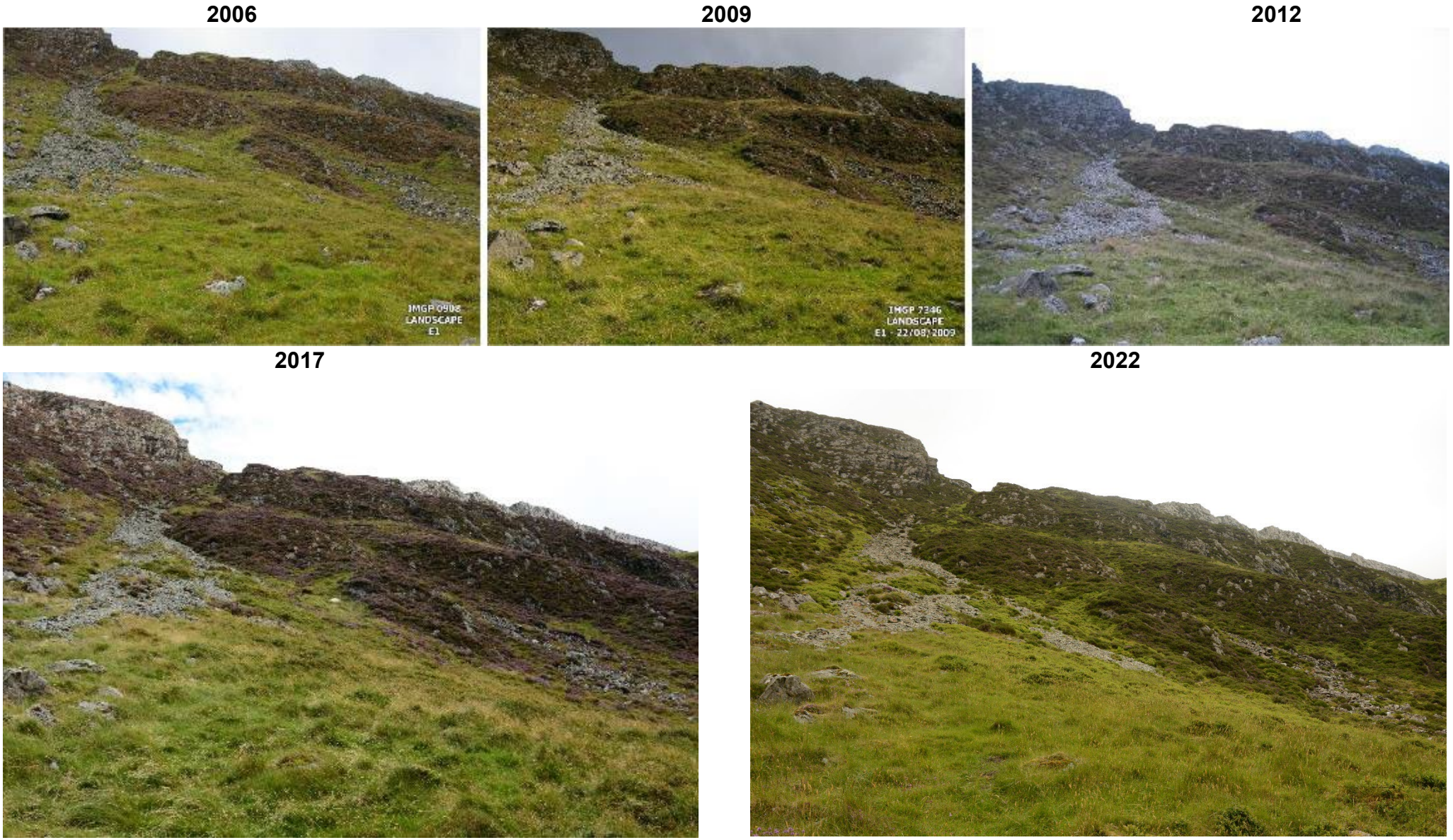


Figure 15 Landscape photo location E2

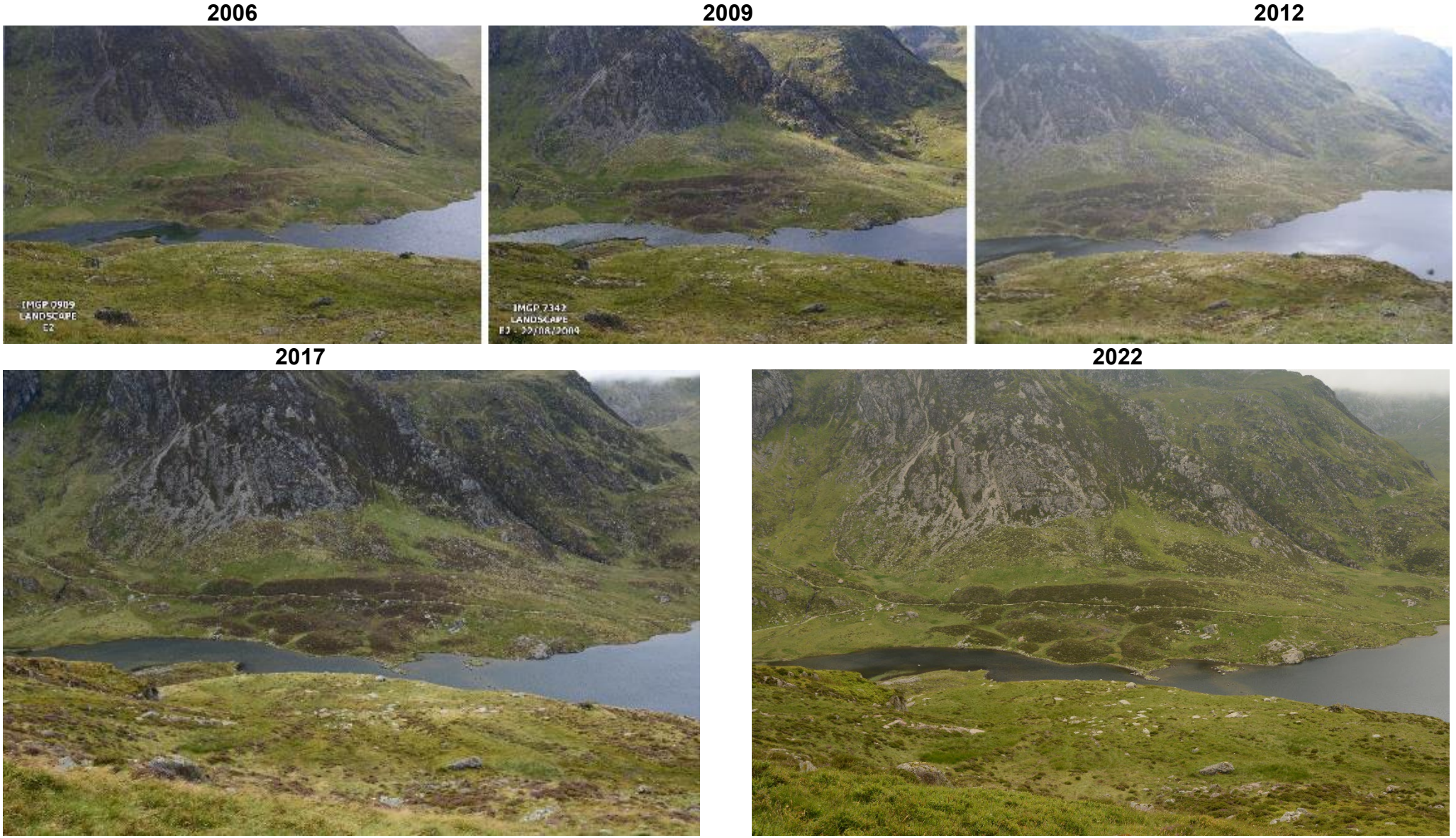


Figure 16 Landscape photo location F1

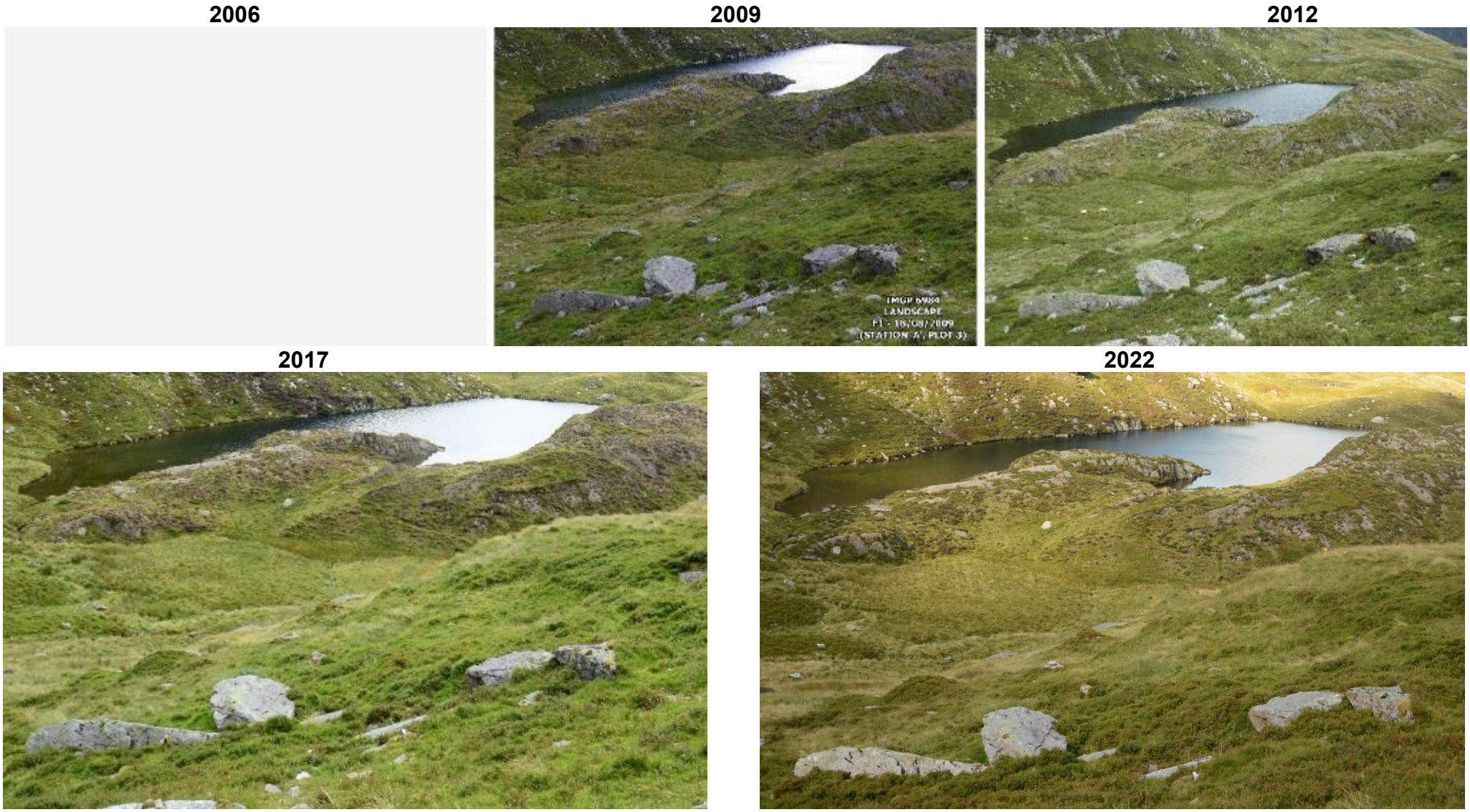


Figure 17 Landscape photo location G1

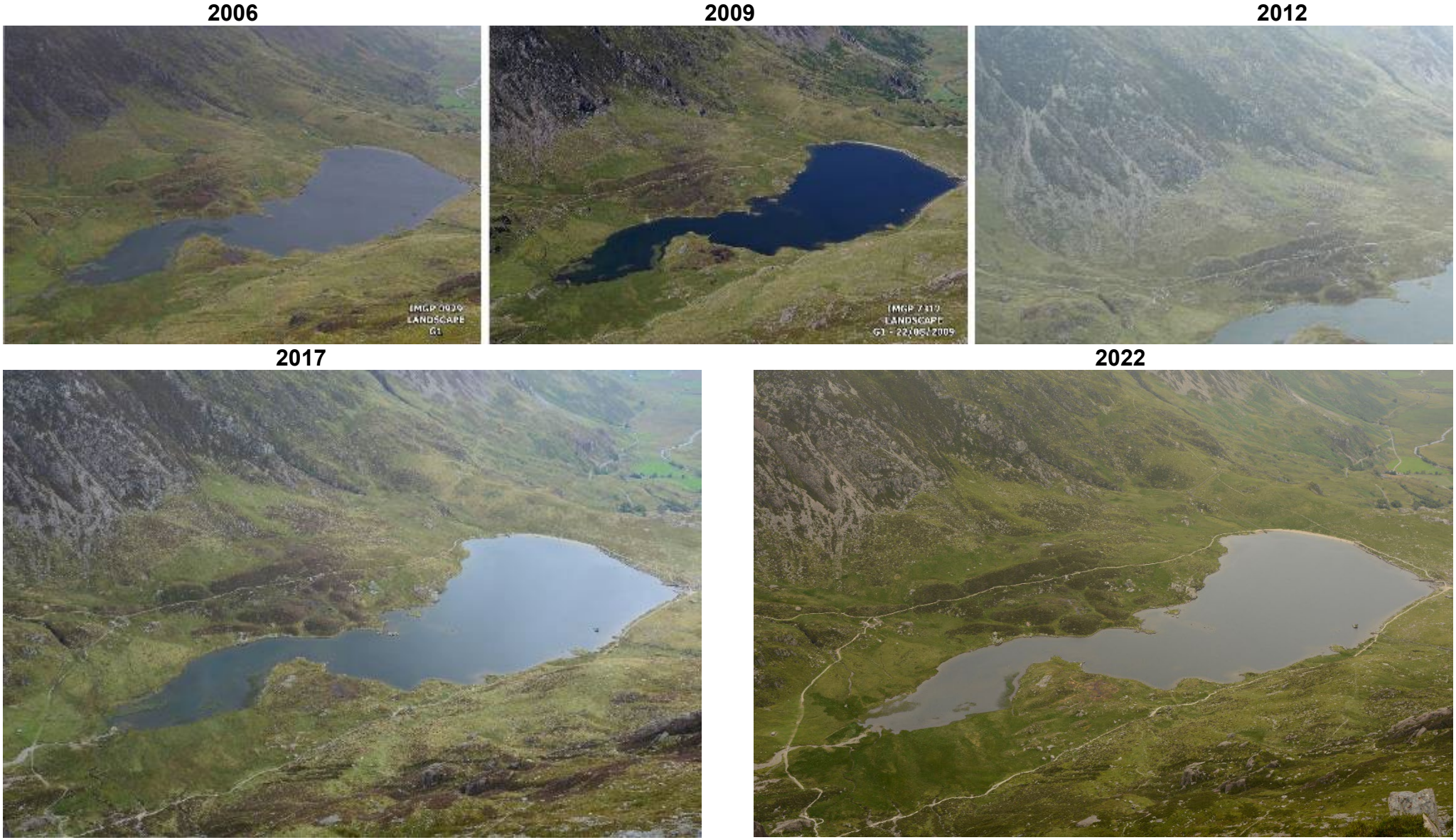


Figure 18 Landscape photo location H1

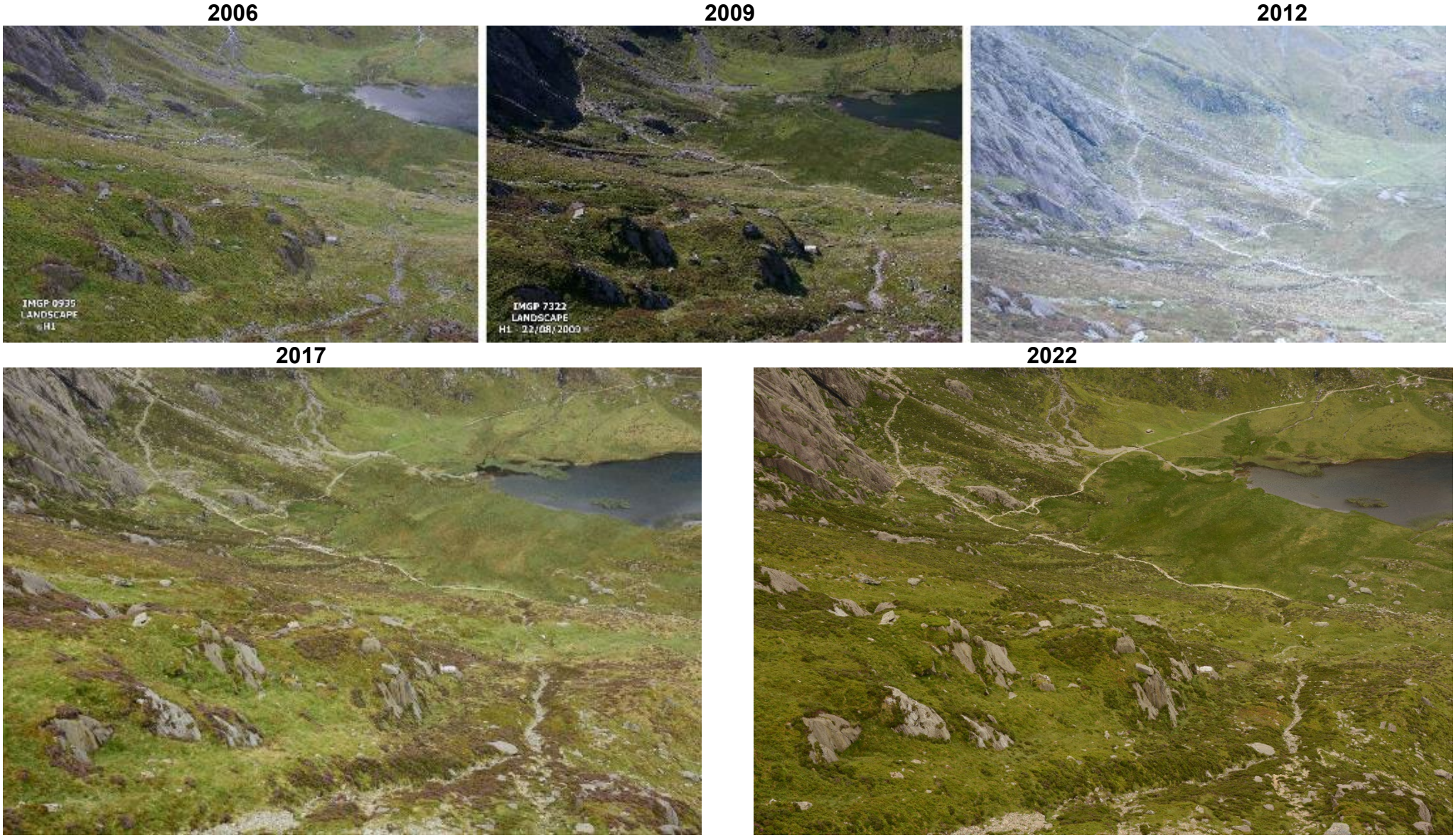


Figure 19 Landscape photo location H2

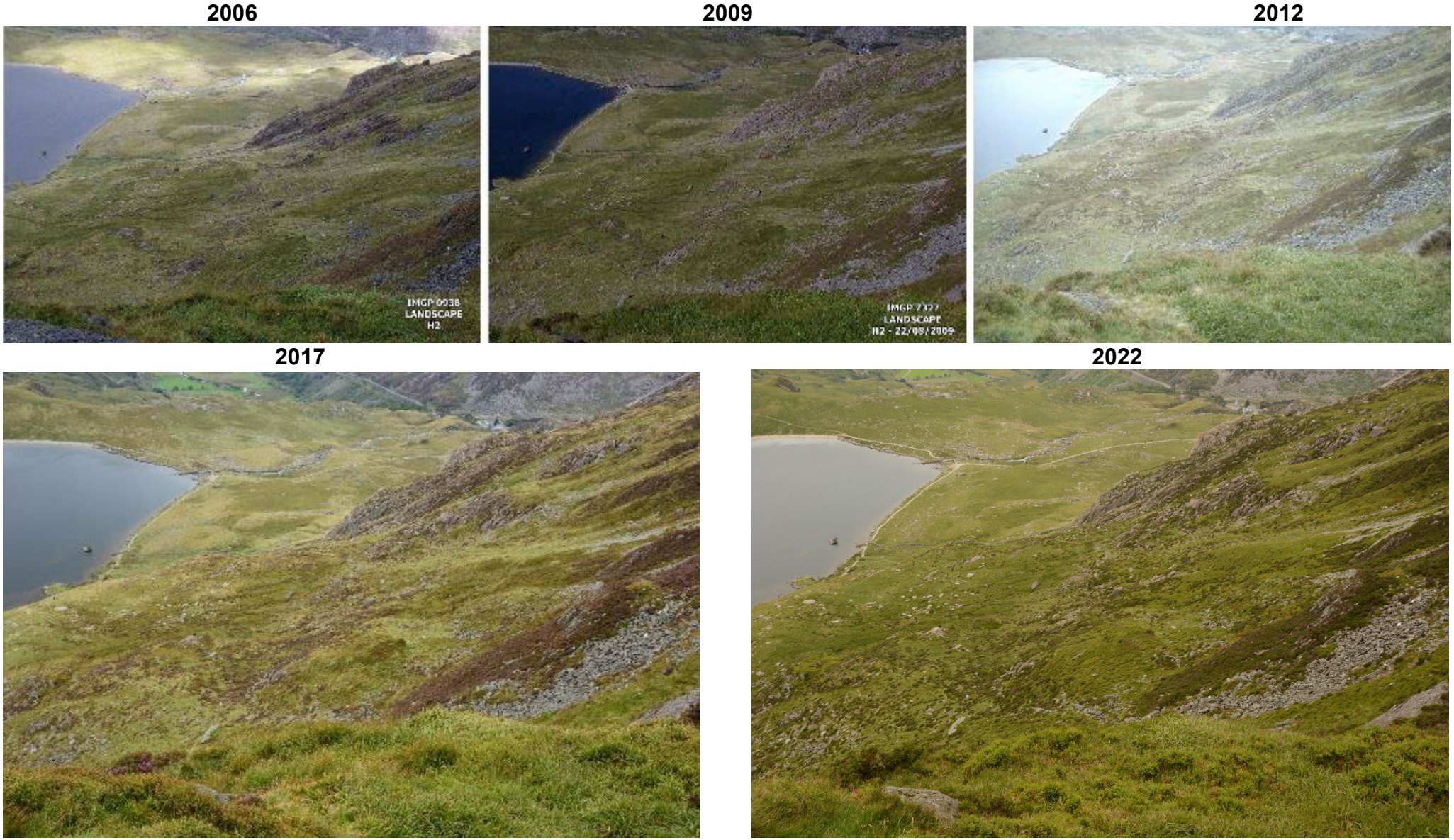


Figure 20 Landscape photo location I1

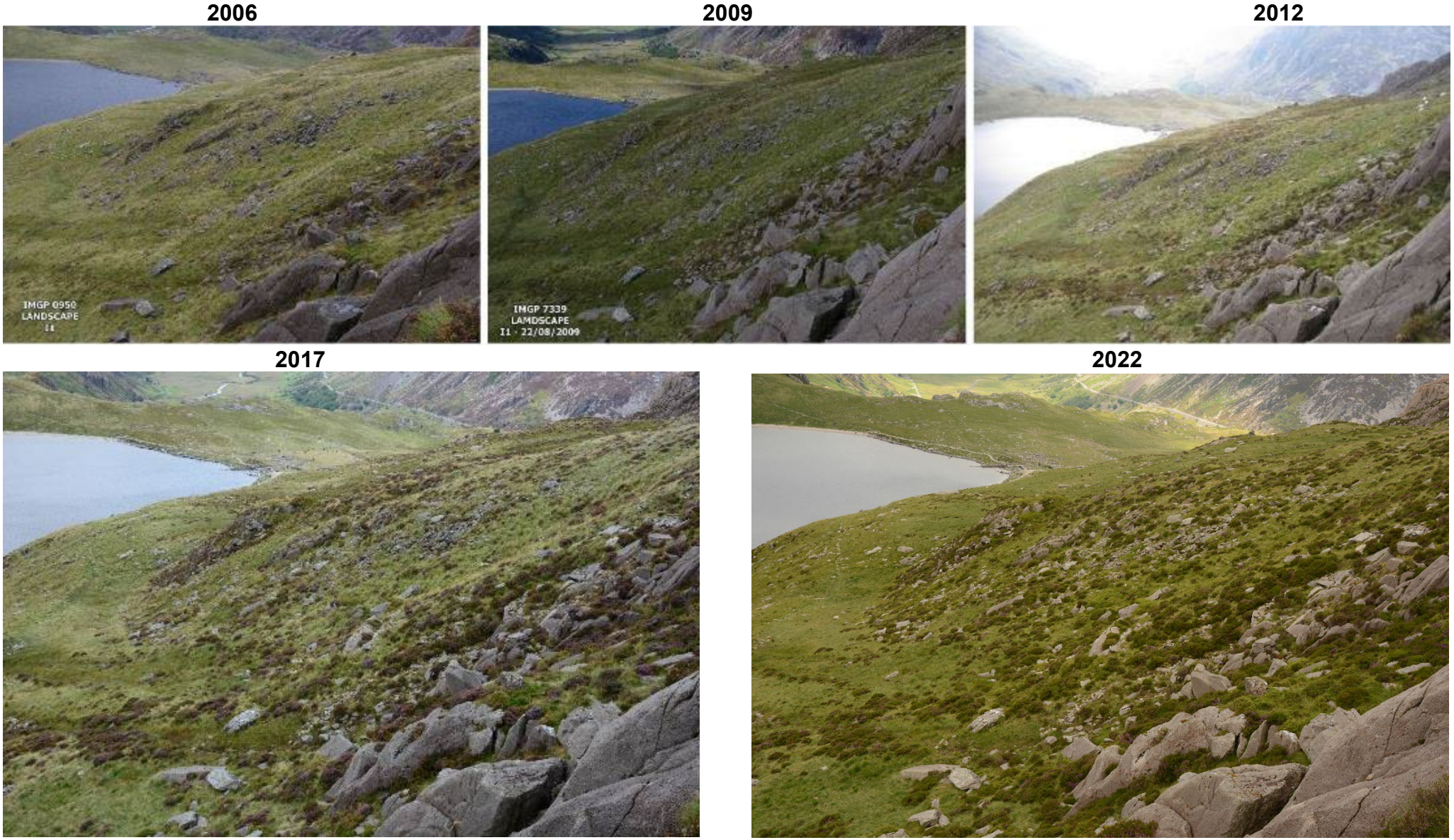


Figure 21 Landscape photo location I2

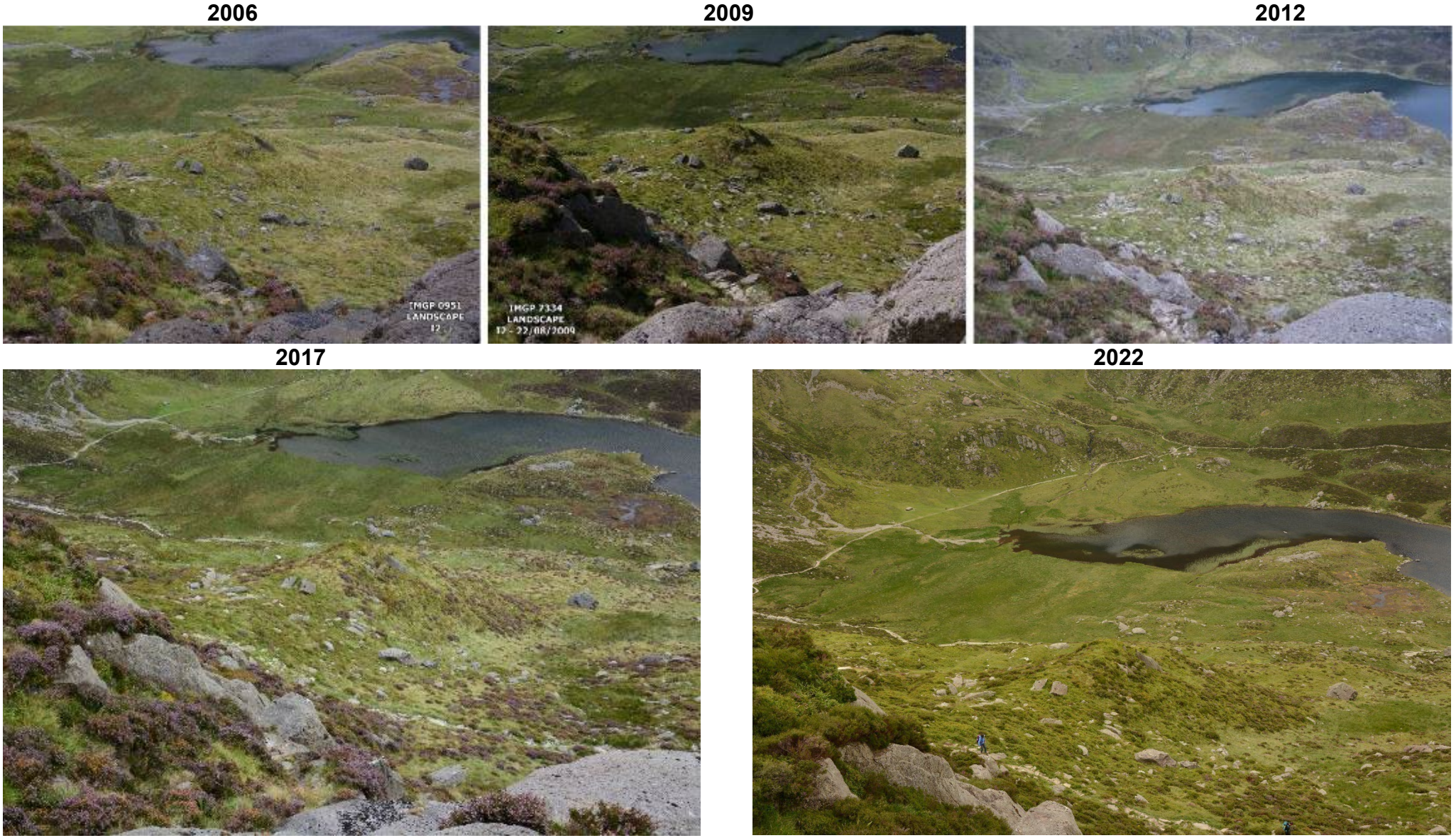


Figure 22 Landscape photo location J1

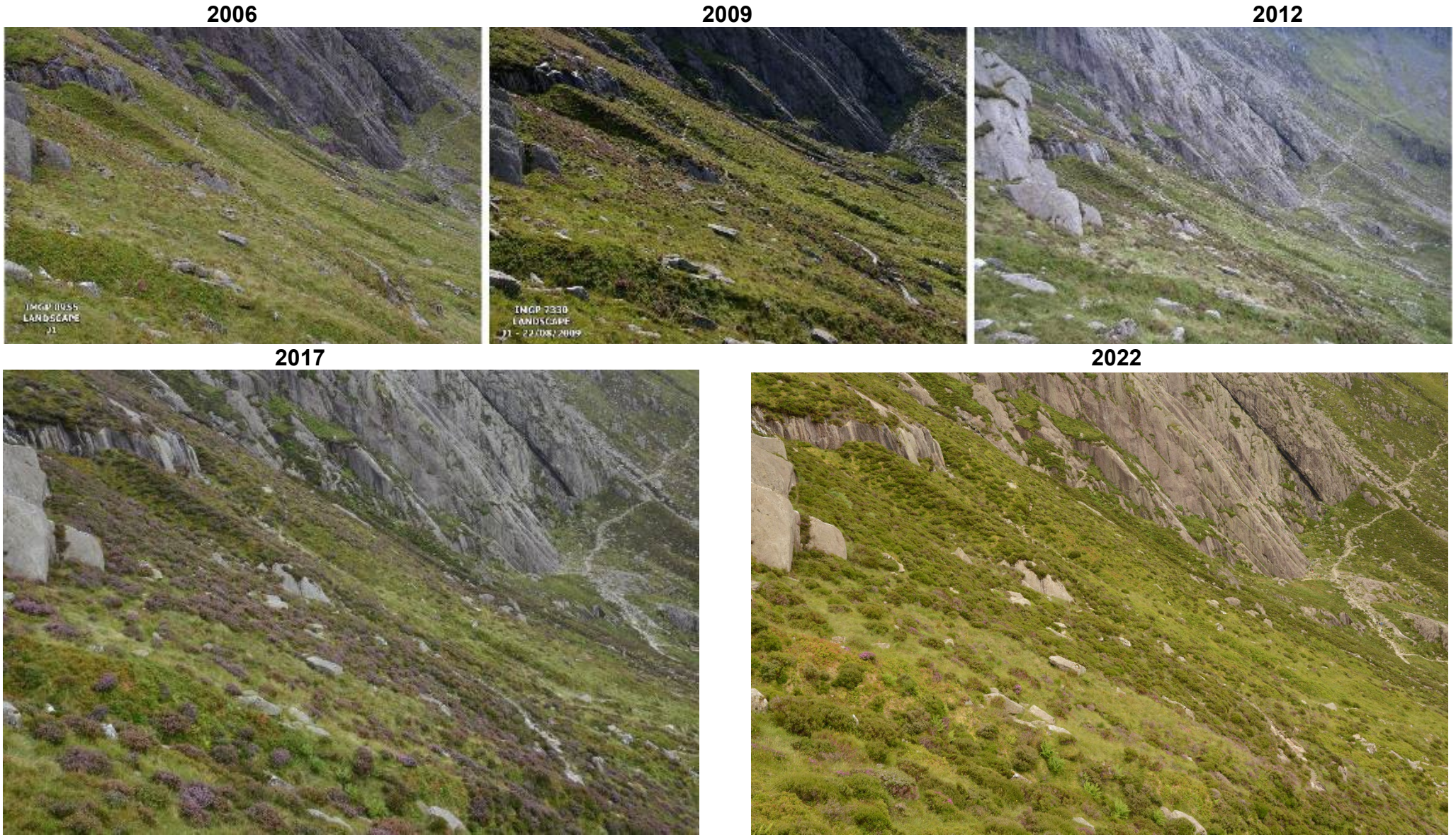


Figure 23 Landscape photo location J2

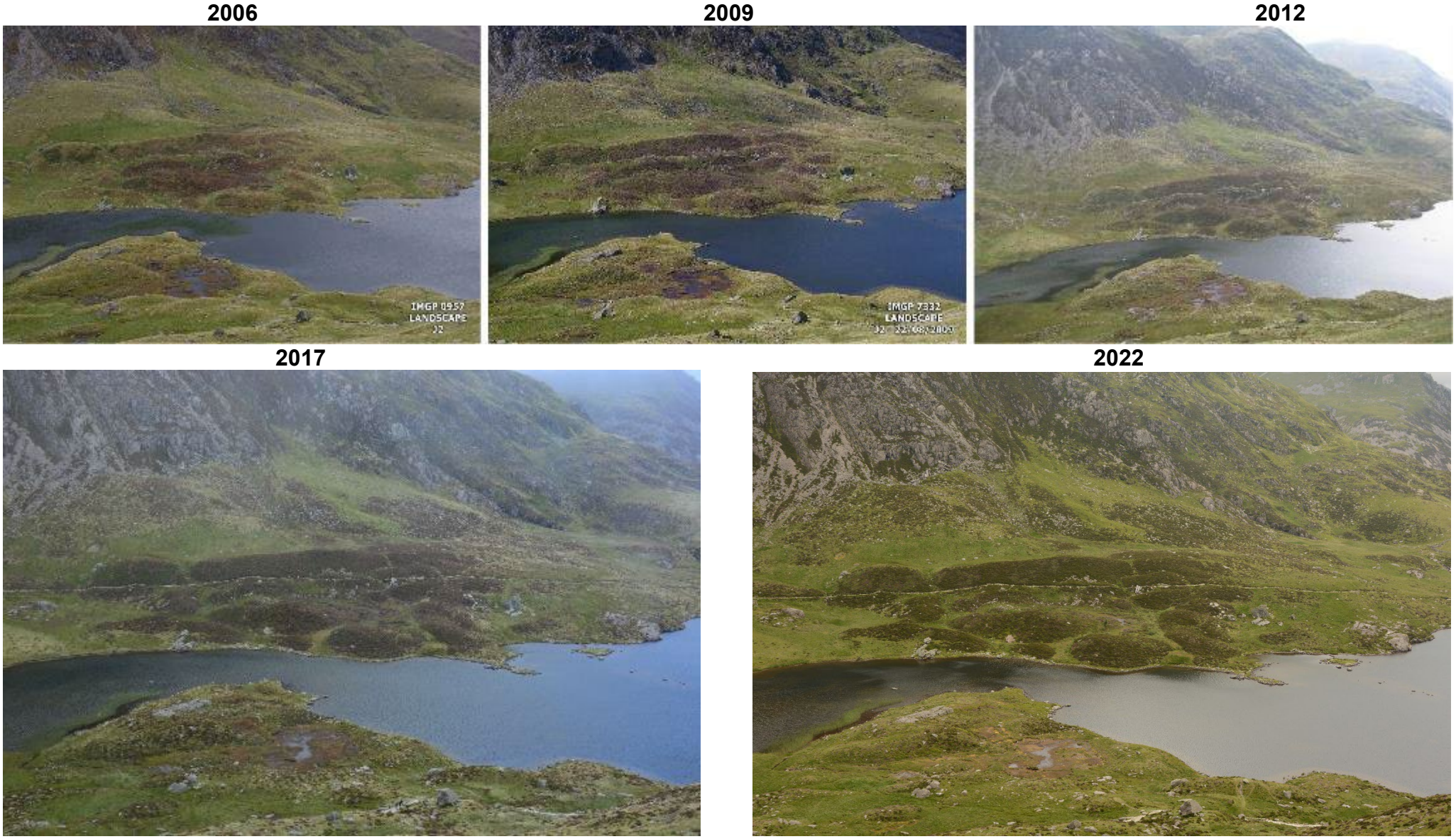


Figure 24 Landscape photo location K1

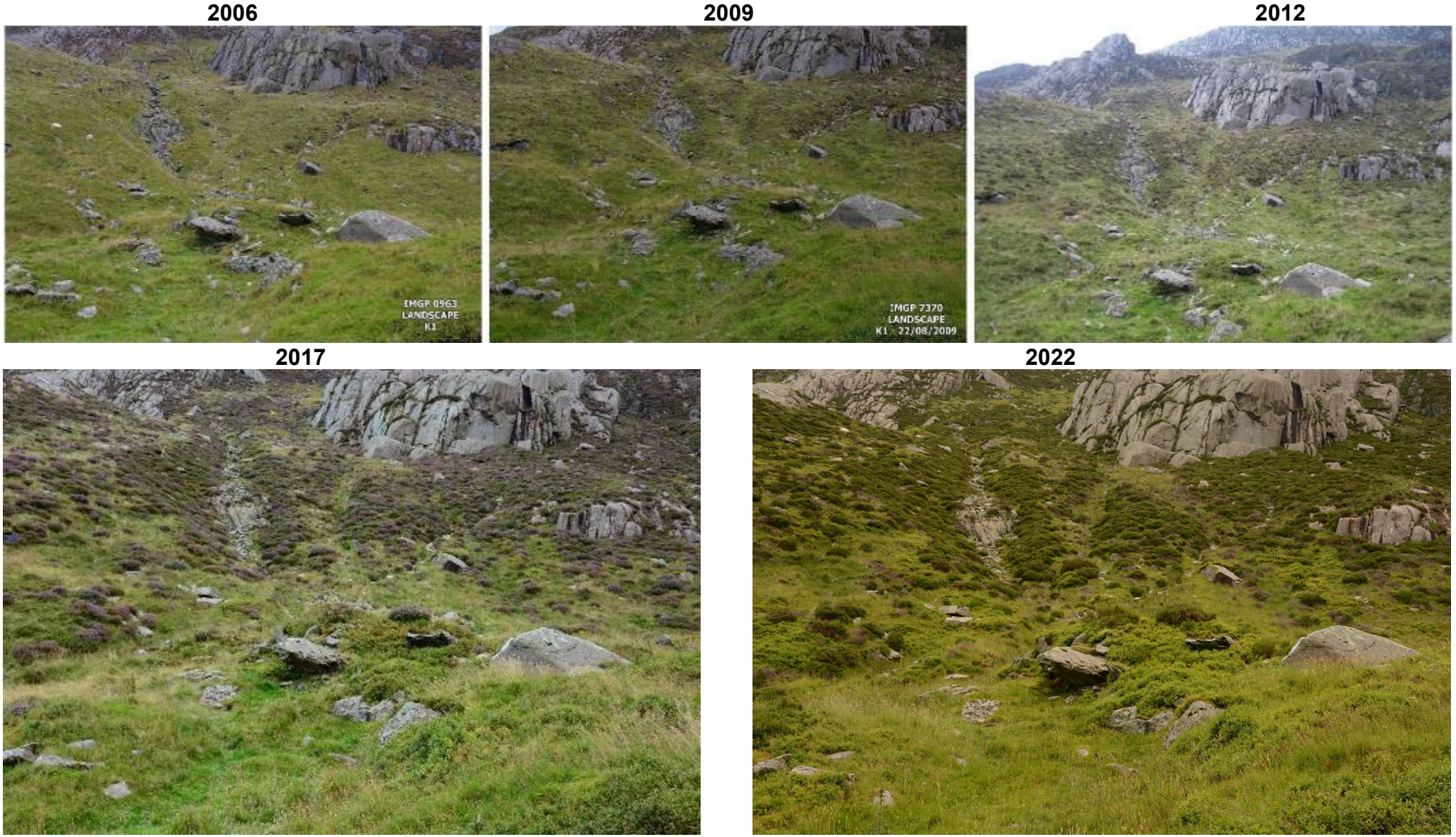


Figure 25 Landscape photo location K2

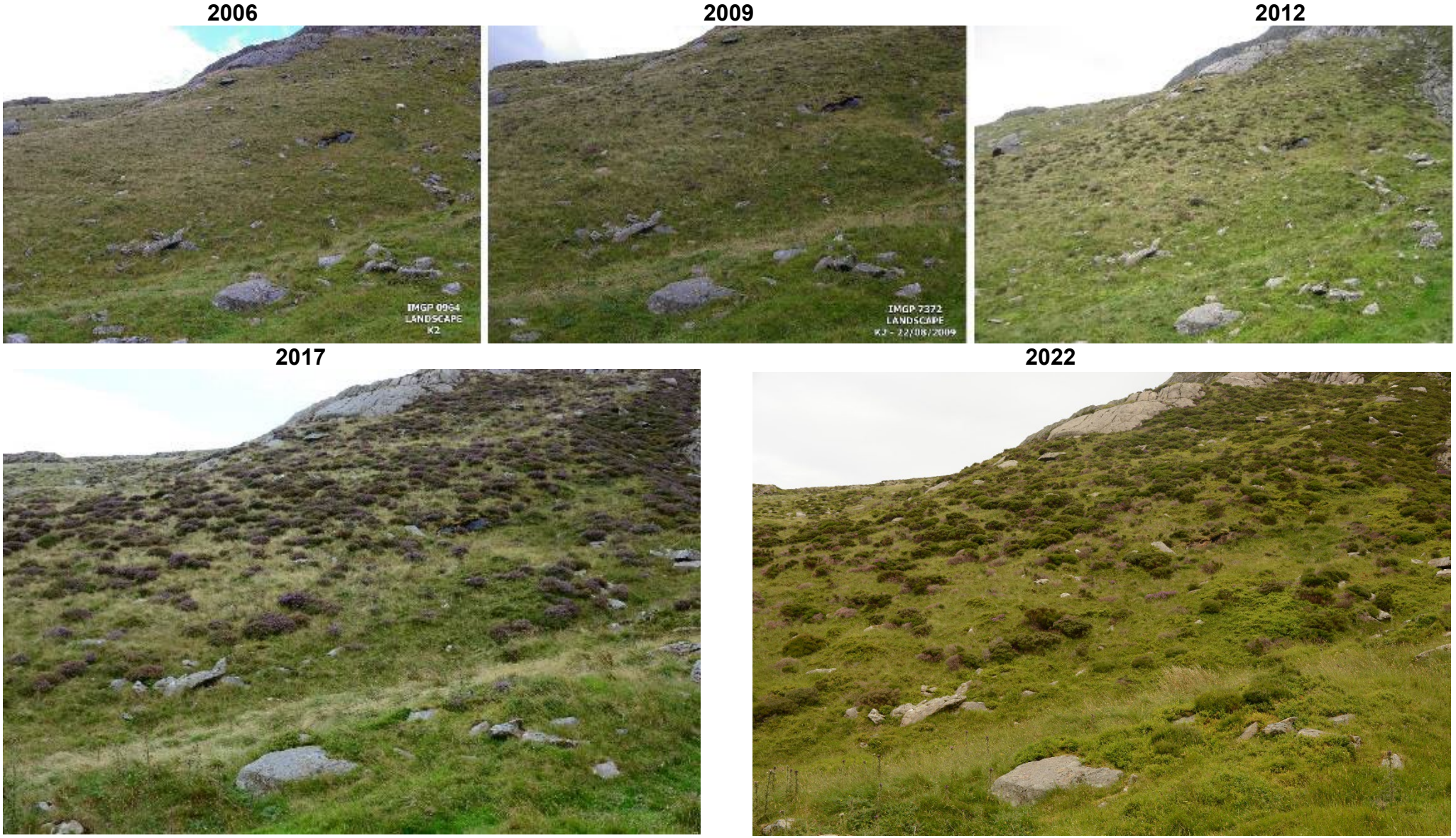


Figure 26 Landscape photo location K3

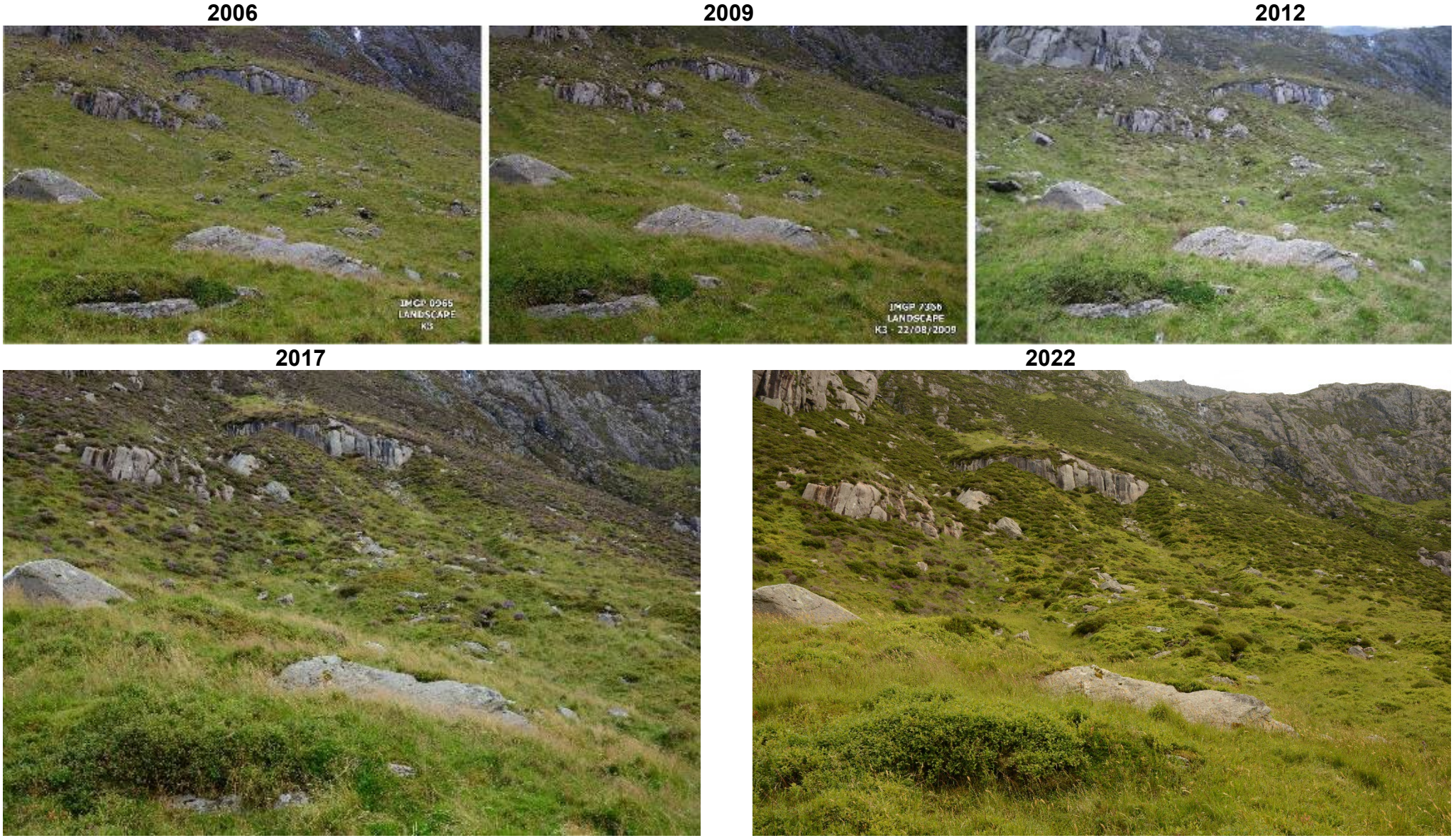


Figure 27 Landscape photo location L1

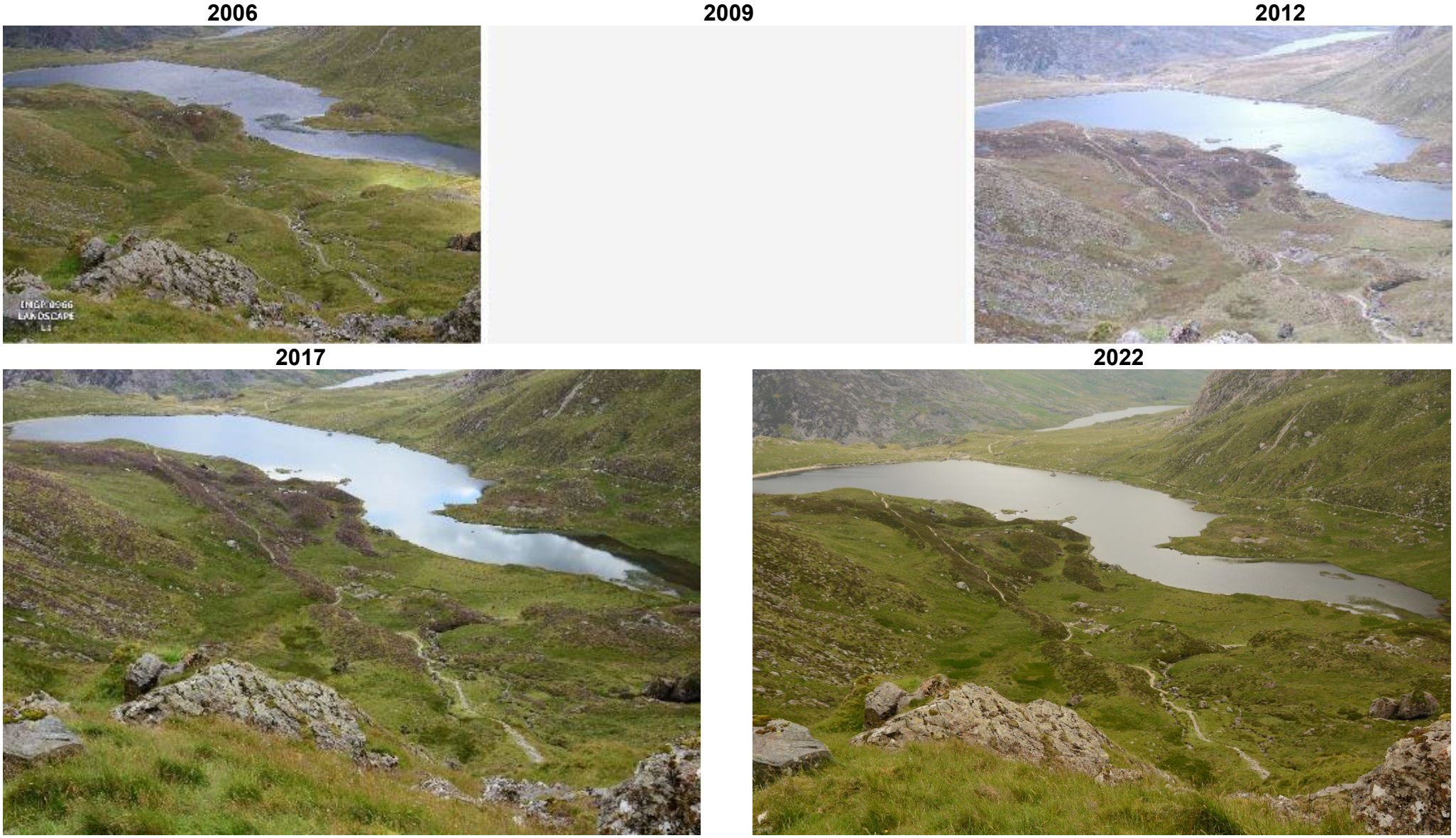


Figure 28 Landscape photo location L2

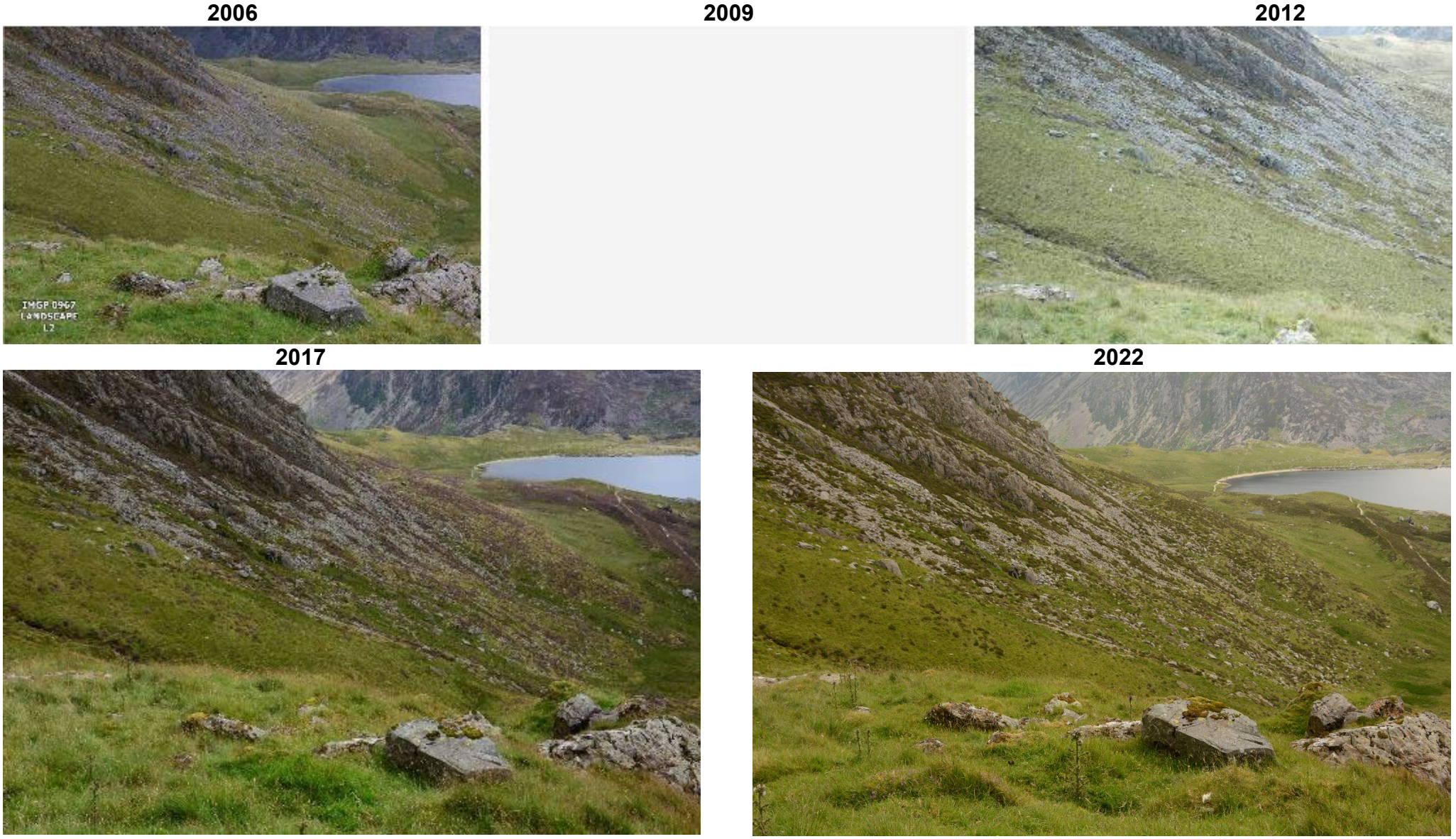


Figure 29 Landscape photo location L3

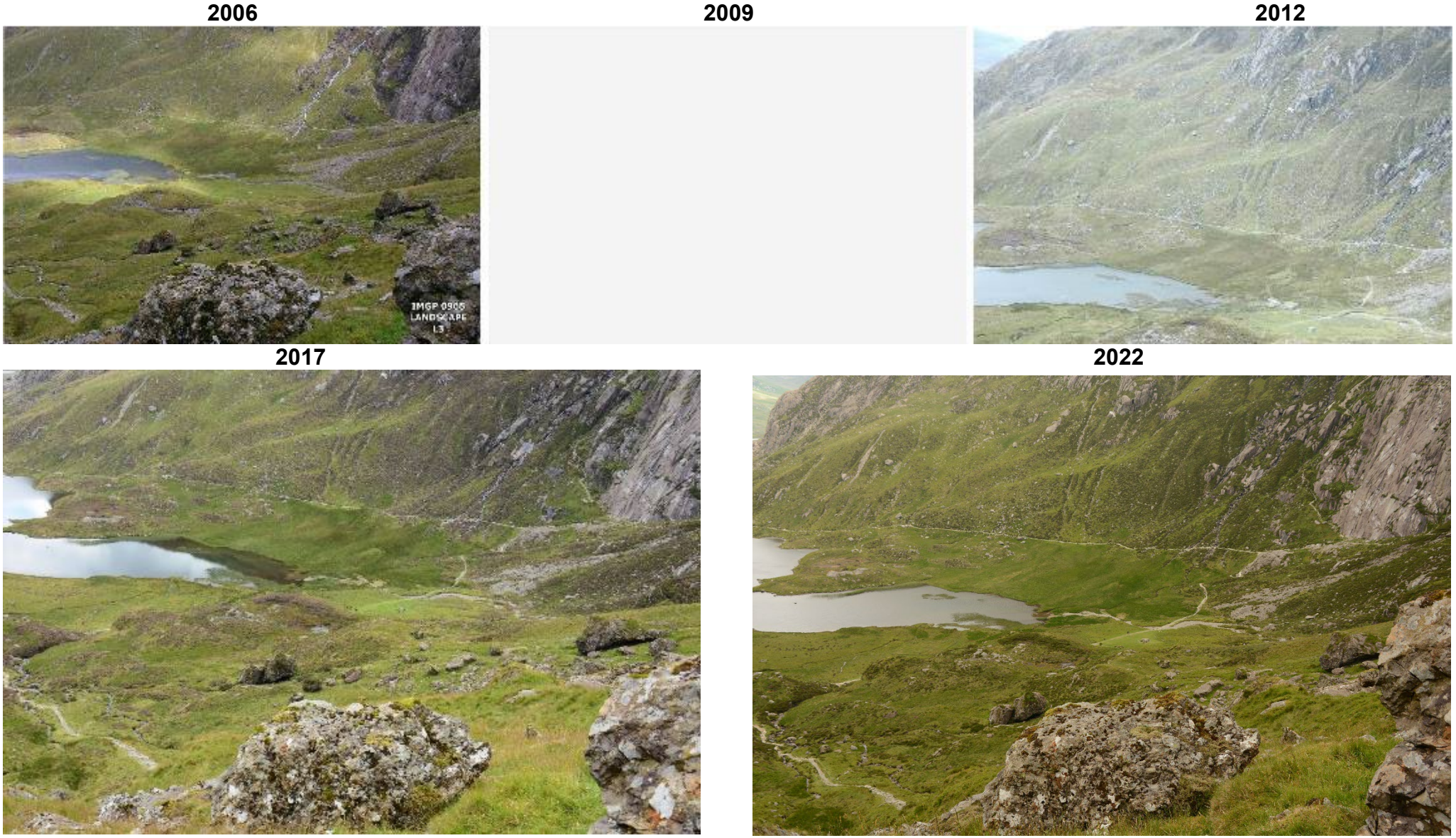


Figure 30 Landscape photo location M1

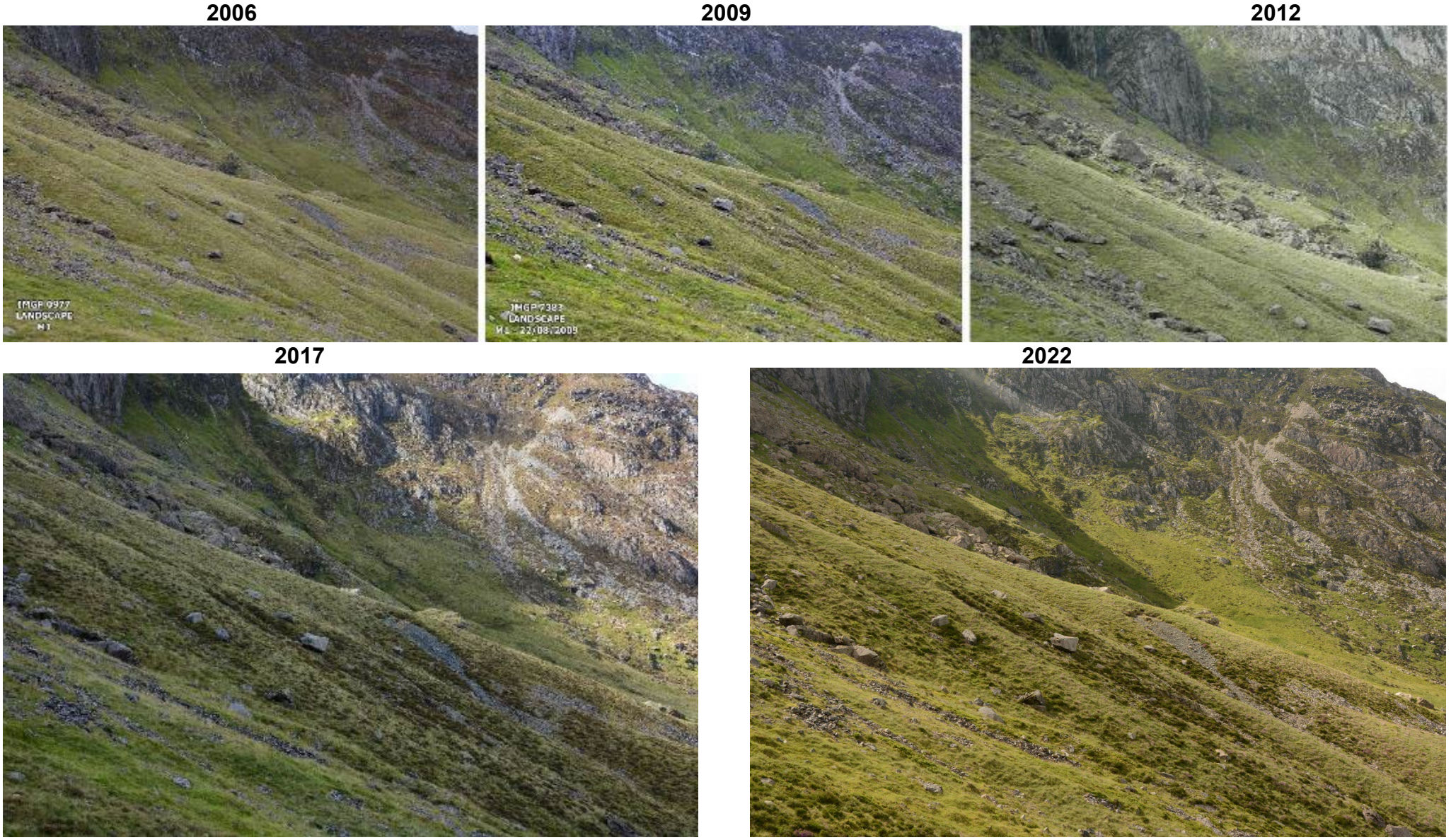


Figure 31 Landscape photo location N1

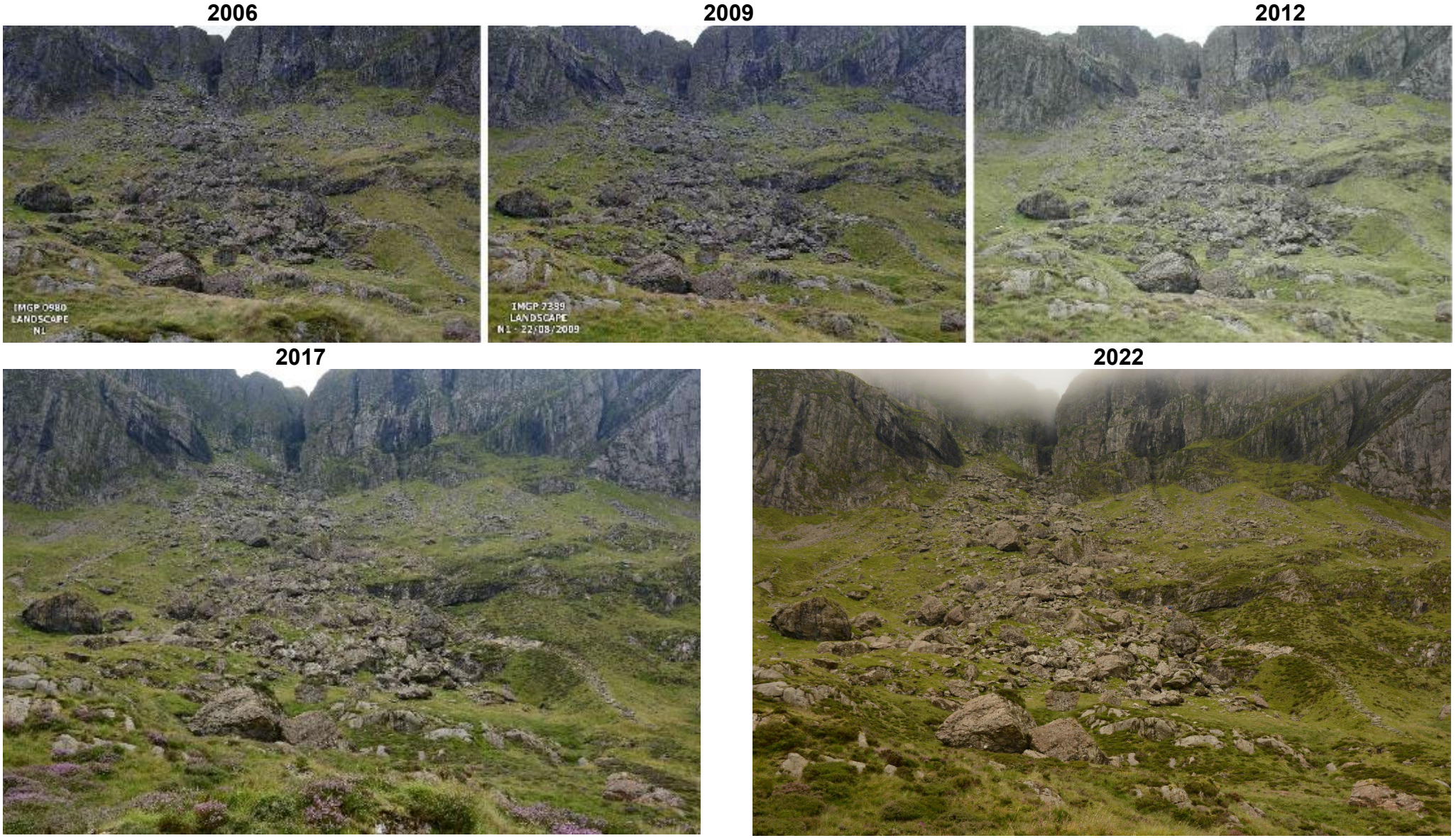


Figure 32 Landscape photo location N2

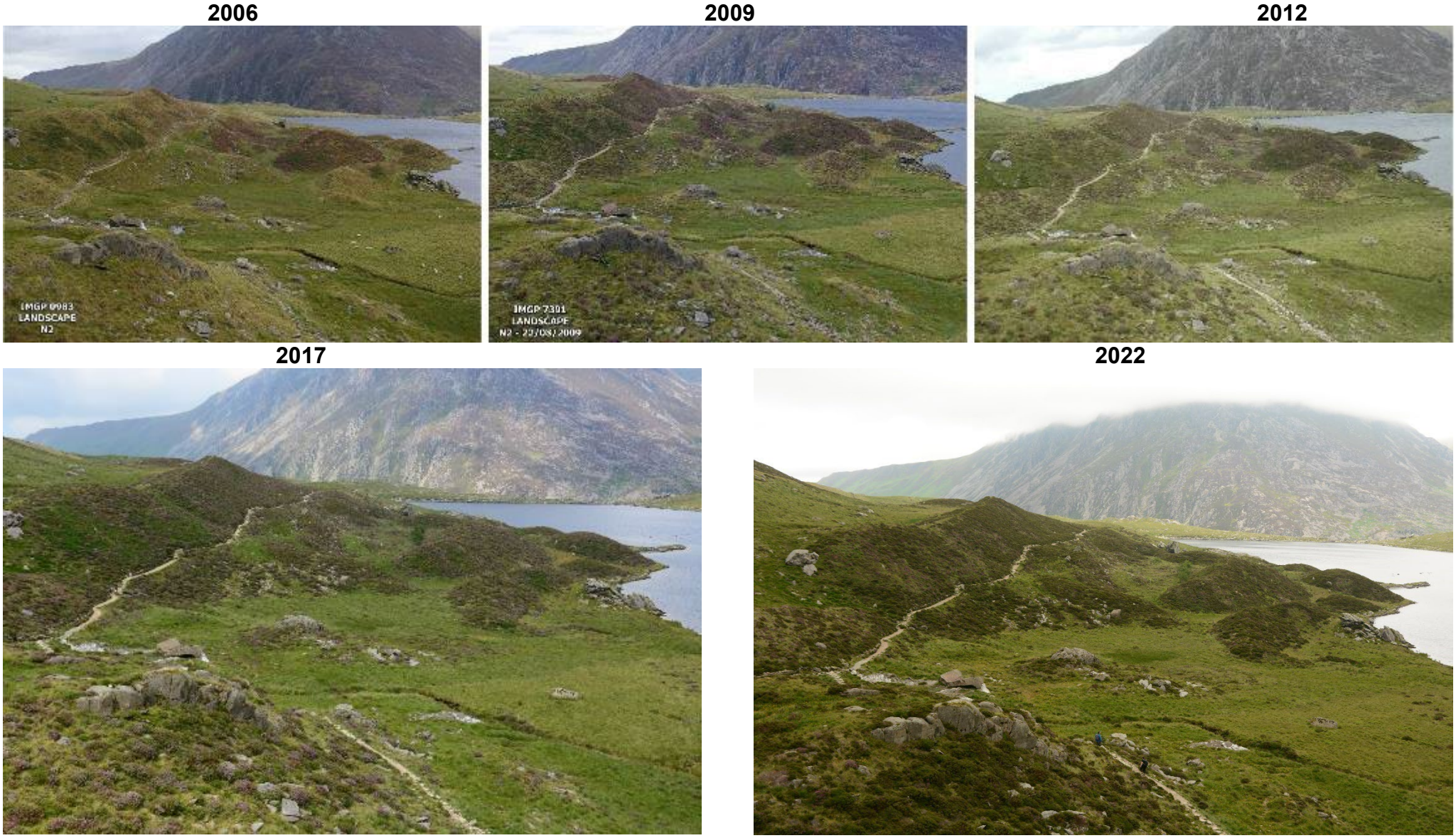


Figure 33 Landscape photo location N3

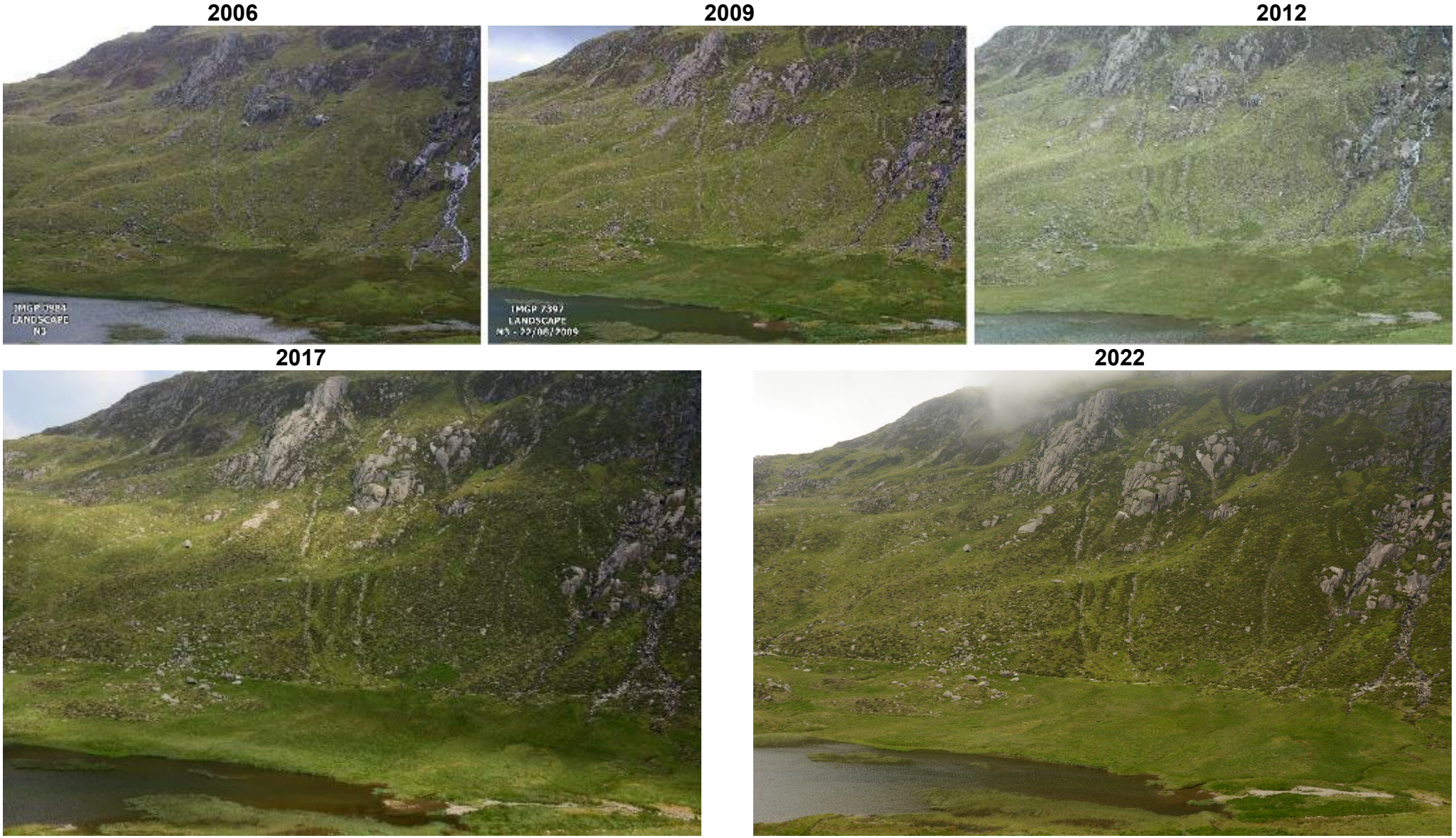


Figure 34 Landscape photo location N4

