Survey to determine the status and distribution of Geyer's Whorl Snail *Vertigo geyeri* on Waun Eurad SSSI, its last known Welsh locality, in November 2021

NRW Evidence Report No. 944

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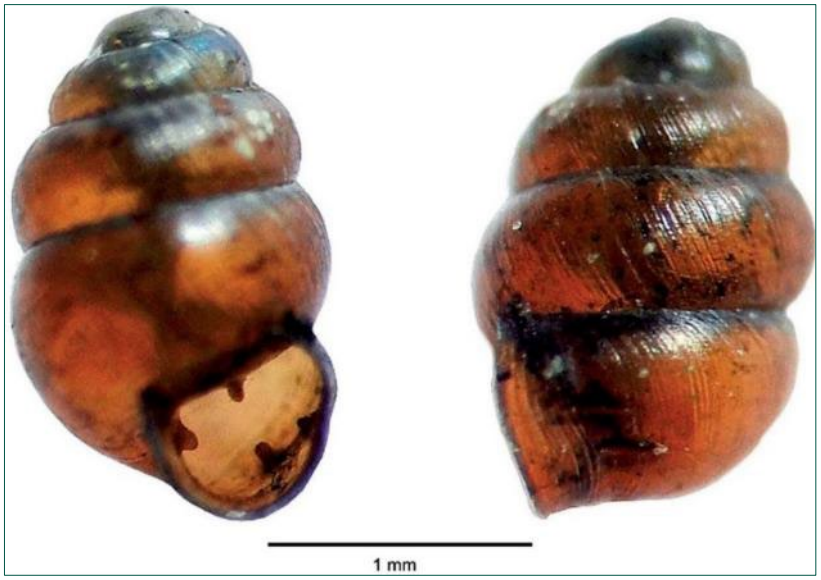

Geyer's Whorl Snail *Vertigo geyeri*

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Crynodeb gweithredol

Cynhaliwyd arolwg o'r boblogaeth Gymreig olaf y gwyddys amdani o Falwen Droellog Geyer *Vertigo geyeri* ar SoDdGA Waun Eurad ar 8 a 9 Tachwedd 2021. Dewiswyd cyfanswm o 17 lleoliad ar hap mewn dau grŵp wedi'u clystyru'n fras o amgylch y Trawsluniau monitro blaenorol 'A' a 'B' (a sefydlwyd yn 2003), a leolir yn ne-orllewin a gogledd-ddwyrain y safle yn y drefn honno. Dewiswyd pob safle fel eu bod yn digwydd mewn ardaloedd lle'r oedd y Gorsfrwynen Ddu *Schoenus nigricans* yn bresennol a barnwyd eu bod yn **Orau** neu'n **Is-orau** ar gyfer y falwen fel y'i diffinnir mewn arolygon blaenorol.

Yn 2021, canfuwyd *V. geyeri* mewn wyth o'r 17 lleoliad, ac roedd saith ohonynt wedi'u clystyru o amgylch yr hen Drawslun 'B'. Canfuwyd un lleoliad â phoblogaeth ohono yn agos at ben deheuol yr hen 'Drawslun A', yn agos at y man lle cofnodwyd y falwen ddiwethaf yn 2003 ond ni chafodd ei chofnodi wedi hynny yn 2007 a 2014. Casglwyd cyfanswm o 66 o sbesimenau *V. geyeri* o'r naw lleoliad a feddiannwyd, sy'n cymharu â'r cyfanswm uchaf blaenorol (ar ôl astudiaethau PhD Sharland) o 92 o falwod o 30 safle yn 2003. Mae hyn yn awgrymu bod y falwen wedi cynnal 'presenoldeb cryf' ar Waun Eurad, o leiaf yn y sector gogledd-ddwyreiniol - ardal sy'n adlewyrchu'n fras bresenoldeb diferion sy'n dyddodi twffa o fewn twmpathau o *S. nigricans*. Yn seiliedig ar yr wybodaeth hon, ar sail eithaf goddrychol, ystyrir bod poblogaeth *V. geyeri* ar Waun Eurad mewn **Cyflwr Ffafriol** er bod y dirywiad yn y niferoedd yn y sector de-orllewinol a ganfuwyd gyntaf yn 2007 yn destun pryder.

Awgrymir bod arolwg mwy systematig o Waun Eurad yn cael ei gynnal yn y dyfodol gan fabwysiadu dull grid lleoli o safleoedd i gwmpasu holl ardaloedd rhannau gogleddol a chanolog y safle (yr ardaloedd hynny sydd wedi'u cynnwys yn yr arolygon ehangach o 1999 i 2000 a 2003) er mwyn cael dealltwriaeth fwy cynhwysfawr o ddosbarthiad presennol y falwen. Bydd hyn hefyd o gymorth i ddatblygu 'Amcan Cadwraeth' diwygiedig i ganiatáu asesiadau cyflwr mwy rheolaidd a symlach o boblogaeth *V. geyeri* ar Waun Eurad.

Mae crynodeb manwl o'r holl astudiaethau *V. geyeri* blaenorol ar Waun Eurad rhwng 1996 a 2014 wedi'i gynnwys, ynghyd â chronolegau o waith V. geyeri ar SoDdGA/GNG Cors Erddreiniog a SoDdGA/GNG Cors Geirch o 1985 i 2019 ac 1996 i 2019 yn y drefn honno. O ystyried fod *V. geyeri* i'w gweld wedi ei cholli o Gors Erddreiniog a Chors Geirch, awgrymir y posibilrwydd o drosglwyddo rhai malwod 'gormodol' o Waun Eurad i gynefin V. geyeri wedi'i adfer ar Gors Erddreiniog.

Cofnodwyd cyfanswm o 14 rhywogaeth arall o folysgiaid yn 2021, ac roedd pob un ohonynt wedi'u cofnodi mewn arolygon blaenorol. Ni chofnodwyd chwe rhywogaeth a gofnodwyd yn 2003 a 2007 yn 2021 gan gynnwys *Aegopinella pura, Ashfordia granulata, Columella aspera, Lauria cylindracea, Leiostyla anglica* a *Trochulus striolata*.

Executive summary

A survey of the last known Welsh population of Geyer's Whorl Snail *Vertigo geyeri* was undertaken on Waun Eurad SSSI on 8th and 9th November 2021. A total of 17 locations were chosen randomly in two groups approximately clustered around the former monitoring Transects 'A' and 'B' (established in 2003), situated in the south-west and north-east of the site respectively. All sites were selected to occur in areas where Black Bog-rush *Schoenus nigricans* was present and were judged to be **Optimal** or **Sub-optimal** for the snail as defined in previous surveys.

In 2021, *V. geyeri* was found at eight of the 17 locations, seven of which were clustered around the former Transect 'B'. A single occupied location was found close to the southern end of the former 'Transect A', close to where the snail was last recorded in 2003 but not recorded subsequently in 2007 and 2014. A total of 66 *V. geyeri* specimens were collected from the nine occupied locations which compares to the previous (post Sharland PhD studies) highest total of 92 snails from 30 sites in 2003. This suggests that the snail has maintained a 'strong presence' on Waun Eurad, at least in the north-eastern sector - an area which broadly reflects the presence of tufa-depositing seepages within tussocks of *S. nigricans*. Based upon this information, on a rather subjective basis, the population of *V. geyeri* on Waun Eurad is considered to be in **Favourable Condition** although the decline in numbers in the south-western sector first detected in 2007 is a cause for concern.

A future, more systematic survey of Waun Eurad is suggested adopting a grid placement of sites to cover all areas of the northern and central parts of the site (those areas included in the wider surveys from 1999 to 2000 and 2003) to gain a more comprehensive understanding of the current distribution of the snail. This will also assist in developing a revised 'Conservation Objective' to allow for more regular and simplified condition assessments of the *V. geyeri* population on Waun Eurad.

A detailed summary of all previous *V. geyeri* studies on Waun Eurad from 1996 to 2014 is included, together with chronologies of *V. geyeri* work on Cors Erddreiniog SSSI/NNR and Cors Geirch SSSI/NNR from 1985 to 2019 and 1996 to 2019 respectively. With the apparent loss of *V. geyeri* from Cors Erddreiniog and Cors Geirch, the possibility of a transfer of some 'excess' Waun Eurad snails to restored *V. geyeri* habitat on Cors Erddreiniog is suggested.

A total of 14 other species of molluscs was recorded in 2021, all of which had been recorded on previous surveys. Six species recorded in 2003 and 2007 were not recorded in 2021 including *Aegopinella pura, Ashfordia granulata, Columella aspera, Lauria cylindracea, Leiostyla anglica* and *Trochulus striolatus.*

Introduction

Geyer's Whorl Snail *Vertigo geyeri* Lindholm, 1925 is a rare, boreal species that was widespread in Britain in the pre-wooded Late-glacial and early Post-glacial periods (Kerney, 1999). It is only known from one small site in lowland southern Britain (Holyoak *et al*., 2006; Willing, 2011) and exhibits a relict distribution pattern elsewhere in upland regions of the British mainland where it is present at nine known centres of distribution (Kerney, 1999, Conchological Society database). The conservation importance of the species has resulted in its inclusion in various schedules and Red Data lists. Categorised as Endangered (category 1) in the GB Invertebrate Red Data Book (Bratton, 1991), it has recently been classed as Near Threatened/Nationally Scarce in the IUCN-based GB Non-Marine Mollusc Status Review (Seddon *et al*., 2014). The species is listed in Annex IIa of the European Community Habitats and Species Directive (92/43/EEC) and is also a Welsh Section 7 'Species of Principal Importance'. In Britain, *V. geyeri* lives in open, unshaded, permanently wet calcareous flushes and fens. Sites are dominated by small sedges, rushes and mosses. Examples of typical associate plants include Quaking-grass *Briza media*, Long-stalked Yellow Sedge *Carex lepidocarpa*, Marsh Horsetail *Equisetum palustre*, Jointed Rush *Juncus articulatus*, Common Butterwort *Pinguicula vulgaris* and the mosses *Drepanocladus revolvens* and *Campylium stellatum*, with scattered tussocks of Black Bog-rush *Schoenus nigricans*. The snail requires surface water levels to be mostly close to the ground surface for most of the year (Cameron, 2003; Cameron *et al*., 2003; Kuczyńska & Moorkens, 2010).

V. geyeri is known from just three localities in Wales (Figure 1; Table 1). It was first reported here in 1985 with a find on Cors Erddreiniog NNR on Anglesey when the author of this report recorded a fossil shell of uncertain age in postglacial (possibly recent) tufa, whilst live specimens were found there in 1988 (Boyce *et al*., 1992; Holmes *et al*., 1995). *V. geyeri* was later found on a second Anglesey site, Waun Eurad SSSI, by Adrian Fowles in 1996 (record from NRW Welsh Invertebrate Database). A third Welsh population was found on Cors Geirch SSSI (part of Corsydd Llŷn/Lleyn Fens SAC) by Adrian Fowles in 1996 "from tussocks in wet valley fen with *Schoenus* but no tufa" (Adrian Fowles, pers. comm.). *V. geyeri* is a Qualifying feature of Cors Erddreiniog SSSI, Cors Geirch SSSI and Waun Eurad SSSI, and a feature of Corsydd Môn/Anglesey Fens SAC and Corsydd Eifionydd/Eifionydd Fens SAC.

A further detailed summary of all previous *V. geyeri* work undertaken on Waun Eurad is given in Appendix 2 and full chronologies of all work undertaken on the snail on Cors Erddreiniog and Cors Geirch is given in Appendix 3.

In 2020, it was concluded that *V. geyeri* had become extinct on Cors Erddreiniog and Cors Geirch (Willing, 2020). The current survey in 2021 was therefore commissioned by Natural Resources Wales to determine the presence and approximate distribution of the snail at its last known Welsh site following a recording hiatus on Waun Eurad since 2014 (Lloyd, 2014). An understanding of this data might provide information to allow consideration of a reintroduction program to recently restored *V. geyeri* habitat on Cors Erddreiniog, a site lying close to Waun Eurad.

Figure 1. Welsh sites where Vertigo geyeri has been recorded

Table 1. Welsh records of *Vertigo geyeri*

Site	Grid reference	Date	Abundance
Cors Erddreiniog	SH475815	July 1985	1 shell
Cors Erddreiniog	SH476818	02/07/1994	1 shell
Cors Erddreiniog	SH47158325	December 1997	None
Cors Erddreiniog	SH471832	15/12/1997	1 shell
Cors Erddreiniog	SH4714383298	23/09/2007	175 shells
Cors Erddreiniog, Cors Nant Isaf	SH4782	29/09/1997	1 shell
Cors Erddreiniog, Cors Nant Isaf	SH47458310	December 1997	None
Cors Erddreiniog, Cors Nant Isaf	SH4740082691	Autumn 2003	1 shell
Cors Erddreiniog, Cors Nant Isaf	SH4742182839	Autumn 2003	1 shell
Cors Erddreiniog, Cors Nant Isaf	SH4742782559	Autumn 2003	1 shell
Cors Erddreiniog, Cors Nant Isaf	SH4745382896	Autumn 2003	1 shell
Cors Erddreiniog, Cors Nant Isaf	SH47478325	Autumn 2003	1 shell