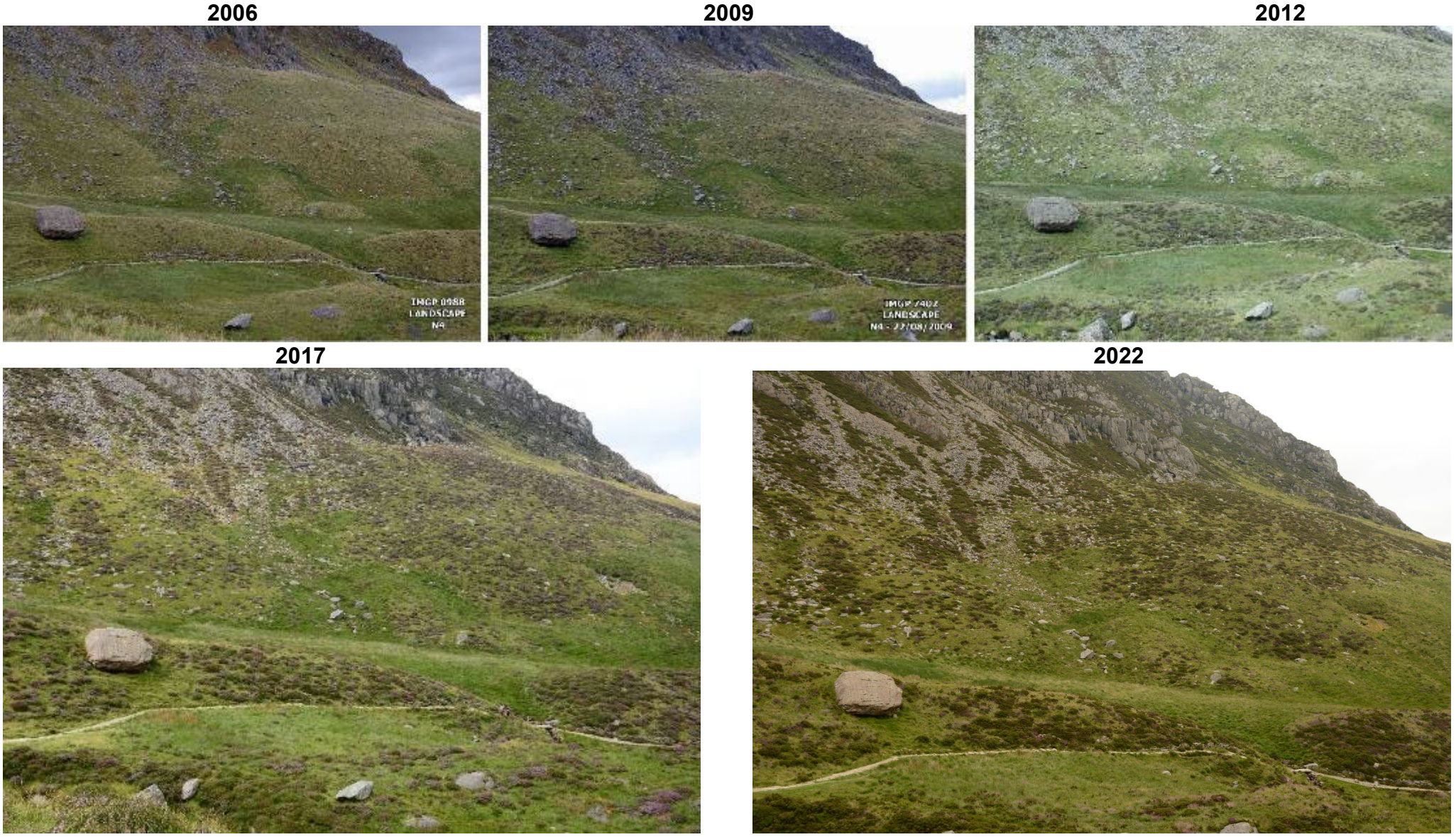


Figure 35 Landscape photo location P1

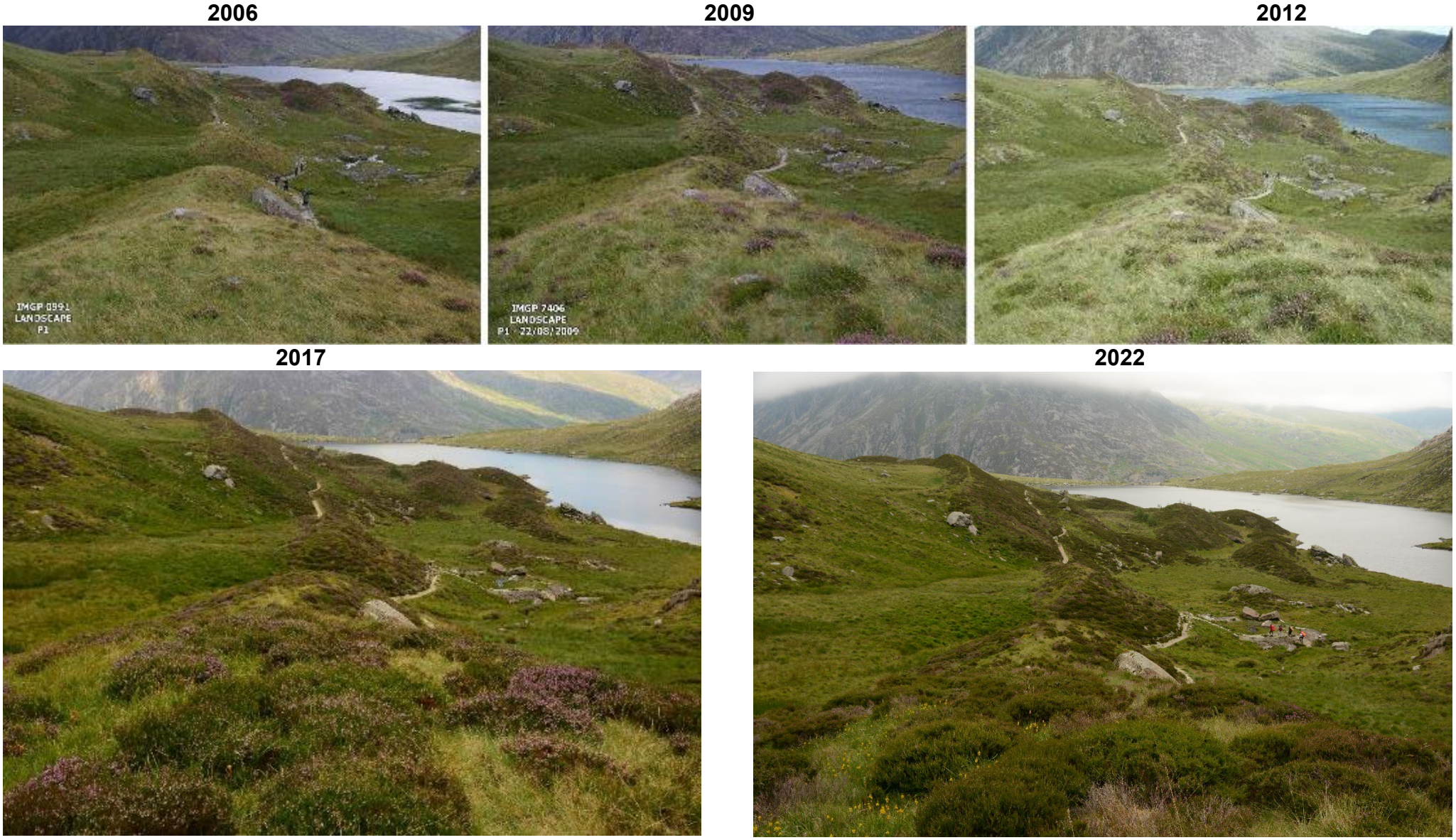


Figure 36 Landscape photo location P2

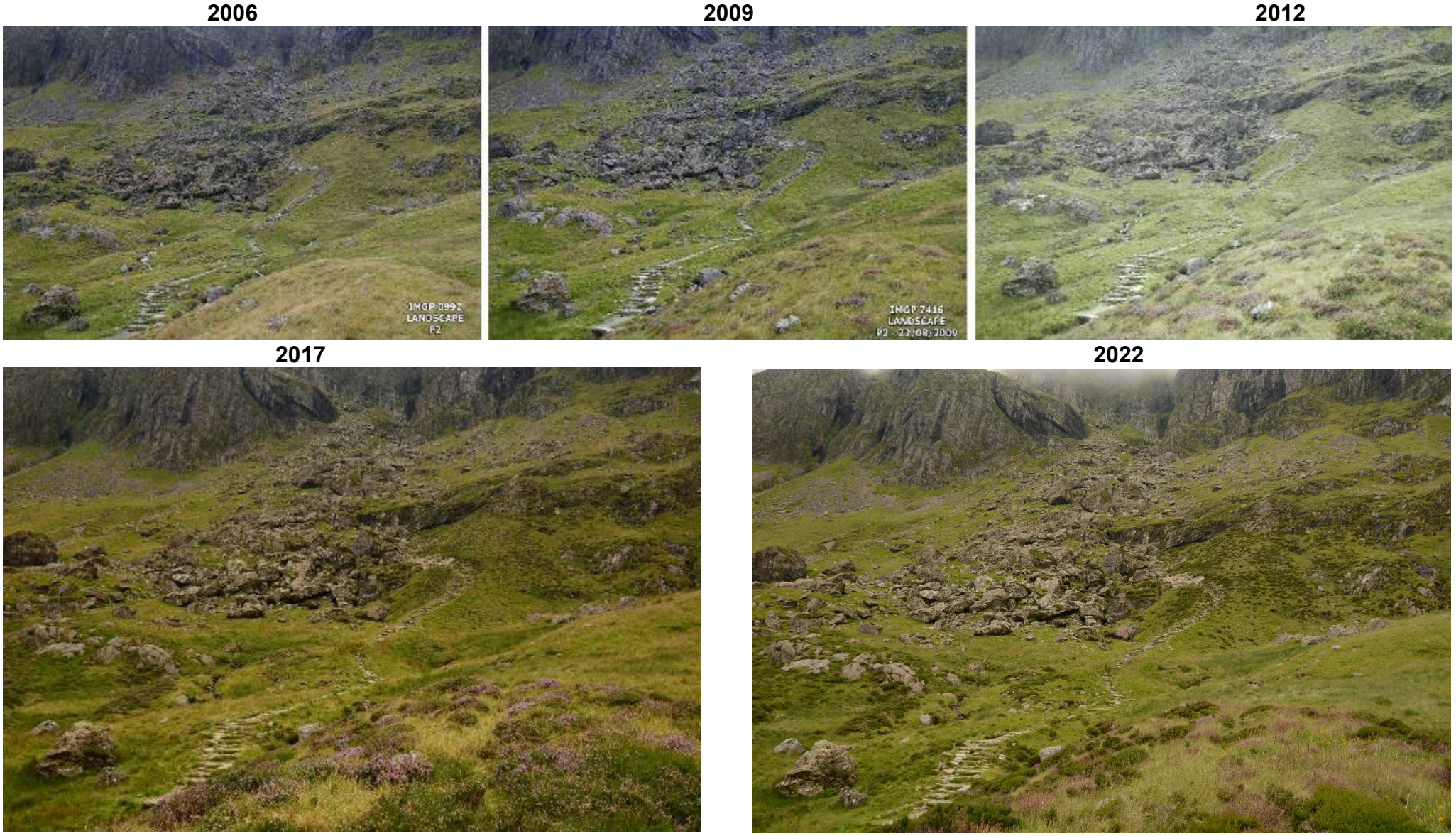


Figure 37 Landscape photo location Q1

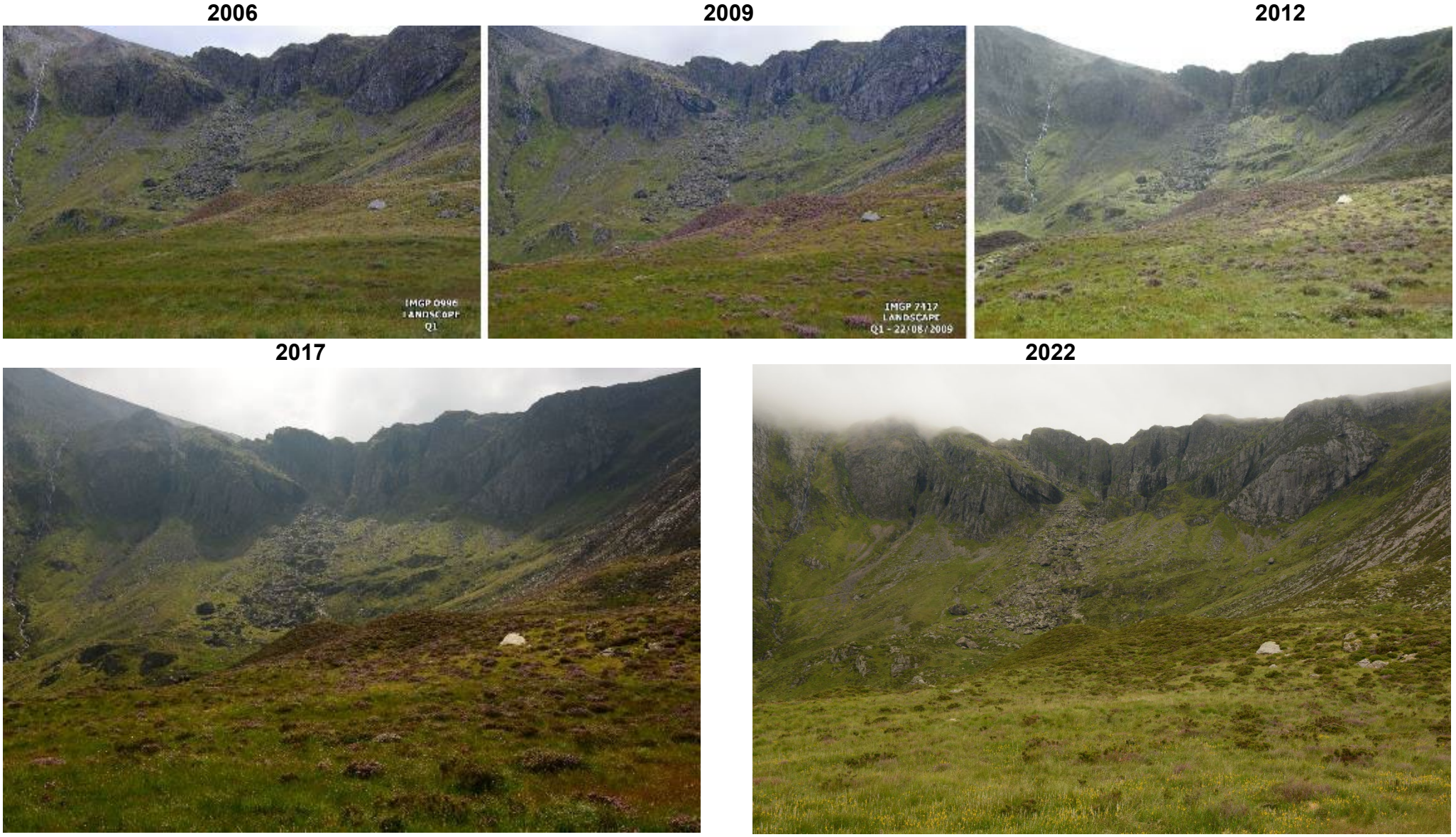


Figure 38 Landscape photo location Q2

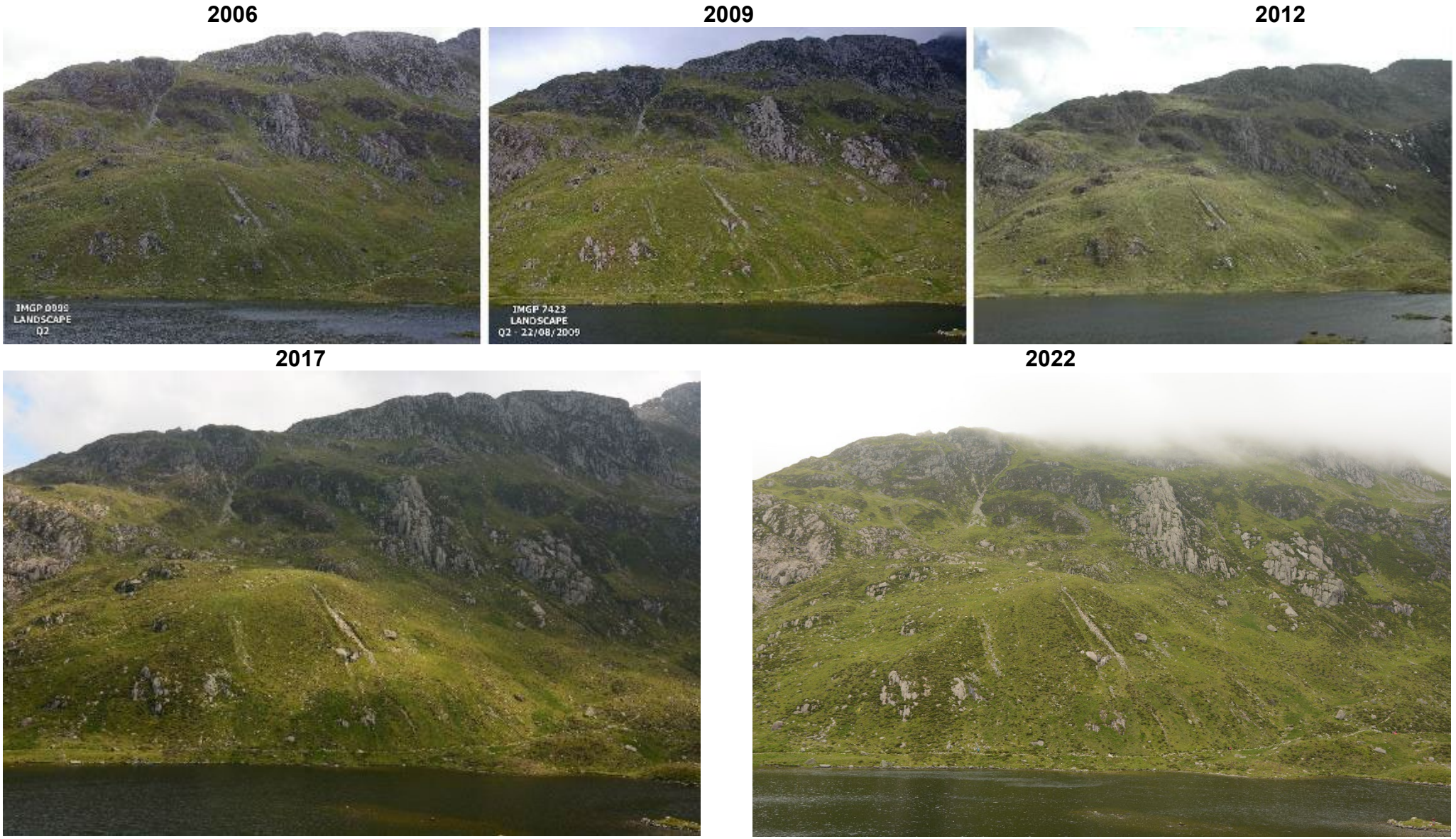


Figure 39 Landscape photo location R1

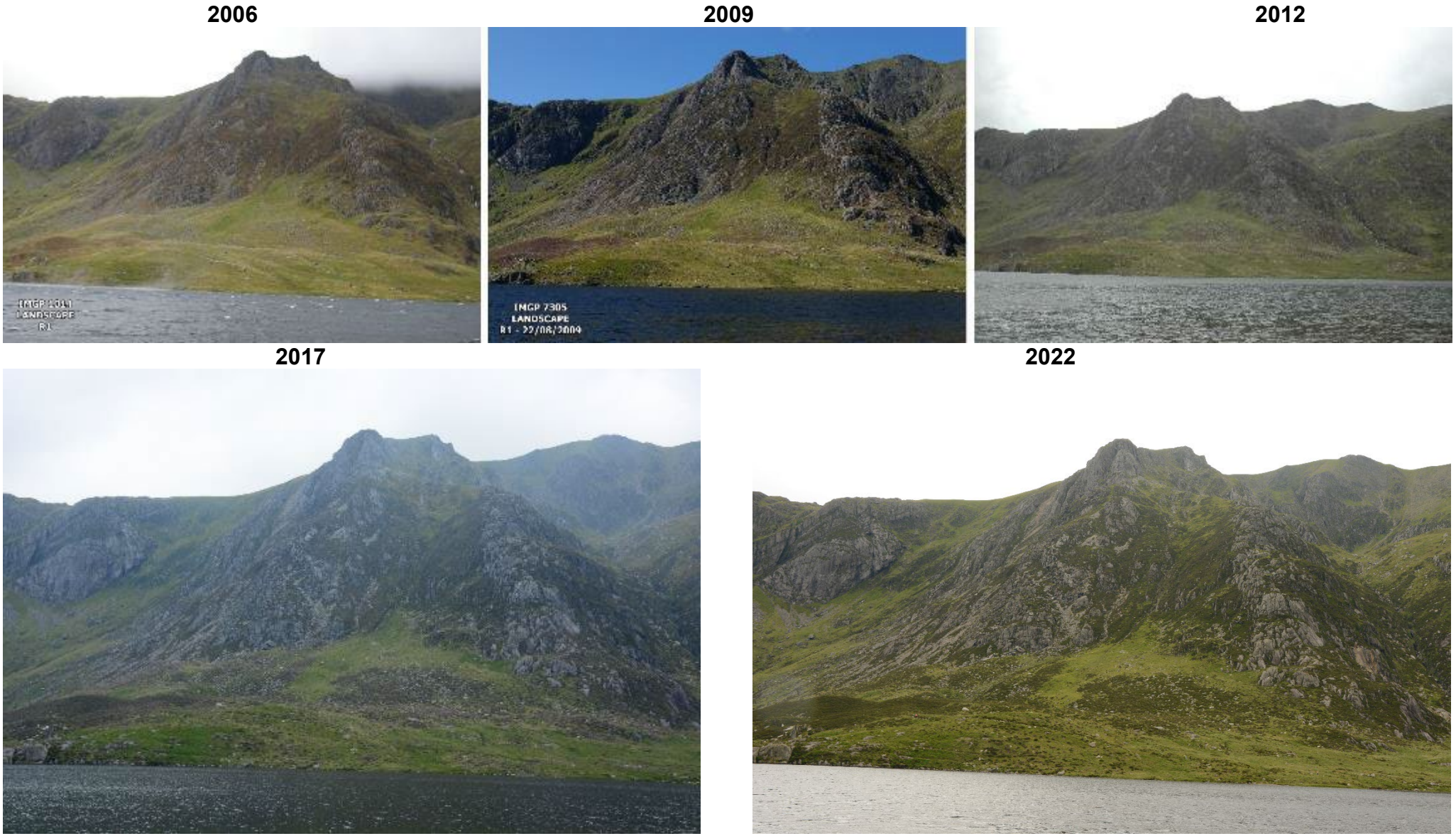


Figure 40 Landscape photo location R2

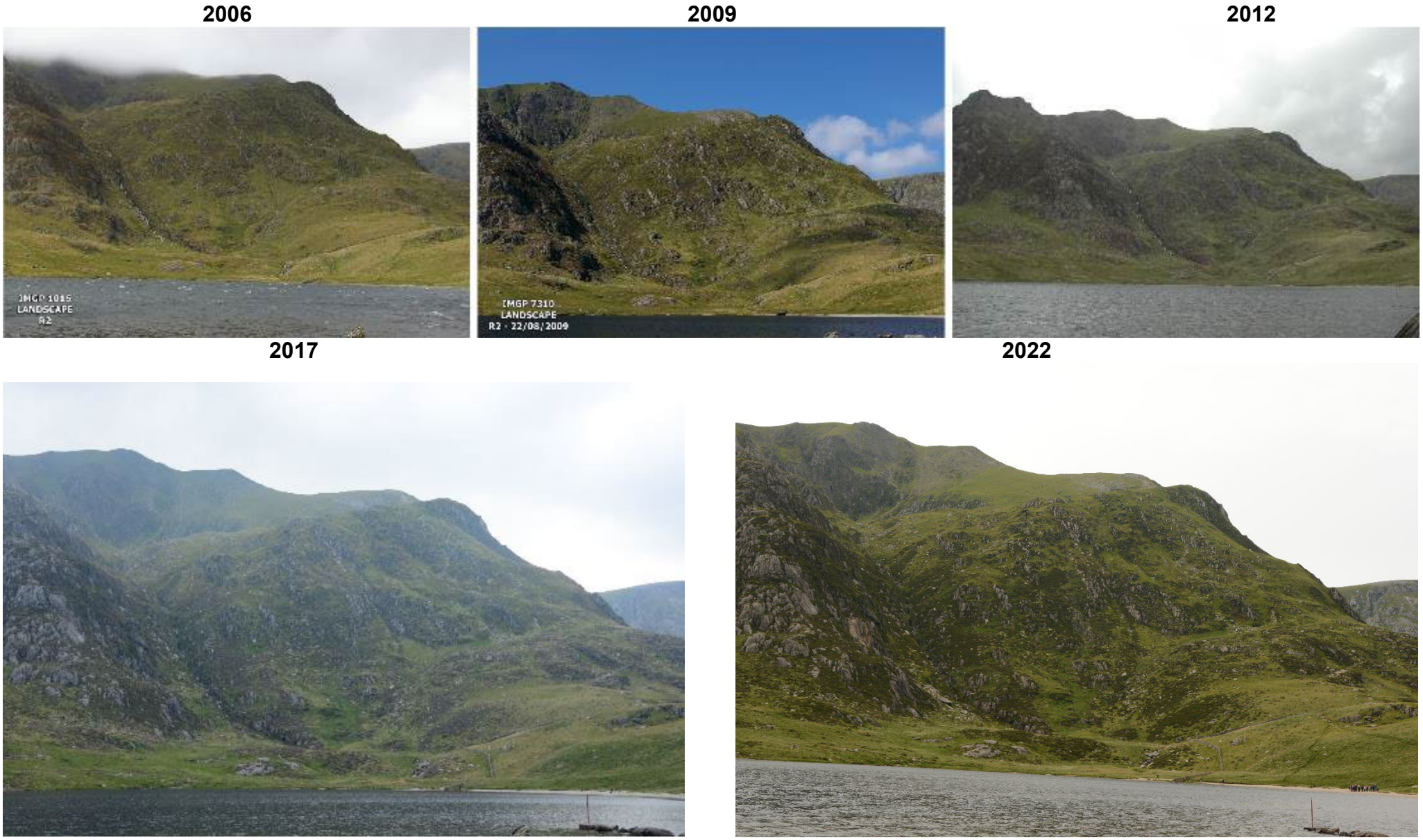


Figure 41 Landscape photo location R3

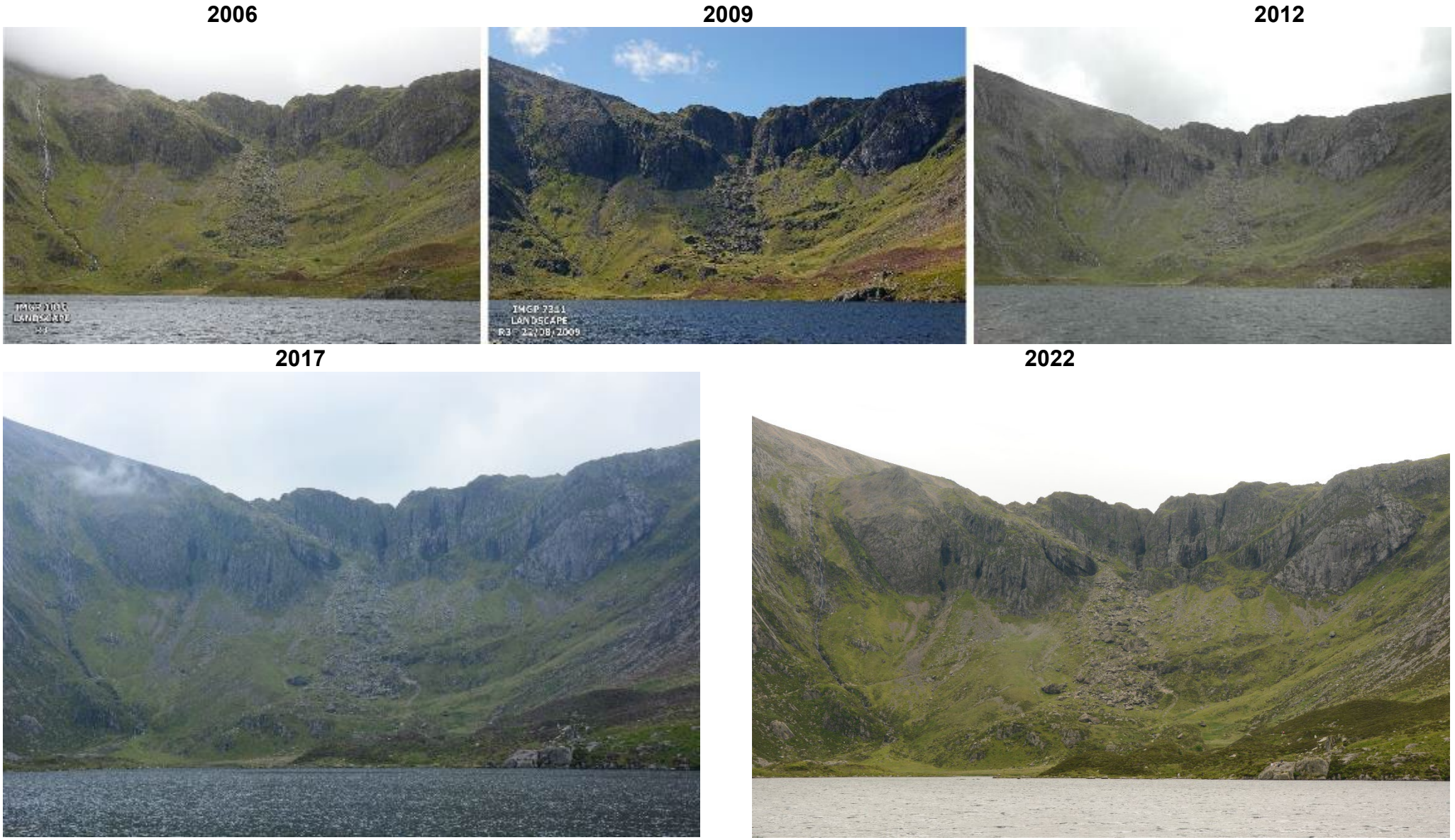


Figure 42 Landscape photo location S1

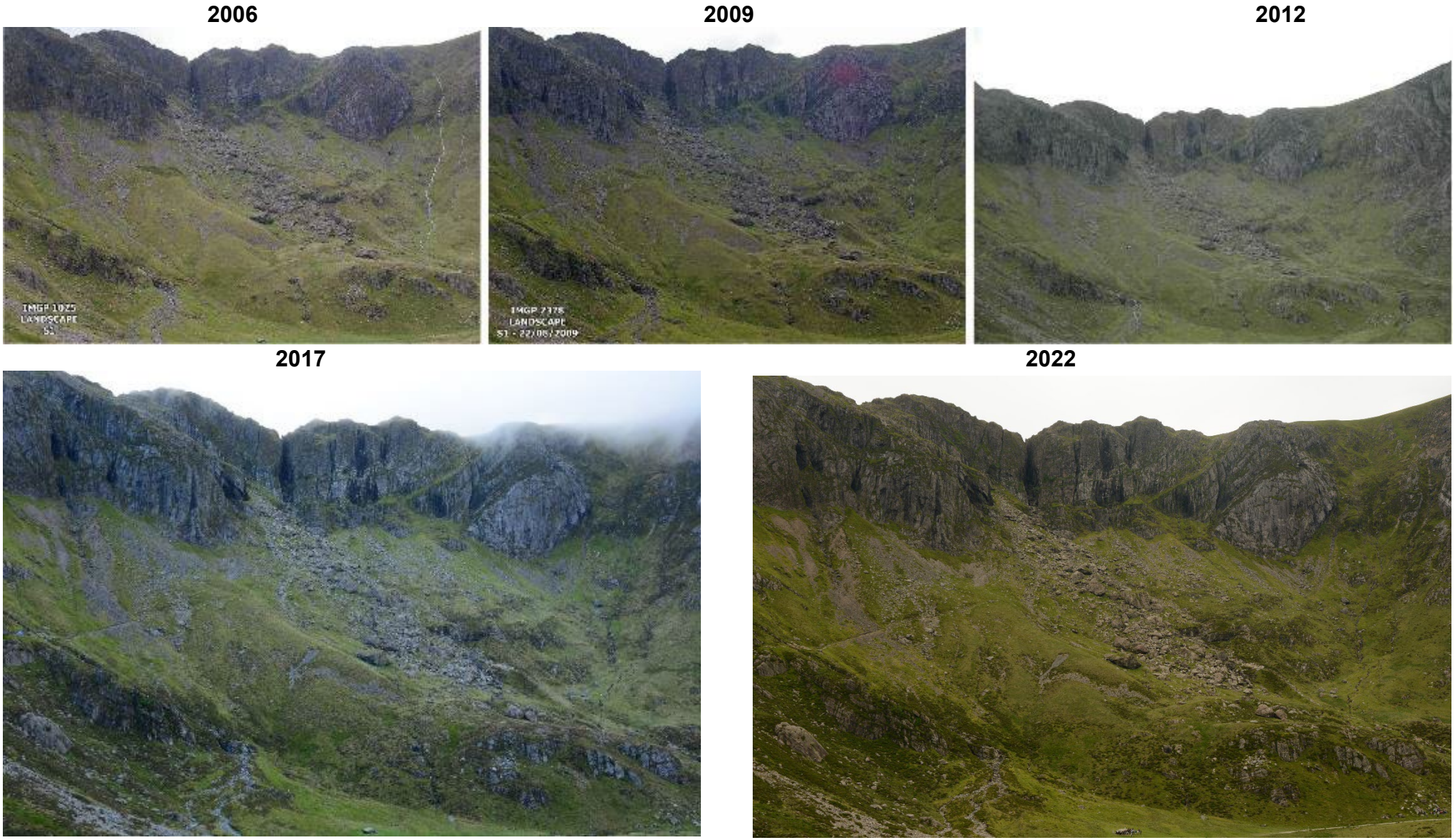


Figure 43 Landscape photo location T1

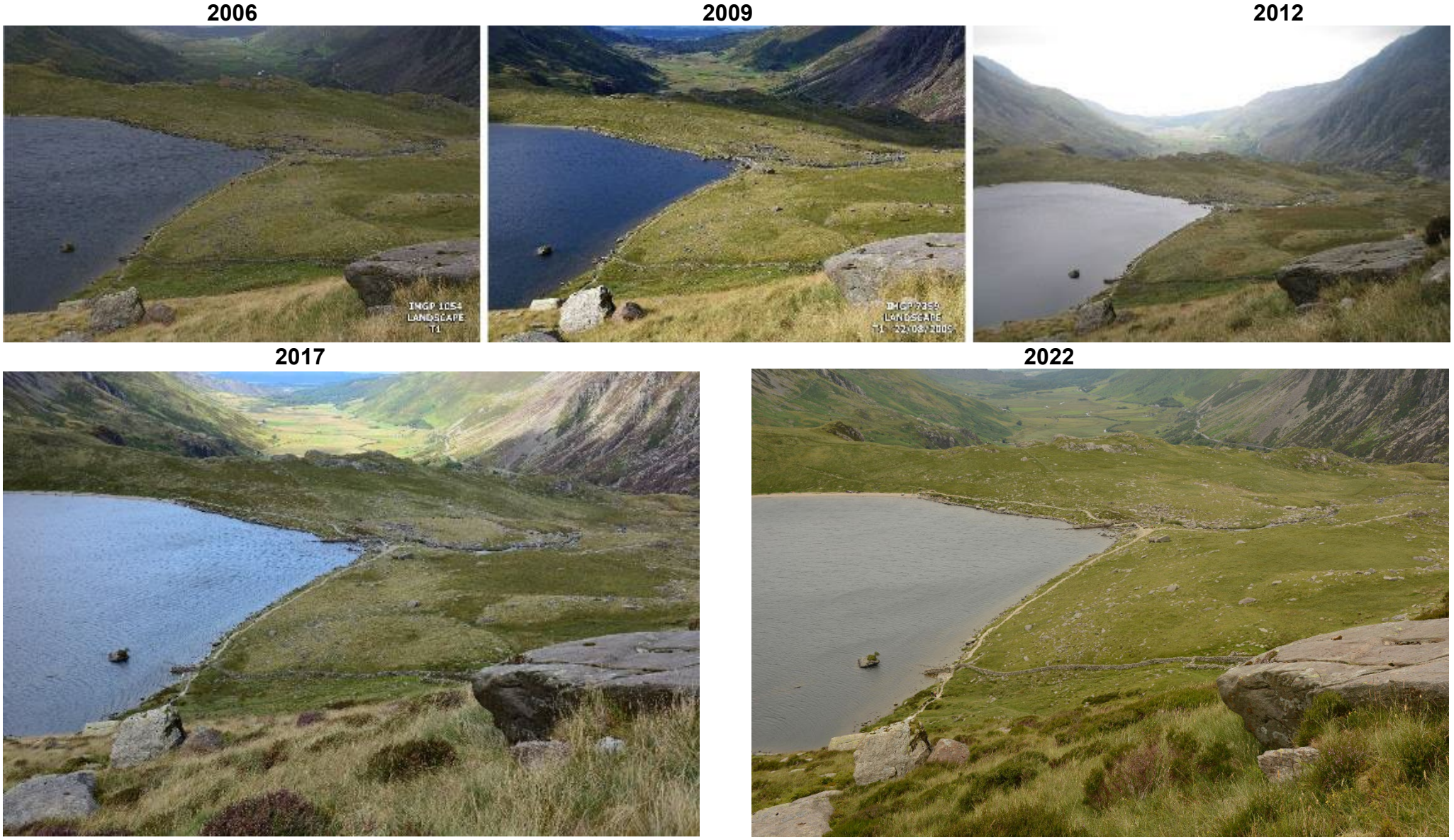
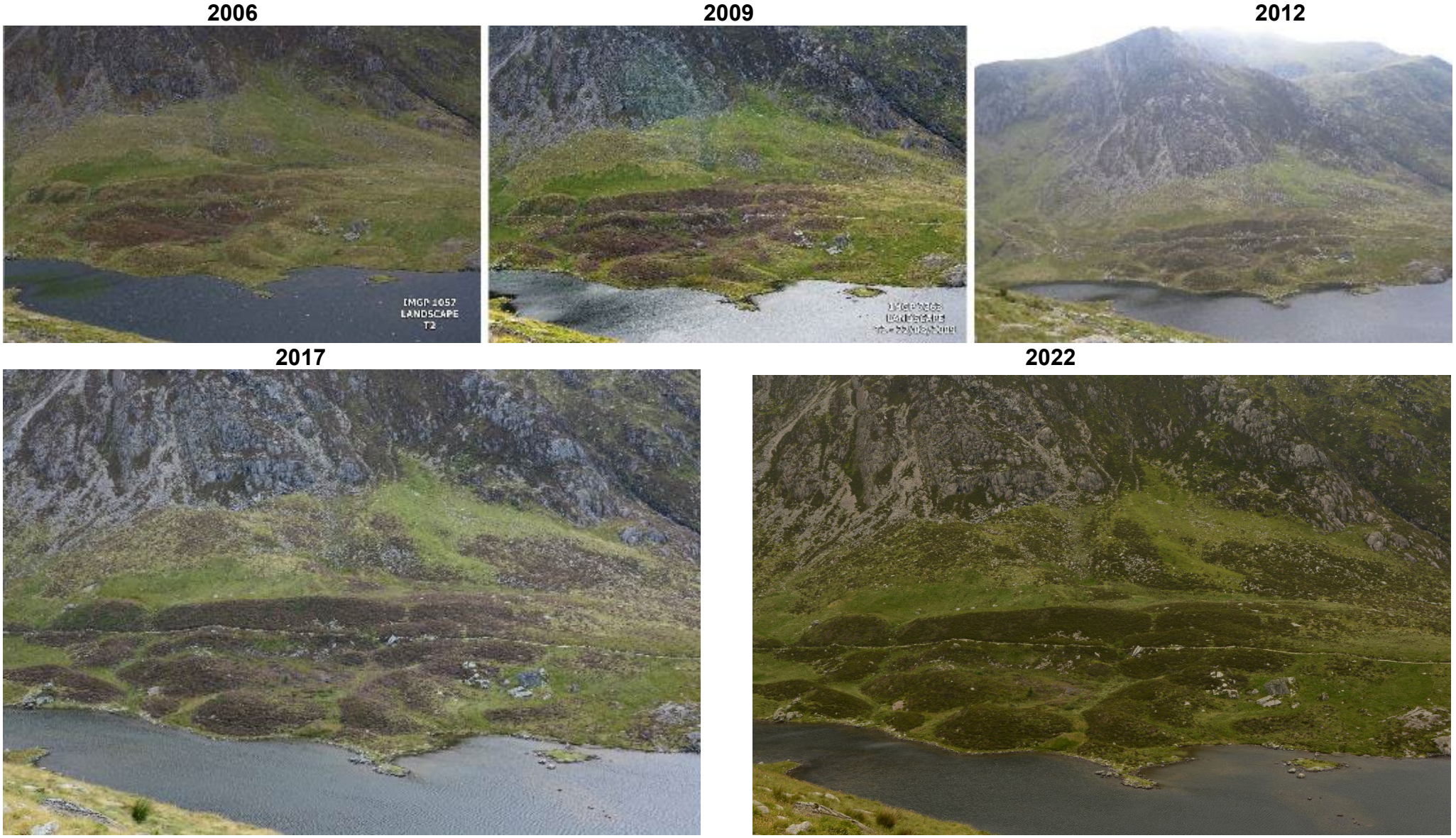


Figure 44 Landscape photo location T2



9.6. Appendix 6 - Landscape/Panorama Photo location Details

Table 32: Details of landscape photograph locations and photograph details for 2022.

(2017 data shown in red. M = Magnetic bearing).

Station	**A**		
Date	15-Jul-22	25-Jul-17	
Easting	64360	64360	**Altitude** 409m
Northing	59981	59976	**GPS error** ±2m
Description	Isolated small rock in open grassland to west of northern exclosure		
Tripod Photo Frame Nos		20220715_092310 A, 20220715_092338 A	
Photo	**Focal length**	**Bearing**	**Frame Nos**
A1	26mm	193º M	LANDSCAPE A1 7868 20220715
A2	23mm	245º M	LANDSCAPE A2 7872 20220715

Station	**B**		
Date	15-Jul-22	25-Jul-17	
Easting	64402	64402	**Altitude** 393m
Northing	59989	59989	**GPS error** ±3m
Description	Rock at extreme SE corner of northern exclosure		