Site	Grid reference	Date	Abundance
Cors Erddreiniog, Cors Nant Isaf	SH474830	20 - 22/10/2007	6 shells
Cors Erddreiniog, Cors Nant Isaf	SH4757083173	20 - 22/10/2007	1 shell
Cors Erddreiniog, Nant Isaf	SH479823	06/10/1988	1 shell
Cors Erddreiniog, Nant Isaf	SH477823	24/06/1994	11 shells
Cors Erddreiniog, Nant Isaf	SH477823	02/07/1994	3 shells
Cors Erddreiniog, Nant Isaf	SH478823	02/07/1994	1 shell
Cors Erddreiniog, Nant Isaf	SH478823	27/06/1996	2 shells
Cors Erddreiniog, Nant Isaf	SH477823	13 - 14/08/1997	None
Cors Erddreiniog, Nant Isaf	SH478824	Autumn 2003	1 shell
Cors Erddreiniog, Nant Isaf	SH4778982302	20/10/2007	3 shells
Cors Geirch	SH3235	20/09/1996	2 shells
Cors Geirch	SH328353	16/09/1998	3 shells
Cors Geirch	SH329351	16/09/1998	1 shell
Cors Geirch	SH32753518	26/07/2005	2 shells
Cors Geirch	SH3275935181	26/07/2005	None
Cors Geirch	SH33083507	18/09/2008	4 shells
Waun Eurad	SH506804	27/08/1996	32 shells
Waun Eurad	SH506805	27/08/1996	25 shells
Waun Eurad	SH506805	27/08/1996	10 shells
Waun Eurad	SH506804	09/09/1996	several shells
Waun Eurad	SH506804	23/11/1996	6 shells
Waun Eurad	SH506805	24/04/1997	None
Waun Eurad	SH506805	29/09/1997	3 shells
Waun Eurad	SH506805	07/04/1998 – 11/10/1999	c180 shells on 02/09/1999
Waun Eurad	SH506805	07/08/1998	1 shell
Waun Eurad	SH506805	Autumn 2003	92 shells
Waun Eurad	SH5061880465	22 - 23/09/2007	12 shells
Waun Eurad	SH506805	09/09/2014	8 shells
Waun Eurad	SH506805	08-09/11/2021	66 shells

Methods

Surveys for *V. geyeri* were undertaken on Waun Eurad over one and a half days on 8th and 9th November 2021. Most of the work was undertaken on the second day in strong winds and heavy rain. Due to the saturated ground conditions, it was not possible to undertake field searches for this tiny snail by direct observation of ground vegetation or by shaking plucked vegetation over a tray. Survey sampling therefore relied upon the well-established technique of selecting potentially suitable habitat and then removing sample material for later laboratory processing.

A wide selection of sample points was selected to approximately cover areas previously sampled along monitoring Transects 'A' and 'B' as used in previous surveys of Waun Eurad in 2003, 2007 and 2014 (Killeen & Moorkens, 2004, 2008; Lloyd, 2014). All survey points were positioned in habitat associated with the nearby presence of *S. nigricans* and broadly conforming to habitat definitions of '**Optimal**' and '**Sub-optimal**' habitat as defined by Killeen & Moorkens (2004, 2007; see Appendix 2).

To make the surveillance results directly comparable with those earlier surveys, techniques involved the refinement of those methods used previously (e.g. Willing, 2017, 2018, 2020) and also described by Killeen & Moorkens (2004, 2008).
At each sampling point:

1. Vegetation (e.g. mosses, sedges and bryophytes and surface vegetation litter) was cut down to about 10cm (if initially higher) and then cut just below ground level over a series of small areas (approx. 15cm x 15cm max) using a serrated kitchen knife. Collected material was then amalgamated into one bag (typically resulting in about 2 - 3 litres of sample material). To avoid significant damage at any one point and to sample from several points at a sample point, material was collected from a total area measuring 0.5m x 0.5m (0.25m^2) and combined from a series of points over about a 2m x 2m.

2. The collected material was retained in polythene bags until returned to the laboratory where samples were placed in fine muslin bags and then air-dried to constant mass. Dried material was then shaken through series of sieves with 5mm, 2mm and 0.5mm meshes (with most *Vertigo* spp. accumulating in the 0.5mm fraction).

3. Counts of adult and juvenile *Vertigo* spp. were made using a x7 to x50 binocular microscope.

4. Other molluscan species were recorded.

5. The following information was also gathered:
    a. Ground moisture levels
    b. The GPS location (at 10 figure level)
    c. A simple site description in terms of major vegetational type
    d. Digital photographs were taken to display key site features.

Surveys were undertaken together with the NRW Invertebrate Ecologist, Dr. Mike Howe.

Results

V. geyeri was found at 8 of the 17 survey locations on Waun Eurad in November 2021. Results are provided in Table 2 and Appendix 1 and site locations in Figure 2.

All locations in the north-eastern section of the site and lying either side of ‘Transect B’ of Killeen & Moorkens (2004, 2008) produced ‘good’ numbers of *V. geyeri* with a total of 66 snails. The cluster of locations situated to the southwest of the site and broadly aggregated around the position of ‘Transect A’ only produced two snails at a single location (Location 3) lying close to where it was last recorded in 2007 (Killeen & Moorkens, 2008) but not recorded at this point in 2014 (Lloyd, 2014).

A total of 14 other species of molluscs were recorded (Appendix 1). Six species recorded in 2003 and 2007 (Killeen & Moorkens, 2004, 2008) were not recorded in 2021 including *Aegopinella pura, Ashfordia granulata, Columella aspera, Lauria cylindracea, Leiostyla anglica and Trochulus striolatus.*

Table 2. Number of *Vertigo geyeri* recorded on Waun Eurad in November 2021

Location no.	Grid reference	No. snails
1	SH5060780506	0
2	SH5061880482	0
3	SH5063080473	2
4	SH5063280483	0
5	SH5063780488	0
6	SH5063580500	0
7	SH5062380500	0
8	SH5065080505	0
9	SH5071480532	15
10	SH5070980545	1
11	SH5069680545	2
12	SH5069080543	1
13	SH5068480551	1
14	SH5067580545	5
15a	SH5069780569	10
15b	SH5069780569	29
16	SH5067180517	0
17	SH5066080509	0
All locations	n/a	**Total: 66**