Tripod Photo Frame Nos		20220715_091919 B, 20220715_091948 B	
Photo	**Focal length**	**Bearing**	**Frame Nos**
B1	25mm	136º M	LANDSCAPE B1 7859 20220715
B2	25mm	159º M	LANDSCAPE B2 7864 20220715

Station	**C**		
Date	12-Jul-22	25-Jul-17	
Easting	64637	64637	**Altitude** 377m
Northing	59849	59849	**GPS error** ±3m
Description	Next to large rock at N. end of lake shore near old reserve entrance		
Tripod Photo Frame Nos		20220712_132659 C, 20220712_132727 C	
Photo	**Focal length**	**Bearing**	**Frame Nos**
C1	30mm	173º M	LANDSCAPE C1 7742 20220712

Station	**D**		
Date	12-Jul-22	25-Jul-17	
Easting	64679	64679	**Altitude** 374m
Northing	59816	59817	**GPS error** ±3m
Description	Stood on large rock beside lake near to footbridge at outfall		
Tripod Photo Frame Nos		20220712_133548 D	
Photo	**Focal length**	**Bearing**	**Frame Nos**
D1	26mm	299º M	LANDSCAPE D1 7751 20220712
D2	26mm	262º M	LANDSCAPE D2 7759 20220712

Station	**E**		
Date	15-Jul-22	28-Aug-17	
Easting	64912	64913	**Altitude** 520m
Northing	59327	59326	**GPS error** ±3m
Description	Erosion scar on steep path up to Y-Gribin, east of lake		
Tripod Photo Frame Nos			
Photo	**Focal length**	**Bearing**	**Frame Nos**
E1	22mm	146º M	LANDSCAPE E1 8254 20220715
E2	22mm	283º M	LANDSCAPE E2 8260 20220715

Table 32 continued.

Station	**F**		
Date	29-Aug-22	09-Aug-17	
Easting	63475	63475	**Altitude** 683m
Northing	59562	59562	**GPS error** ±3m
Description	Station A, Plot 3 (rock outcrop above Peg 2)		
Tripod Photo Frame Nos	20220829_171723 F		
Photo	**Focal length**	**Bearing**	**Frame Nos**
F1	18mm	14º M	LANDSCAPE F1 9964 20220829

Station	**G**		
Date	21-Jul-22	01-Sep-17	
Easting	64952	64953	**Altitude** 796m
Northing	58732	58732	**GPS error** ±3m
Description	Edge of plateau area below Y-Gribin ridge, SE of lake. ***Approach from main ridge path, not from below*.** Station at the top of the Cneifion Arete		
Tripod Photo Frame Nos	20220721_161931 G, 20220721_162010 G		
Photo	**Focal length**	**Bearing**	**Frame Nos**
G1	26mm	324º M	LANDSCAPE G1 8340 20220721

Station	**H**		
Date	21-Jul-22	01-Sep-17	
Easting (H1)	64882	64884	**Altitude** 612m / 611m
Northing (H1)	59153	59150	**GPS error** ±3m
Easting (H2)	64885		
Northing (H2)	59157		
Description	On top of large rock outcrop on steep slopes east of lake. On top of Sub-Cneifion Rib. H1 and H2 taken from slightly different places, looking down N and S sides of Sub-Cneifion Rib		
Tripod Photo Frame Nos	20220721_150958 H1		
Photo	**Focal length**	**Bearing**	**Frame Nos**
H1	23mm	257º M	LANDSCAPE H1 8323 20220721
H2	22mm	352º M	LANDSCAPE H2 8336 20220721

Station	**I**		
Date	15-Jul-22	28-Aug-17	
Easting	64820	64816	**Altitude** 517m
Northing	59188	59182	**GPS error** ±3m
Description	Smaller outcrop on steep slope east of lake, lower down than Station H. Lower down Sub-Cneifion Rib. Use path to south of Rib and traverse onto platform.		
Tripod Photo Frame Nos	20220715_141651 I, 20220715_141739 I		
Photo	**Focal length**	**Bearing**	**Frame Nos**
I1	30mm	354º M	LANDSCAPE I1 8230 20220715
I2	25mm	273º M	LANDSCAPE I2 8235 20220715

Station	**J**		
Date	15-Jul-22	28-Aug-17	
Easting	64737	64735	**Altitude** 478m
Northing	59190	59186	**GPS error** ±2m