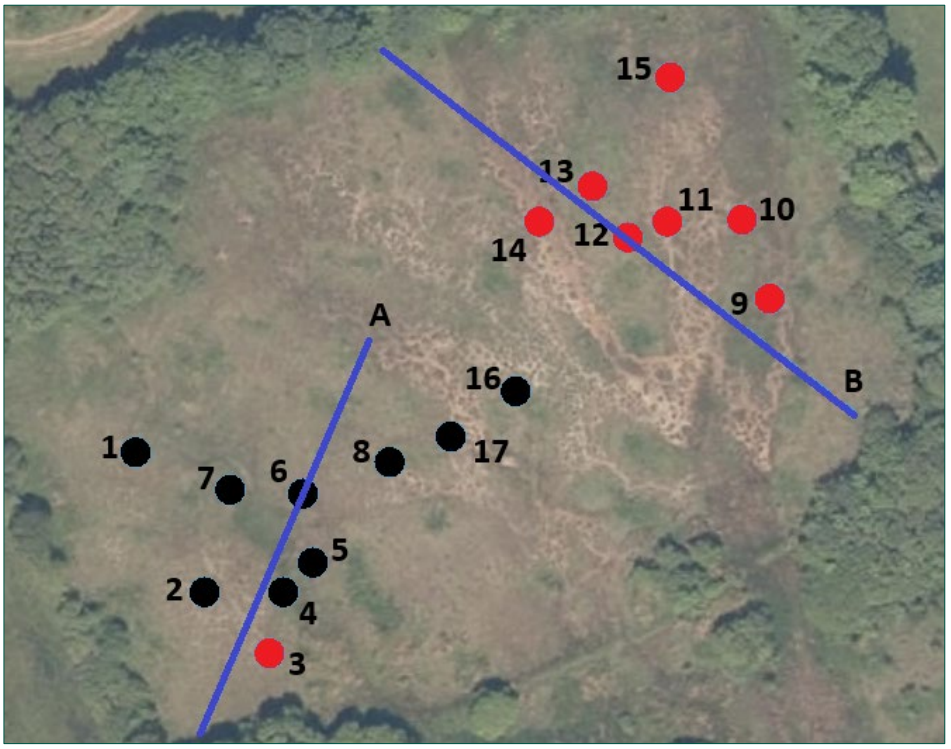

Figure 2. *Vertigo geyeri* survey results on Waun Eurad in November 2021. Locations are numbered 1 to 17. Red points = presence; Black points = absence. Transects A & B (from Killeen & Moorkens, 2004) are approximately 64m & 105m in length respectively.

1. Discussion & recommendations

The survey of Waun Eurad in November 2021 demonstrates the continued strong presence of *V. geyeri* within the SSSI. The distribution confirms that the snail is present in 'good numbers' in the north-east sector of the site (Figure 2), a situation first shown in the 2003 survey (Killeen & Moorkens, 2004; Figures 4 & 5) and again in 2007 and 2014 (Killeen & Moorkens, 2008; Lloyd 2014; Figures 6 & 7). This area has the predominance of calcareous springs and flushes with short *Carex* spp. and moss-dominated lawns lying between a network of shallow channels. Also, as in 2007 and 2014 (Killeen & Moorkens, 2008; Lloyd, 2014), the south-west corner of the site is largely devoid of the snail. In 2021, only 2 specimens were recorded from Location 3 lying at the southern end of the survey sites and very close to where a single specimen was recorded at the lower end of 'Transect A' in 2007. The south-west area is generally drier and does not display the network of shallow drainage channels present in the north-east. Although all the survey locations* in this area (In 2021*, 1 to 8, 16 & 17) support *S. nigricans* and can be judged at least **Sub-optimal** for *V. geyeri* (using habitat descriptors in the Killeen & Moorkens [2004, 2007]), the snail has been largely unrecorded here since at least 2007.

Sharland (2000) recommended that *V. geyeri* surveys on Waun Eurad are undertaken in September as she demonstrated (during the two-year survey period) that numbers of the snail were then at their highest. The 2021 survey was undertaken later in the year in November but still produced large numbers of the snail - 66 specimens recovered from 17

samples. By contrast, the previous peak (after the 2-year Sharland studies) were in August 2003 (Killeen & Moorkens, 2004) when 92 specimens were recovered from 30 sample sites. Based upon this information, on a rather subjective basis, in November 2021 the *V. geyeri* population on Waun Eurad is considered to be in **Favourable Condition**. The reason/s for the decline in *V. geyeri* in the south-western sector first detected in 2007 and the apparent failure of snail populations to recover there are unclear.

The 2021 survey locations were rather unevenly distributed leaving survey gaps in the north-west and south-east sectors of the site, the latter containing the location of the 'Sharland monitoring plot' (Sharland, 2000). To gain a more comprehensive understanding of *V. geyeri* distribution over the whole site, it is suggested that a more systematic survey is undertaken to assess the entire area using a random grid pattern. The 2021 survey, although finding good numbers of *V. geyeri*, is likely to have underestimated the population of the snail due to these survey gaps.

The definitions of **Optimal** and **Sub-optimal** *V. geyeri* habitat as defined in Killeen & Moorkens (2004, 2008) may seem somewhat prescriptive and inflexible. Thus '**Optimal** habitat' has '*flushed fen grassland with sedge/moss lawns 5 – 15cm'* and it is stated that *'during sampling the water table is less than 0 – 5cm of the soil surface'.* In terms of the vegetation height, it surely depends upon the time of year that the survey is undertaken in that later in the year vegetation even in '**Optimal** habitat' is likely to exceed this figure. Similarly, during episodes of management grazing the vegetation height in **Sub-optimal** habitat where the grassland height was > 15cm may relatively rapidly be reduced to height conforming with an **Optimal** level. Also, the water table will vary, sometimes quite rapidly, depending upon weather conditions. Thus, the 2021 survey period corresponded with a period of high precipitation where most of the area to the north-east of the site was saturated with water which in many places resulted in water depths of at least 2 to 3cm. This was the area supporting *V. geyeri* at every location and so might be assessed as **Optimal** for the snail. Judged on the water table criteria, however, this area would, at least temporarily, be assessed as **Sub-optimal**.

2. Acknowledgements

Natural Resources Wales is thanked for funding this project, which was managed by Dr. Mike Howe. Mike is also thanked for his help during all the field survey and for making valued comments that have improved the final report draft and then for editing this into NRW reporting format.

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Appendix 1. Molluscs recorded on Waun Eurad by location in November 2021.

Terrestrial species: locations 1 to 9

Location no.	1	2	3	4	5	6	7	8	9
Vertigo geyeri (live / fresh dead)	-	-	1	-	-	-	-	-	8
V. geyeri (juvenile live)	-	-	1	-	-	-	-	-	7
V. geyeri (dead shell)	-	-	-	-	-	-	-	-	6
V. geyeri total: live / fresh dead	-	-	2	-	-	-	-	-	15
Carychium minimum	-	1	-	-	1	-	-	-	3
Oxyloma elegans	5	13	9	8	6	2	5	6	8
Cochlicopa lubrica	-	1	8	2	6	1	-	-	24
Vertigo antivertigo	-	-	-	-	-	-	-	-	9
Vertigo pygmaea	8	18	11	3	2	1	-	3	7
Vertigo spp.	-	-	-	-	-	-	-	-	4
Punctum pygmaeum	-	-	-	-	-	-	-	-	-
Nesovitrea hammonis	3	3	10	5	3	2	4	-	7
Zonitoides nitidus	-	-	-	1	4	-	1	-	2
Vallonia pulchella	-	-	-	-	-	-	-	-	-
Vitrea sp.	-	1	-	-	-	-	-	-	
Euconulus alderi	2	4	6	-	2	-	-	-	20
Cepaea nemoralis	-	-	1	1	-	1	-	-	-

Aquatic species: locations 1 to 9

Location no.	1	2	3	4	5	6	7	8	9
Galba truncatula	-	7	3	-	8	2	2	2	1
Euglesa personata	-	2	-	-	-	-	-	-	2

Terrestrial species: locations 10 to 17

Location no.	10	11	12	13	14	15a	15b	16	17
Vertigo geyeri (live / fresh dead)	1	2	1	1	1	10	21	-	-
V. geyeri (juvenile live)	-	-	-	-	4	-	8	-	-

Location no.	10	11	12	13	14	15a	15b	16	17
V. geyeri (dead shell)	-	-	-	-	-	-	7	-	-
V. geyeri total: live / fresh dead	1	2	1	1	5	10	29	-	-
Carychium minimum	-	-	-	-	-	-	-	-	-
Oxyloma elegans	10	5	4	13	6	11	16	1	3
Cochlicopa lubrica	-	4	-	-	-	5	9	3	2
Vertigo antivertigo	-	7	2	8	3	25	8	-	-
Vertigo pygmaea	1	-	20	5	-	1	7	7	3
Vertigo spp.	-	-	-	-	1	1	2	-	-
Punctum pygmaeum	-	-	-	-	4	-	-	-	-
Nesovitrea hammonis	-	1	1	4	8	3	-	6	-
Zonitoides nitidus	3	-	-	-	-	1	-	-	-
Vallonia pulchella	-	1	-	-	-	6	15	1	5
Vitrea sp.	-	-	--	-	-	-	-	-	-
Euconulus alderi	4	3	-	4	4	4	6	-	-
Cepaea nemoralis	-	-	-	-	-	-	1	-	-

Aquatic species: locations 10 to 17

Location no.	10	11	12	13	14	15a	15b	16	17
Galba truncatula	8	2	1	5	1	16	8	-	2
Euglesa personata	3	-	-	-	-	-	-	-	-

Appendix 2. Previous surveys of *Vertigo geyeri* on Waun Eurad

Discovery

Vertigo geyeri was first discovered on Waun Eurad SSSI by Adrian Fowles (then with the Countryside Council for Wales) in 1996 (see Table 1). He did not undertake an extensive survey of the site but noted that the presence of the snail was associated with areas where *Schoenus nigricans* was present.

Eva Sharland (1998-1999)

The first detailed study of *V. geyeri* on Waun Eurad was undertaken by Eva Sharland between April 1998 and October 1999 as part of PhD studies at Sheffield University (Sharland, 2000). As this research forms the foundation for all later studies of the snail on

Waun Eurad, a detailed summary and consideration of the methods, results and conclusions is included here.

At the outset of this work, Sharland established a transect grid on a large part of the north of the site. This consisted of 8 transect lines (set 10m apart) and was used to provide 42 evenly spaced sample points where 25 x 25cm quadrats were used to remove vegetation/litter samples that were used to obtain a general picture of *V. geyeri* presence (Figure 3). Based upon these results, a permanent monitoring plot was selected (lying close towards the south-east of the scoping grid) to form the basis for regular quadrat monitoring throughout the 19-month study period. The plot consisted of a rectangular block 20m x 15m divided into 300 $1m^2$ to allow for detailed vegetation and random *V. geyeri* quadrat sampling. In addition to the detailed regular surveys in the monitoring plot, Waun Eurad was also investigated on a more general level by two additional wider ranging surveys. The first of these is described by Sharland as 'non-random vegetative bracketing', a process whereby other parts of the area outside the study plot were sampled. Fifteen locations were located where standard quadrats were used to assess the *V. geyeri* presence and numbers and the vegetation described by the use six general vegetation communities (Table 3).

Table 3. Vegetation communities used by Sharland (2000) on Waun Eurad.

Vegetation types (T)	Vegetation community
T1	*Schoenus nigricans* tussock
T2	Non-tussocky *S. nigricans*
T3	*Menyanthes trifolium*
T4	*Juncus subnodulosus*
T5	*Iris pseudacorus* & *Filipendula ulmaria*
T6	*Pulicaria dysenterica* and *Carex* spp.

The second wider survey is described by Sharland (2000) as 'non-quantitative sample' and was designed to sample all vegetation types across the site (beyond those areas supporting various *Schoenus nigricans* associations). Eighteen samples were taken from 16 loosely described vegetation types (Table 11, pp.72-73 in Sharland [2000]).