Description	Eastern slope to north of Idwal Slabs		
Tripod Photo Frame Nos	20220715_143807 J, 20220715_143859 J		
Photo	**Focal length**	**Bearing**	**Frame Nos**
J1	25mm	210º M	LANDSCAPE J1 8243 20220715
J2	23mm	304º M	LANDSCAPE J2 8250 20220715

Table 32 continued.

Station	**K**			
Date	12-Jul-22	28-Aug-17		
Easting	64636	64637	**Altitude**	431m
Northing	59179	59179	**GPS error**	±3m
Description	Boulder (E side of), a fair way above main path along base of eastern Cwm, NE of Idwal Slabs			
Tripod Photo Frame Nos		20220712_154756 K, 20220712_154819 K		
Photo	**Focal length**	**Bearing**	**Frame Nos**	
K1	30mm	210º M	LANDSCAPE K1 7796 20220712	
K2	30mm	74º M	LANDSCAPE K2 7801 20220712	
K3	26mm	144º M	LANDSCAPE K3 7806 20220712	

Station	**L**			
Date	15-Jul-22	13-Aug-17		
Easting	63941	63924	**Altitude**	512m
Northing	59054	59017	**GPS error**	±3m
Description	Large rock beside Peg 1 of Plot 14. Large mean error in 2017 GPS coordinates (41m)			
Tripod Photo Frame Nos		20220715_122607 L, 20220715_122642 L		
Photo	**Focal length**	**Bearing**	**Frame Nos**	
L1	26mm	53º M	LANDSCAPE L1 8075 20220715	
L2	26mm	21º M	LANDSCAPE L2 8080 20220715	
L3	26mm	85º M	LANDSCAPE L3 8085 20220715	

Station	**M**			
Date	12-Jul-22	30-Aug-17		
Easting	64267	64267	**Altitude**	450m
Northing	58880	58888	**GPS error**	±3m
Description	Where main path crosses watercourse just above Idwal Slabs (before new bridge)			
Tripod Photo Frame Nos		20220712_163312 M, 20220712_163357 M		
Photo	**Focal length**	**Bearing**	**Frame Nos**	
M1	23mm	309º M	LANDSCAPE M1 7811 20220712	

Station	**N**			
Date	15-Jul-22	25-Jul-17		
Easting	64217	64220	**Altitude**	411m