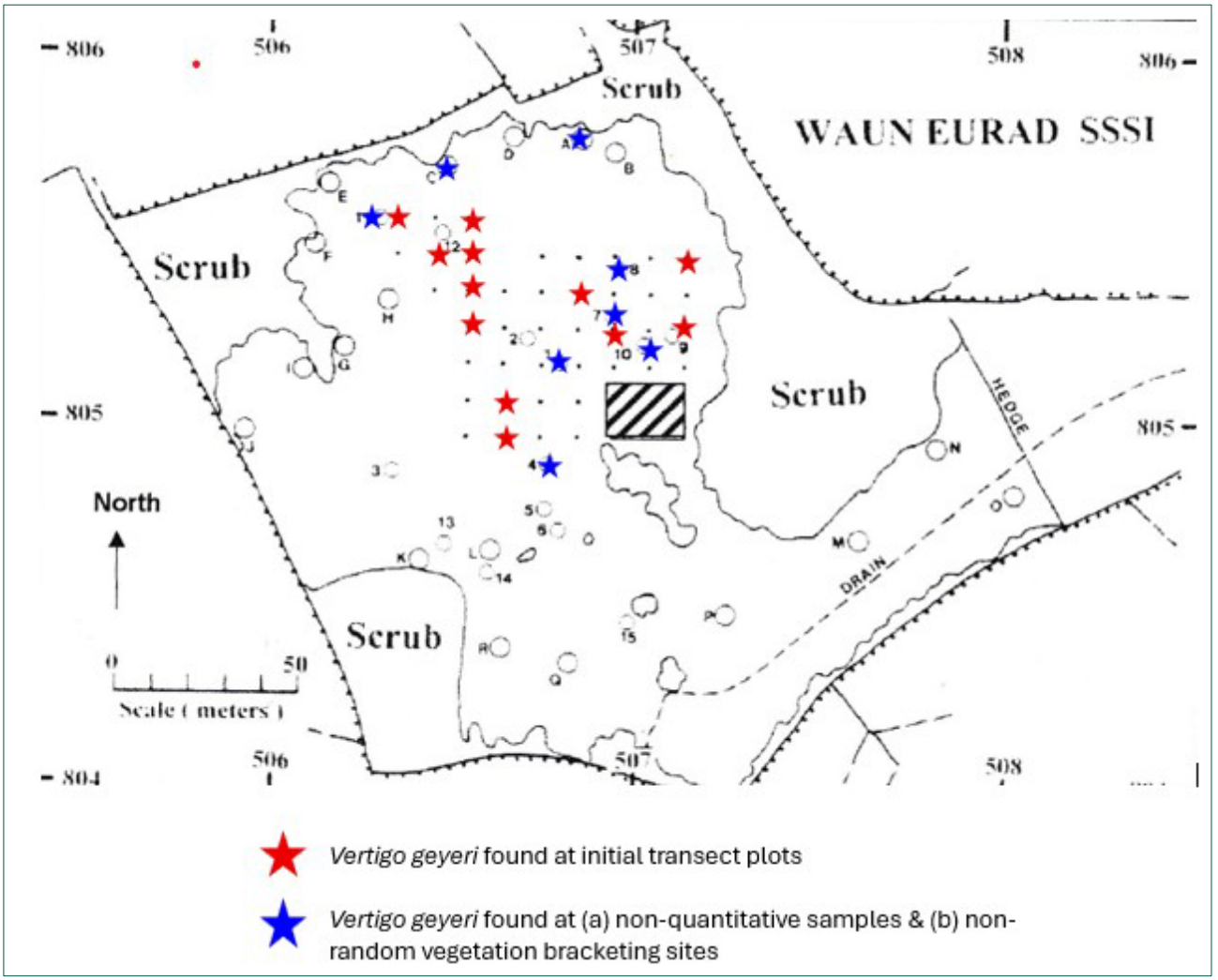

Figure 3. The location of the monitoring plot (hatched rectangle) on Waun Eurad and records of *Vertigo geyeri*. This map has been constructed using the base map and report data taken from Sharland (2000).

A summary of Sharland results

(A) The initial transect grid consisted of 42 survey points: Figure 47, p.76 in Sharland (2000) displays 36 of these, the remaining 6 lying within the monitoring plot. Of these 36 points, *V. geyeri* is shown as present at 12 (although the actual number of snails found at each is not given) and shown in Figure 3. Additionally, there would have been further records of the snail from those points (not shown on the map) lying within the monitoring plot. No vegetation data is supplied for these initial survey sites.

(B) The 'Non-random Vegetative Bracketing' surveyed 15 locations. A total of 49 *V. geyeri* was found at 6 of these which in each case were from the two *S. nigricans* vegetation communities T1 and T2 (see Figure 3 & Table 3).

(C) The 18 'Non-quantitative Sample' recorded single *V. geyeri* specimens from just two locations both lying on the northern Waun Eurad margins and neither supporting vegetation communities with *S. nigricans* present. (Samples A and C in Table 11, p.72 in Sharland [2000]; also shown on Figure 3).

(D) The study monitoring plot was divided into 300 m^2 plots of which 128 were surveyed (Figure 37, p.62: in Sharland [2000]). *V. geyeri* was recorded in 99 quadrats and numbers of the snail within the 25 cm x 25 cm quadrats were recorded in abundance classes (Table 4).

Table 4. Counts of *Vertigo geyeri* at 128 plots by abundance class on Waun Eurad. From: Sharland (2000).

V. geyeri abundance classes (mean nos.) per 25 cm x 25 cm quadrat (0.63 m^2)	Number of quadrats supporting this number of snails within the Sharland monitoring plant
0	29
1 – 2	32
3 – 7	35
8 – 16	22
17 – 32	7
33 – 64	2
>65	1
Total	**128**

Within the monitoring plot, Sharland commissioned a botanical mapping exercise to plot vegetation communities to a higher definition than would be given by an NVC classification alone. Four communities were identified with the one where *S. nigricans* is present being further split into 5 sub-types. To appreciate the range of plant associations present within the monitoring plot and therefore understand the subsequent discussion relating to *V. geyeri* distribution there, it is useful to include details of the four vegetation communities, and these are given in Table 5 (modified from Sharland [2000]).

Table 5. Vegetation communities on Waun Eurad. From: Sharland (2000)

Vegetation classification types	Vegetation communities
T1	*Molinia* and short sedges. (NVC equivalent: *Molinia caerulea*, *Cirsium dissectum* fen meadow [sub-community M24b])

Vegetation classification types	Vegetation communities
T2	*Schoenus nigricans* flushes (NVC: *S. nigricans, Juncus subnodulosus* mire [*Brizia media, Pinguicula vulgaris* sub-community M13b]). This sub-divided into sub-types: **T2A**: *S. nigricans* tussocks **T2B**: Bryophyte rich short sedge lawns; **T2C**: Bryophyte rich short sedge lawns **T2D**: *Molinia* & *S. nigricans* **T2E:** *Juncus subnodulosus* & *S. nigricans*
T3	*Juncus subnodulosus* rush pasture (NVC: equivalent *Juncus subnodulosus, Cirsium palustre* fen meadow sub-community M22a)
T4	*Leocharis uniglumis, Eriphorum angustifolium* (no NVC equivalent)

Within the monitoring plot, *V. geyeri* was recorded from vegetation types T1, T2A, T2B, T2C, T3 and T4 (as displayed in Sharland [2000], Figure 38 histogram, p.67) Of these, *V. geyeri* numbers were highest in the three *S. nigricans* sub-types (T2A, T2B & T2C) with the peak numbers in T2C, the 'bryophyte poor short sedge lawns'. It is interesting to note the presence, albeit in low numbers, of *V. geyeri* in all non-*S. nigricans* vegetation types, but seemingly not in two of the *S.nigricans* sub-types T2D and T2E. In discussing this situation, Sharland states that "within the permanent plot area *V. geyeri* is restricted to that part of the fen in which *Schoenus nigricans* occurs, but within that area it is not confined to quadrats with *Schoenus* present". She also states that "outside the permanent plot, the species was, however, restricted to quadrats with *S. nigricans* or *Juncus subnodulosus* stands". This is, however, not entirely the case as Sharland noted, as described above, the presence of single *V. geyeri* specimens in two 'Non-quantitative samples' taken at the extreme north of the site in areas where no *S. nigricans* was recorded (as shown in Figure 3).

Sharland concludes that, for a number of reasons, Waun Eurad is 'less than an optimum environment for *V. geyeri*'. Firstly she notes the relatively low densities of the snail found during her studies (compared to numbers of the snail found at other sites such as in Ireland) and the erratic Waun Eurad hydrology. Here Sharland (2000) writes (p.83) "*Waun Eurad does not seem to be ideal for V. geyeri as the water level fluctuates seasonally, with some areas of the site under water for months at a time and then in subsequent months the same areas maybe dry with no standing water at all. …….. V. geyeri appears on this basis to have a fairly tenuous hold on its existence at Waun Eurad*". In one of her key summaries, Sharland summarises the conservation dilemma facing those trying to maintain *V. geyeri* sites - "*The environment in which V. geyeri exists is a fragile equilibrium which can be easily damaged by removal of grazing which allows undergrowth to grow rapidly and crowd out the existing vegetation community. Conversely, if the area is managed unsympathetically by too much grazing or by harsh mechanical clearance processes then this also has a detrimental effect on the habitat*".

Killeen & Moorkens 2003 survey

In August 2003, a monitoring assessment of *V. geyeri* on Waun Eurad was undertaken (Killeen & Moorkens, 2004). This assessed the site in three ways:

1. a resurvey of the Sharland monitoring plot;

2. a general survey of most of the Waun Eurad site;

3. the establishment and survey of two transects designed to act as benchmarks for future monitoring work.

(1) The **Sharland plot survey** sampled 5 different vegetation types within this relatively small area (15m x 20m plot) and *V. geyeri* was found to be present in all. The area supported a mosaic of vegetation communities, all within an area where *S. nigricans* was present. It was concluded that the basic vegetation 'pattern' observed in the plot had not changed by more than 10% since it was last surveyed, four years previously in 1999.

(2) The **general wider survey** of the site initially involved identifying three broad vegetation / habitat 'classes' based upon their perceived suitability for *V. geyeri* which were described thus:

- **Optimal Habitat**: Flushed fen grassland with sedge/moss lawns 5-15cm tall, containing species such as *Carex viridula* subsp. *brachyrrhyncha, Pinguicula vulgaris, Briza media, Equisetum palustre, Juncus articulatus* and the mosses *Drepanocladus revolvens* and *Campylium stellatum*, with scattered tussocks of *Schoenus nigricans* no greater than 80cm tall. Water table between 0- 5cm of the soil surface, but not above ground level.
- **Sub-optimal Habitat**: Vegetation composition as above but either vegetation height is less than 5cm or greater than 15cm, or the water table is below 5cm or ground is flooded at the time of sampling.
- **Unsuitable Habitat**: Any other habitat.

The site was divided into 22 unequally sized cells (or segments) of which 7 were judged to contain '**Optimal**', 8 '**Sub-optimal**' and 7 '**Unsuitable**' habitat (Figure 4). The presence of *V. geyeri* within each of these cells was chiefly determined in the field by closely examining moss and sedge material and by shaking the material over a white plastic tray to release any adhering snails. At certain sites, bulk samples of vegetation were collected for later processing off-site (by drying and sieving the material) and results are shown in Table 6.

V. geyeri was found at all the **Optimal** sites although only in field samples from cells P and Q (not bulk samples). This suggests that, even in seemingly ideal conditions, there is localised variability in the snail's distribution. The snail was found in 6 of the 8 **Sub-optimal** sites, but at one site (I) it was found in the bulk sample but conversely at Site K it was found in the field but not in the bulk. *V. geyeri* was not recorded from any of the sites deemed **Unsuitable**.

The survey established two transects (64m & 105m lengths) to obtain a range of habitats across the site (Figures 4 & 5). As with the whole site survey, *V. geyeri* presence was determined by field sampling, but chiefly to obtain quantitative data, by the removal and off-site processing of bulk samples; 5 were taken from each zone except for one longer zone where 3 sets of 5 samples were taken. The distribution of three classes of vegetation suitability along each transect (**Optimal**, **Sub-optimal** and **Unsuitable**) is displayed in the report (Killeen & Moorkens, 2004) as different coloured bands on linear bands.

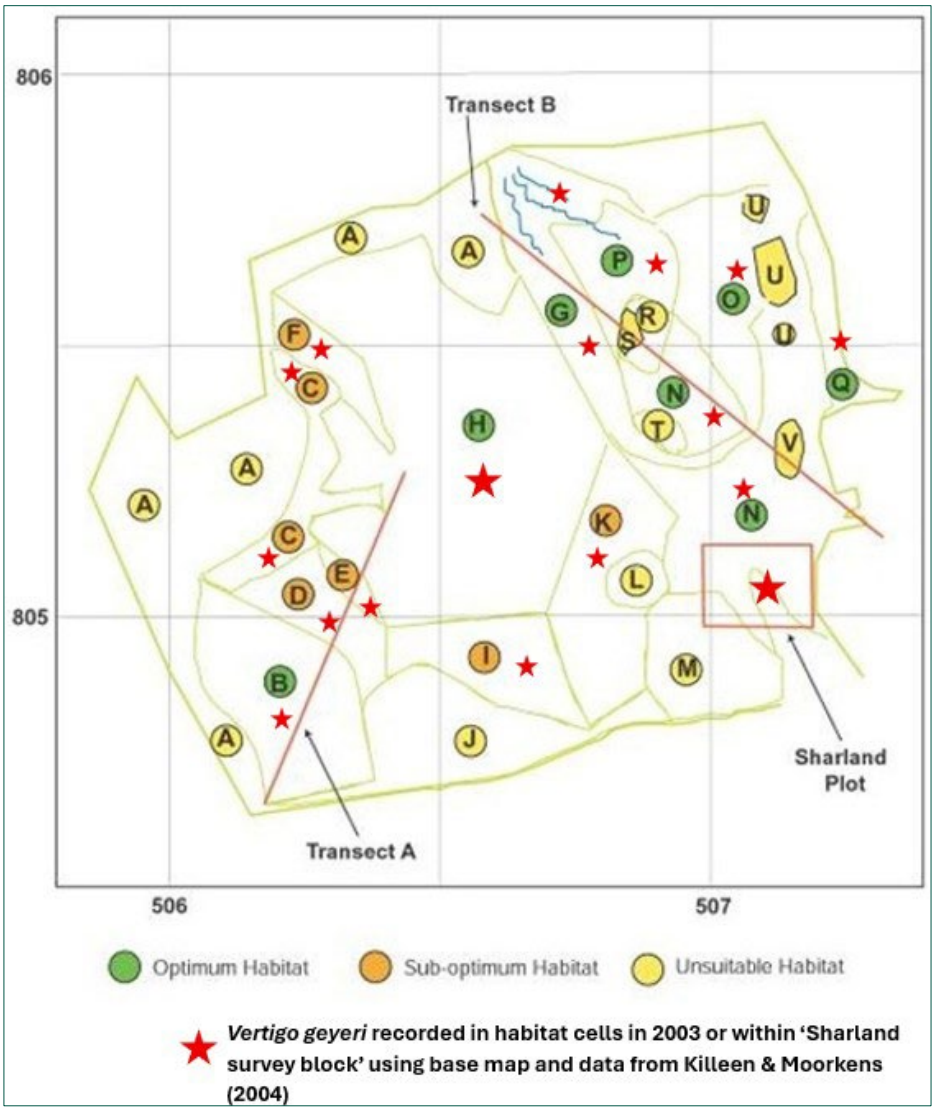

Figure 4. Map showing the presence of *Vertigo geyeri* in habitat blocks on Waun Eurad in August 2003. Constructed using base map and report data from Killeen & Moorkens (2004).