Northing	59173	59174	**GPS error**	±2m
Description	Rock outcrop near southern end of lake, below block scree			
Tripod Photo Frame Nos		20220715_104952 N, 20220715_105050 N		
Photo	**Focal length**	**Bearing**	**Frame Nos**	
N1	25mm	232º M	LANDSCAPE N1 7957 20220715	
N2	26mm	20º M	LANDSCAPE N2 7964 20220715	
N3	26mm	96º M	LANDSCAPE N3 7965 20220715	
N4	25mm	342º M	LANDSCAPE N4 7970 20220715	

Station	**P**			
Date	15-Jul-22	25-Jul-17		
Easting	64146	64147	**Altitude**	420m
Northing	59200	59204	**GPS error**	±3m
Description	Southernmost portion of moraines, on crest, quite near path			
Tripod Photo Frame Nos		20220715_102941 P, 20220715_103113 P		
Photo	**Focal length**	**Bearing**	**Frame Nos**	
P1	25mm	38º M	LANDSCAPE P1 7949 20220715	
P2	23mm	215º M	LANDSCAPE P2 7952 20220715	

Table 32 continued.

Station	**Q**		
Date	15-Jul-22	25-Jul-17	
Easting	64367	64367	**Altitude** 404m
Northing	59641	59639	**GPS error** ±3m
Description	Peaty hillock at northern extremity of moraines, quite near main path		
Tripod Photo Frame Nos		20220715_100201 Q, 20220715_100239 Q	
Photo	**Focal length**	**Bearing**	**Frame Nos**
Q1	25mm	210º M	LANDSCAPE Q1 7905 20220715
Q2	25mm	131º M	LANDSCAPE Q2 7913 20220715

Station	**R**		
Date	12-Jul-22	25-Jul-17	
Easting	64680	64684	**Altitude** 377m
Northing	59807	59805	**GPS error** ±3m
Description	Large boulder just south of lake outfall (crouched beneath)		
Tripod Photo Frame Nos		20220712_134921 R, 20220712_134949 R	
Photo	**Focal length**	**Bearing**	**Frame Nos**
R1	26mm	246º M	LANDSCAPE R1 7760 20220712
R2	26mm	275º M	LANDSCAPE R2 7765 20220712
R3	30mm	218º M	LANDSCAPE R3 7775 20220712

Station	**S**		
Date	12-Jul-22	28-Aug-17	
Easting	64632	64633	**Altitude** 429m
Northing	59177	59179	**GPS error** ±3m
Description	Large bounder on eastern lower slope of Cwn, north of Idwal slabs. Opposite side of boulder from Station K.		
Tripod Photo Frame Nos		20220712_150035 S	
Photo	**Focal length**	**Bearing**	**Frame Nos**
S1	25mm	250º M	LANDSCAPE S1 7792 20220712

Station	**T**		
Date	12-Jul-22	28-Aug-17	
Easting (T1)	64771	64775	**Altitude** 463m
Northing (T1)	59402	59403	**GPS error** ±3m
Easting (T2)	64768	64770	
Northing (T2)	59401	59401	
Description	Grassy hillside with scattered boulders north of Sub-Cneifion Rib. T1 and T2 not taken from same point, T2 is c4m towards Twll Du from T1		
Tripod Photo Frame Nos		20220712_142740 T1, 20220712_142826 T1, 20220712_143708 T2,	
Photo	**Focal length**	**Bearing**	**Frame Nos**
T1	26mm	345º M	LANDSCAPE T1 7781 20220712
T2	23mm	280º M	LANDSCAPE T2 7787 20220712

9.7. Appendix 7 - Higher-level plot photos

Figure 45 Plot 01. Y Garn summit

2004 **2022**

Top: from Peg 2 to Peg 1, Bottom: Plot from Peg 2

Figure 46 Plot 16. South-eastern slopes of Y Garn

2004 **2022**

Top: view along the line of Peg 2 to Peg 1, Bottom: Peg 1 location from easterly Y Garn path

Figure 47 Plot 17. Plateau crest of Esgair Felen, Glyder Fawr

2004 **2022**

Top: Peg 1 location, Bottom: Along line from Peg 1 to Peg 2

Figure 48 Plot 30. Upper Cwm Cneifion

2004 **2022**

Top: From Peg 1 to Peg 2, Bottom: Quadrat 2

9.8. Appendix 8 Species names

Table 33 Scientific, English, and Welsh names of vascular plant species mentioned in this report.

Scientific name	English name	Welsh name
Sorbus aucuparia	Rowan	Criafolen
Calluna vulgaris	Heather	Grug
Empetrum hermaphroditum	Mountain Crowberry	Creiglusen Ddeurywiol
Empetrum nigrum	Crowberry	Creiglysen
Erica cinerea	Bell Heather	Grug y Mêl
Erica tetralix	Cross-leaved Heath	Grug Croesddail
Vaccinium myrtillus	Bilberry	Llusen, Llus
Vaccinium vitis-idaea	Cowberry	Llusen Goch
Asplenium adiantum-nigrum	Black Spleenwort	Duegredynen Goesddu
Blechnum spicant	Hard Fern	Gwibredynen
Cryptogramma crispa	Parsley Fern	Rhedyn Persli
Diphasiastrum alpinum	Alpine Clubmoss	Cnwp-Fwsogl Alpaidd
Dryopteris dilatata	Broad Buckler Fern	Marchredynen Lydan
Dryopteris oreades	Mountain Male Fern	Marchredynen y Mynydd
Huperzia selago	Fir Clubmoss	Cnwp-Fwsogl Mawr
Hymenophyllum wilsonii	Wilson's Filmy-fern	Rhedynach Teneuwe Wilson
Lycopodium clavatum	Stag's-horn Clubmoss	Cnwp-Fwsogl Corn Carw
Oreopteris limbosperma	Lemon-scented Fern	Rhedynen Bêr y Mynydd
Selaginella selaginoides	Lesser Clubmoss	Cnwp-Fwsogl Bach
Carex binervis	Green-ribbed Sedge	Hesgen Ddeulasnod
Carex caryophyllea	Spring-sedge	Hesgen Gynnar
Carex canescens	White Sedge	Hesgen Benwen
Carex demissa	Common Yellow-sedge	Hesgen Felen
Carex echinata	Star Sedge	Sêr-Hesgen
Carex nigra	Common Sedge	Hesgen Gyffredin
Carex panicea	Carnation Sedge	Hesgen Lwydlas
Carex pilulifera	Pill Sedge	Hesgen Bengron
Carex pulicaris	Flea Sedge	Hesgen y Chwain
Eriophorum angustifolium	Common Cottongrass	Plu'r Gweunydd
Eriophorum vaginatum	Hare`s-tail Cottongrass	Plu`r Gweunydd Unben
Juncus bulbosus	Bulbous Rush	Brwynen Oddfog
Juncus effusus	Soft-rush	Brwynen Babwyr
Juncus squarrosus	Heath Rush	Brwynen Droellgorun
Luzula campestris	Field Wood-rush	Milfyw
Luzula multiflora	Heath Wood-rush	Coedfrwynen Luosben
Trichophorum germanicum	Deergrass	Clwbfrwynen y Mawn

Table 33 continued

Scientific name	English name	Welsh name
Agrostis canina	Velvet Bent	Maeswellt y Cwn
Agrostis capillaris	Common Bent	Maeswellt Cyffredin
Agrostis stolonifera	Creeping Bent	Maeswellt Rhedegog
Agrostis vinealis	Brown Bent	Maeswellt-y-Cwn y Mynydd
Anthoxanthum odoratum	Sweet Vernal-grass	Perwellt y Gwanwyn
Avenella flexuosa	Wavy Hair-grass	Brigwellt Main
Cynosurus cristatus	Crested Dog`s-tail	Rhonwellt y Ci
Danthonia decumbens	Heath-grass	Glaswellt y Rhos
Deschampsia cespitosa	Tufted Hair-Grass	Brigwellt Garw
Festuca ovina	Sheeps Fescue	Peiswellt y Defaid
Festuca rubra	Red Fescue	Peiswellt Coch
Festuca vivipara	Viviparous Fescue	Peiswellt Bywhiliog
Holcus lanatus	Yorkshire Fog	Maswellt Penwyn
Holcus mollis	Creeping Soft-grass	Maswellt Rhedegog
Molinia caerulea	Purple Moor-grass	Glaswellt y Gweunydd
Nardus stricta	Mat-grass	Cawnen Ddu
Poa annua	Annual Meadow-grass	Gweunwellt Unflwydd
Achillea millefolium	Achillea millefolium	Yarrow
Alchemilla glabra	Smooth Lady's-mantle	Mantell-Fair Lefn
Campanula rotundifolia	Harebell	Clychau`r Eos
Cardamine pratensis	Cuckoo Flower	Blodyn Llefrith
Cerastium fontanum	Common Mouse-ear	Clust-y-Llygoden Gulddail
Cirsium palustre	Marsh Thistle	Ysgallen y Gors
Dactylorhiza maculata	Heath Spotted-orchid	Tegeirian Brych
Drosera rotundifolia	Round-leaved Sundew	Gwlithlys
Epilobium brunnescens	New Zealand Willowherb	Helyglys Seland Newydd
Euphrasia agg.	Eyebright	Effros
Galium saxatile	Heath Bedstraw	Briwydd Wen
Hypericum pulchrum	Slender St John`s-wort	Eurinllys Meinsyth
Lysimachia nemorum	Yellow Pimpernel	Gwlyddyn Melyn Mair
Lysimachia nummularia	Creeping-Jenny	Siani Lusg
Micranthes stellaris	Starry Saxifrage	Tormaen Serennog
Narthecium ossifragum	Bog Asphodel	Llafn y Bladur
Oxalis acetosella	Wood-sorrel	Suran y Coed
Oxyria digyna	Mountain Sorrel	Suran y Mynydd
Pinguicula vulgaris	Common Butterwort	Tafod y Gors

Table 33 continued

Scientific name	English name	Welsh name
Plantago lanceolata	Ribwort Plantain	Llyriad yr Ais
Polygala serpyllifolia	Heath Milkwort	Amlaethai`r Waun
Potentilla erecta	Tormentil	Tresgl y Moch
Potentilla sterilis	Barren Strawberry	Llwyn Coeg-Fefus
Prunella vulgaris	Selfheal	Y Feddyges Las
Ranunculus acris	Meadow Buttercup	Blodyn Ymenyn
Rumex acetosa	Common Sorrel	Suran y Cŵn
Rumex acetosella	Sheep`s Sorrel	Suran yr Ŷd
Sagina procumbens	Procumbent Pearlwort	Corwlyddyn Gorweddol
Scorzoneroides autumnalis	Autumn Hawkbit	Peradyl yr Hydref
Sedum anglicum	English Stonecrop	Briweg y Cerrig
Solidago virgaurea	Goldenrod	Eurwialen
Succisa pratensis	Devil`s-bit Scabious	Tamaid y Cythraul
Taraxacum officinale	Dandelion	Dant y Llew
Thymus drucei	Wild Thyme	Teim Gwyllt
Trifolium repens	White Clover	Meillionen Wen
Tussilago farfara	Colt's-foot	Carn yr Ebol
Viola palustris	Marsh Violet	Fioled y Gors
Viola riviniana	Common Dog-violet	Fioled Gyffredin

10. Correction for Turner (2018)

A small error was found in a lookup formula referencing critical values for the Wilcoxon signed-rank test for paired samples in one of the Excel tables used to generate Table 5 of Turner (2018). The result of the error was to ascribe significance at the level $p < 0.01$ to a number of changes in cell data for species with a relatively low number of occurrences. A corrected table (Table 35) is presented below. The species changes which had erroneous significance ascribed to them are also listed separately in Table 34. The reported results of significance tests on changes in these species using McNemar's test remain unchanged.

Table 34 Corrected species significance results for Table 5 in Turner (2018)

Species/variable	Wilcoxon signed rank test trend and significance		
	2006 - 2017	2009 - 2017	2012 - 2017
Erica cinerea	ns	ns	ns
Erica tetralix	.	.	ns
Diphasiastrum alpinum	.	ns	.
Huperzia selago	-, **	ns	ns
Eriophorum angustifolium	.	.	ns
Achillea millefolium	.	ns	ns
Cirsium palustre	.	ns	ns
Euphrasia sp.	.	ns	.
Prunella vulgaris	.	.	ns
Ranunculus acris	ns	.	.
Sedum anglicum	ns	.	.
Viola riviniana	.	ns	.
Exposed peat	ns	.	ns

ns changed significance level.

Some of the changed significance levels have little or no effect on the text as the changes were also significant using McNemar's Test. These include changes for *Erica cinerea, Huperzia selago, Achillea millefolium, Cirsium palustre* and *Euphrasia*, and the variable Exposed Peat. Those which are unsupported include decreases in the frequency of *Erica tetralix, Diphasiastrum alpinum, Ranunculus acris* and *Sedum anglicum*, and an increase in the frequency of *Prunella vulgaris*.

Table 35 Corrected version of Table 5 in Turner (2018) Summary of mean cell frequency values and the significance of changes between 2006, 2009, 2012 and 2017.

Species/variable	Mean and Standard Error (SE)								Differences of means			Wilcoxon signed rank test Trend, significance			McNemar's test Trend, significance		
	2006		2009		2012		2017		2017 - 2006	2017 - 2009	2017 - 2012	2017 - 2006	2017 - 2009	2017 - 2012	2017 - 2006	2017 - 2009	2017 - 2012
	Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE									
Calluna vulgaris	2.93	0.77	2.91	0.73	5.22	1.19	6.02	1.26	3.09	3.11	0.80	+, *	+, *	+, ***	+, ***	+, ***	+, ***
Empetrum hermaphroditum	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.05	0.05	0.05	.	.	.	.	.	.
Empetrum nigrum	3.18	0.93	3.02	0.90	2.33	0.78	2.58	0.81	-0.60	-0.44	0.25	.	-, ***	.	-, ***	-, *	.
Erica cinerea	0.80	0.52	0.58	0.35	1.07	0.61	1.00	0.50	0.20	0.42	-0.07	.	.	.	.	+, ***	.
Erica tetralix	0.73	0.51	0.76	0.54	1.02	0.55	0.85	0.54	0.13	0.09	-0.16	.	.	.	.	.	.
Vaccinium myrtillus	8.38	1.45	8.84	1.45	8.65	1.41	9.38	1.42	1.00	0.55	0.73	+, ***	+, ***	+, ***	+, ***	+, *	+, **
Diphasiastrum alpinum	0.45	0.44	0.53	0.37	0.40	0.22	0.44	0.28	-0.02	-0.09	0.04	.	.	.	.	.	.
Huperzia selago	0.49	0.25	0.18	0.09	0.15	0.07	0.04	0.03	-0.45	-0.15	-0.11	-, **	.	.	-, ***	-, *	.
Lycopodium clavatum	0.07	0.05	0.00	0.00	0.04	0.04	0.05	0.05	-0.02	0.05	0.02	.	.	.	.	.	.
Selaginella selaginoides	0.16	0.12	0.16	0.10	0.05	0.04	0.05	0.04	-0.11	-0.11	0.00	.	.	.	.	.	
Carex sp.	7.67	1.29	5.96	1.14	5.25	1.01	6.04	1.06	-1.64	0.07	0.78	-, ***	+, ***	+, ***	-, ***	.	+, **
Eriophorum angustifolium	1.71	0.73	1.53	0.71	1.80	0.87	1.78	0.77	0.07	0.25	-0.02	.	.	.	.	.	.
Eriophorum vaginatum	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.00	.	.	.	.	.	
Juncus sp.	1.00	0.50	0.85	0.49	1.20	0.52	0.89	0.48	-0.11	0.04	-0.31	.	.	.	.	.	-, *
Trichophorum cespitosum	1.35	0.57	1.38	0.51	0.75	0.42	1.00	0.35	-0.35	-0.38	0.25	.	.	.	.	-, *	.
Molinia caerulea	2.69	1.03	4.62	1.26	2.20	0.95	3.07	1.06	0.38	-1.55	0.87	+, *	.	+, **	+, ***	-, ***	+, ***
Nardus stricta	10.78	1.26	7.96	1.13	11.22	1.20	8.55	1.15	-2.24	0.58	-2.67	-, **	+, ***	-, *	-, ***	.	-, ***
Achillea millefolium	1.05	0.52	0.82	0.40	0.51	0.26	0.36	0.21	-0.69	-0.45	-0.15	.	.	.	-, ***	-, **	.
Alchemilla sp.	0.31	0.27	0.20	0.18	0.00	0.00	0.13	0.13	-0.18	-0.07	0.13	.	.	.	-, **	.	+, *
Campanula rotundifolia	1.62	0.67	1.18	0.60	0.67	0.44	1.00	0.52	-0.62	-0.18	0.33	.	.	.	-, ***	.	+, *
Cardamine pratensis	0.09	0.09	0.09	0.09	0.20	0.18	0.13	0.13	0.04	0.04	-0.07	.	.	.	.	.	.
Cerastium fontanum	0.15	0.13	0.04	0.04	0.09	0.06	0.15	0.11	0.00	0.11	0.05	.	.	.		.	.
Cirsium palustre	0.53	0.35	0.22	0.15	0.33	0.17	0.47	0.22	-0.05	0.25	0.15	.	.	.	.	+, *	.
Dactylorhiza sp.	0.05	0.05	0.04	0.04	0.02	0.02	0.02	0.02	-0.04	-0.02	0.00	.	.	.	.	.	
Drosera rotundifolia	0.35	0.29	0.27	0.18	0.27	0.18	0.29	0.18	-0.05	0.02	0.02	.	.	.	.	.	.
Epilobium brunnescens	0.07	0.07	0.00	0.00	0.00	0.00	0.02	0.02	-0.05	0.02	0.02	.	.	.	.	.	.
Euphrasia sp.	0.73	0.36	0.13	0.06	0.27	0.25	0.44	0.30	-0.29	0.31	0.16	.	.	.	-, *	+, ***	.
Filipendula ulmaria	0.02	0.02	1.82	0.88	0.04	0.04	0.00	0.00	-0.02	-1.82	-0.04	.	.	.	.	-, ***	.
Galium saxatile	15.89	1.36	13.87	1.43	13.53	1.39	14.69	1.45	-1.20	0.82	1.16	-, ***	+, ***	+, ***	-, ***	+, **	+, ***
Hieracium sp.	0.04	0.03	0.02	0.02	0.02	0.02	0.00	0.00	-0.04	-0.02	-0.02	.	.	.	.	.	.
Hypericum pulchrum	0.04	0.03	0.05	0.04	0.05	0.04	0.11	0.08	0.07	0.05	0.05	.	.	.	.	.	.
Hypochoeris radicata	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	-0.02	.	.	.			.
Lysimachia nemorum	0.25	0.22	0.20	0.18	0.15	0.15	1.87	0.80	1.62	1.67	1.73	.	.	.	.	.	.
Narthecium ossifragum	1.35	0.75	1.49	0.76	1.65	0.74	0.36	0.17	-0.98	-1.13	-1.29	.	.	.	+, ***	+, ***	.
Oxalis acetosella	0.31	0.17	0.45	0.26	0.24	0.13	0.00	0.00	-0.31	-0.45	-0.24	.	.	.	.	.	.
Pedicularis sylvatica	0.00	0.00	0.00	0.00	0.05	0.05	0.02	0.02	0.02	0.02	-0.04	.	.	.			.
Pinguicula vulgaris	0.07	0.05	0.05	0.04	0.00	0.00	0.87	0.58	0.80	0.82	0.87	.	.	.	.	.	.
Plantago lanceolata	1.53	0.75	1.00	0.59	0.69	0.44	0.73	0.32	-0.80	-0.27	0.04	-, ***	-, ***	.	-, ***	.	.
Polygala serpyllifolia	1.16	0.34	0.60	0.29	0.53	0.18	5.00	0.98	3.84	4.40	4.47	.	.	.	-, *	.	.
Potentilla erecta	5.69	1.13	4.29	0.97	4.53	0.98	0.00	0.00	-5.69	-4.29	-4.53	.	.	.	-, **	+, **	.
Potentilla sterilis	0.02	0.02	0.00	0.00	0.00	0.00	0.36	0.26	0.35	0.36	0.36	.	.	.	.		
Prunella vulgaris	0.51	0.32	0.38	0.27	0.31	0.18	0.33	0.21	-0.18	-0.05	0.02	.	.	.	.	.	.
Ranunculus acris	0.38	0.21	0.45	0.25	0.20	0.13	0.00	0.00	-0.38	-0.45	-0.20	.	.	.	.	.	.
Ranunculus bulbosus	0.00	0.00	0.04	0.04	0.13	0.10	0.04	0.04	0.04	0.00	-0.09	.	.	.		.	-, *
Rumex acetosa	0.02	0.02	0.07	0.05	0.07	0.05	0.15	0.10	0.13	0.07	0.07	.	.	.	.	.	.
Scorzoneroides autumnalis	0.07	0.06	0.22	0.12	0.04	0.03	0.22	0.15	0.15	0.00	0.18	.	.	.	.	.	.
Sedum anglicum	0.40	0.26	0.25	0.15	0.44	0.22	0.31	0.20	-0.09	0.05	-0.13	.	.	.	.	.	.
Solidago virgaurea	0.04	0.03	0.05	0.03	0.02	0.02	0.11	0.08	0.07	0.05	0.09	.	.	.	.	.	.
Taraxacum officinale agg.	0.04	0.03	0.02	0.02	0.02	0.02	0.00	0.00	-0.04	-0.02	-0.02	.	.	.	.	.	.
Thymus drucei	2.13	0.83	1.56	0.73	1.00	0.54	1.00	0.57	-1.13	-0.56	0.00	.	.	.	-, ***	-, ***	
Trifolium repens	0.40	0.38	0.29	0.29	0.38	0.33	0.16	0.16	-0.24	-0.13	-0.22	.	.	.	-, **	-, *	-, **
Viola palustris	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	.	.	.	.		
Viola riviniana	1.02	0.55	1.29	0.58	0.84	0.44	0.58	0.29	-0.44	-0.71	-0.25	.	.	.	-, **	-, ***	.
Sphagnum sp.	4.71	1.19	4.82	1.12	3.36	0.85	4.09	0.96	-0.62	-0.73	0.73	-, ***	-, ***	+, ***	-, **	-, **	+, **
Ferns	0.51	0.20	0.51	0.19	0.89	0.29	0.62	0.26	0.11	0.11	-0.27	.	.	.	.	.	.
Other graminoids	21.45	0.97	21.24	0.96	21.04	0.97	20.45	1.04	-1.00	-0.78	-0.58	-, ***	-, ***	-, ***	-, ***	-, **	-, *
Other bryophytes	22.29	0.83	22.78	0.77	21.55	0.88	21.60	0.83	-0.69	-1.18	0.05	-, ***	-, ***	+, ***	-, **	-, ***	.
Lichens	3.85	0.82	4.05	0.77	4.11	0.82	0.80	0.24	-3.05	-3.25	-3.31	.	.	.	-, ***	-, ***	-, ***
Bare ground	0.35	0.19	0.40	0.19	0.80	0.31	0.55	0.28	0.20	0.15	-0.25	.	.	-, **	.	.	.
Exposed peat	1.65	0.81	1.65	0.82	1.87	0.84	1.45	0.71	-0.20	-0.20	-0.42	.	.	.	-, *	-, *	-, ***
Rock	5.22	0.94	4.87	0.89	4.00	0.82	3.49	0.78	-1.73	-1.38	-0.51	.	-, *	-, ***	-, ***	-, ***	-, *
Litter	23.09	0.65	24.58	0.20	21.65	0.83	23.51	0.71	0.42	-1.07	1.85	+, ***	.	+, *	.	-, ***	+, ***
Sheep Droppings	1.91	0.40	1.53	0.45	1.09	0.31	0.80	0.21	-1.11	-0.73	-0.29	-, **	-, ***	-, ***	-, ***	-, ***	.
HEATH	10.22	1.46	10.75	1.45	11.98	1.48	12.65	1.48	2.44	1.91	0.67	+, *	+, **	+, ***	+, ***	+, ***	+, **
HEATH SUM	16.02	2.70	16.11	2.53	18.29	2.76	19.89	2.80	3.87	3.78	1.60	+, *	+, *	+, ***	+, ***	+, ***	+, ***
GRAMINOID SUM	46.65	3.38	43.55	2.75	43.47	2.46	41.80	2.48	-4.85	-1.75	-1.67	-, **	-, ***	-, **	-, ***	.	.
CALC GRASS SUM	12.09	3.64	10.69	2.75	6.60	2.09	7.22	2.52	-4.87	-3.47	0.62	-, *	-, ***	+, ***	-, ***	-, ***	.

Data Archive Appendix

Data outputs associated with this project are archived in the Document Management System (DMS) location: Land Management Protected Sites/Protected Sites - Gwynedd>Eryri / Snowdonia SSSI (SH66.11)/Surveillance, server–based storage at Natural Resources Wales.

The data archive contains:

The final report in Microsoft Word and Adobe PDF formats.

A full set of maps produced in JPEG format.

A full set of images produced in JPEG format.

Plot and quadrat data in Excel format

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue https://libcat.naturalresources.wales (English Version) and https://catllyfr.cyfoethnaturiol.cymru (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record no 121565

Published by:
Natural Resources Wales
Maes y Ffynnon,
Bangor
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