Table 6. A summary of general results of the 2003 survey of *Vertigo geyeri* on Waun Eurad (additional to Transects A & B). From: Killeen & Moorkens (2004).

Habitat cells	*V. geyeri* present in cell: present from field sampling = ✓ present in bulk sample = ✓* ✖ = not recorded	Description of habitat suitability: O = optimal SO = sub-optimal U = unsuitable
A	✖	**U**
B	✓ ✓*	**O**
C	✓ ✓*	**SO**
D	✓ ✓*	**SO**
E	✓ ✓*	**SO**
F	✓ ✓*	**SO**
G	✓ ✓*	**O**
H	✓ ✓*	**O**
I	✓ ✓*	**SO**
J	✖	**U**
K	✓	**SO**
L	✖	**SO**
M	✖	**SO**
N	✓ ✓*	**O**
O	✓ ✓*	**O**
P	✓	**O**
Q	✓	**O**
R	✖	**U**
S	✖	**U**
T	✖	**U**
U	✖	**U**
V	✖	**U**

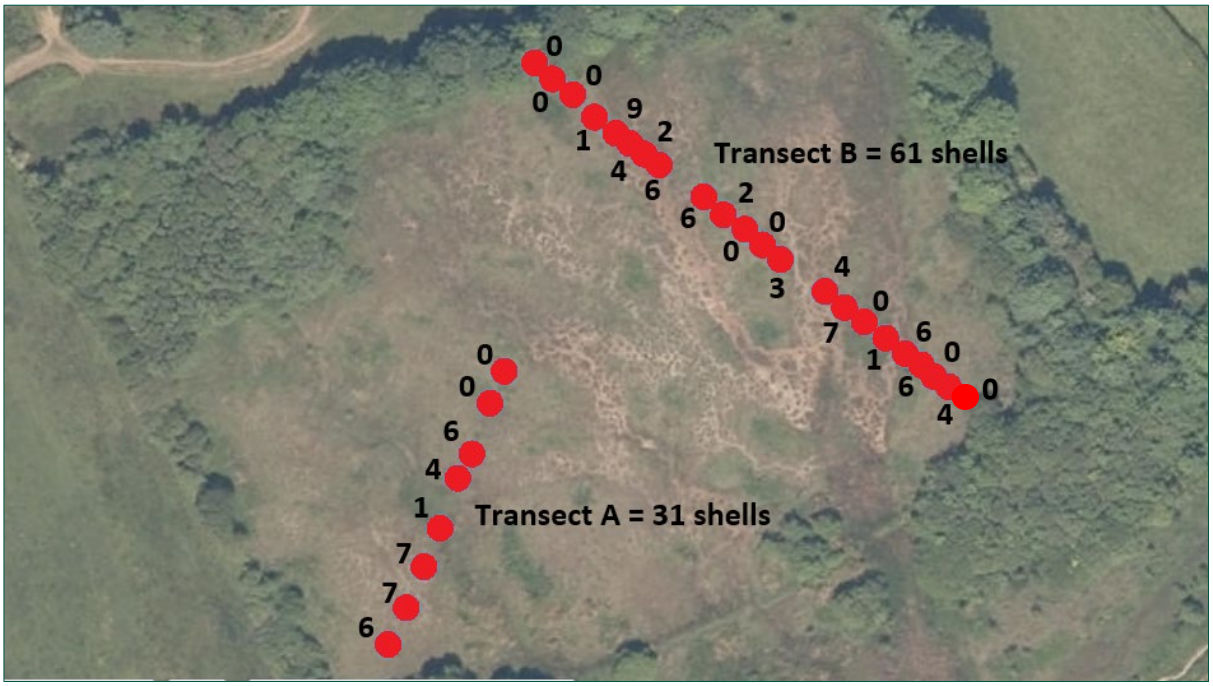

Figure 5. *Vertigo geyeri* transect results August 2003**.** Numbers at each point are *V. geyeri* counts.

The 2003 survey report provides summaries of the *V. geyeri* collected in the 3 different habitat types along the two transects (Tables 7 & 8).

Table 7. Numbers of *Vertigo geyeri* on Waun Eurad Transect A in 2003 in relation to habitat condition.

Habitat type	No. of samples	No. of samples with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	20	13	26
Sub-optimal	10	4	5
Unsuitable	10	0	0

Table 8. Numbers of *Vertigo geyeri* on Waun Eurad Transect B in 2003 in relation to habitat condition.

Habitat type	No. of samples	No. of samples with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	40	24	48
Sub-optimal	30	12	13
Unsuitable	80	0	0

The survey report included a detailed Conservation Objective (Monitoring Protocol) to allow monitoring judgements to be made as to whether the Waun Eurad *V. geyeri* population is in 'Favourable Condition'. This Objective contained criteria on (1) numbers of samples containing snails, (2) the proportion of habitat along the transects in **Optimal** and

/ or **Sub-optimal** condition and (3) the extent of ground saturation present along each of the two transects. Applying this Conservation Objective, the population of *V. geyeri* was judged to be in **Favourable Condition** on Waun Eurad in 2003.

Killeen & Moorkens 2007 Survey

The two monitoring transects established in 2003 were re-surveyed for *V. geyeri* presence, vegetational community presence and soil hydrology in September 2007 (Killeen & Moorkens, 2008). Sampling was only undertaken along the two monitoring transects and no wider examination of the site or re-examination of the 'Sharland' survey plot were undertaken.

The two transects were initially surveyed by adopting field assessment by shaking vegetation over a tray. On 'Transect A', 54 shake samples were taken at 9 different locations (including **Optimal**, **Sub-optimal** and **Unsuitable** habitat) but only 3 *V. geyeri* were found at two points (Table 9). On 'Transect B', 60 shake samples were taken at 12 different locations (**Optimal** and **Sub-optimal** only) and only produced 1 *V. geyeri* from a single sample (Table 10). Due to the low numbers of recovered by field sampling alone, it was concluded that this technique was unsuitable for use during the saturated field conditions present during the survey period. It was therefore decided to take bulk samples along the transects. On 'Transect A', samples were taken at 5 locations (**Optimal** and **Sub-optimal** only). Only a single *V. geyeri* was found at one location at the southern transect end (Figure 6; Table 11).

Table 9. Numbers of *Vertigo geyeri* recorded during in-field 'shake samples' on Waun Eurad Transect A in 2007 in relation to habitat condition.

Habitat type	No. of samples	No. of samples with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	3	2	3
Sub-optimal	4	0	0
Unsuitable	2	0	0

Table 10. Numbers of *Vertigo geyeri* recorded during in-field 'shake samples' on Waun Eurad Transect B in 2007 in relation to habitat condition.

Habitat type	No. of samples	No. of samples with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	6	1	1
Sub-optimal	6	0	0
Unsuitable	0	0	0

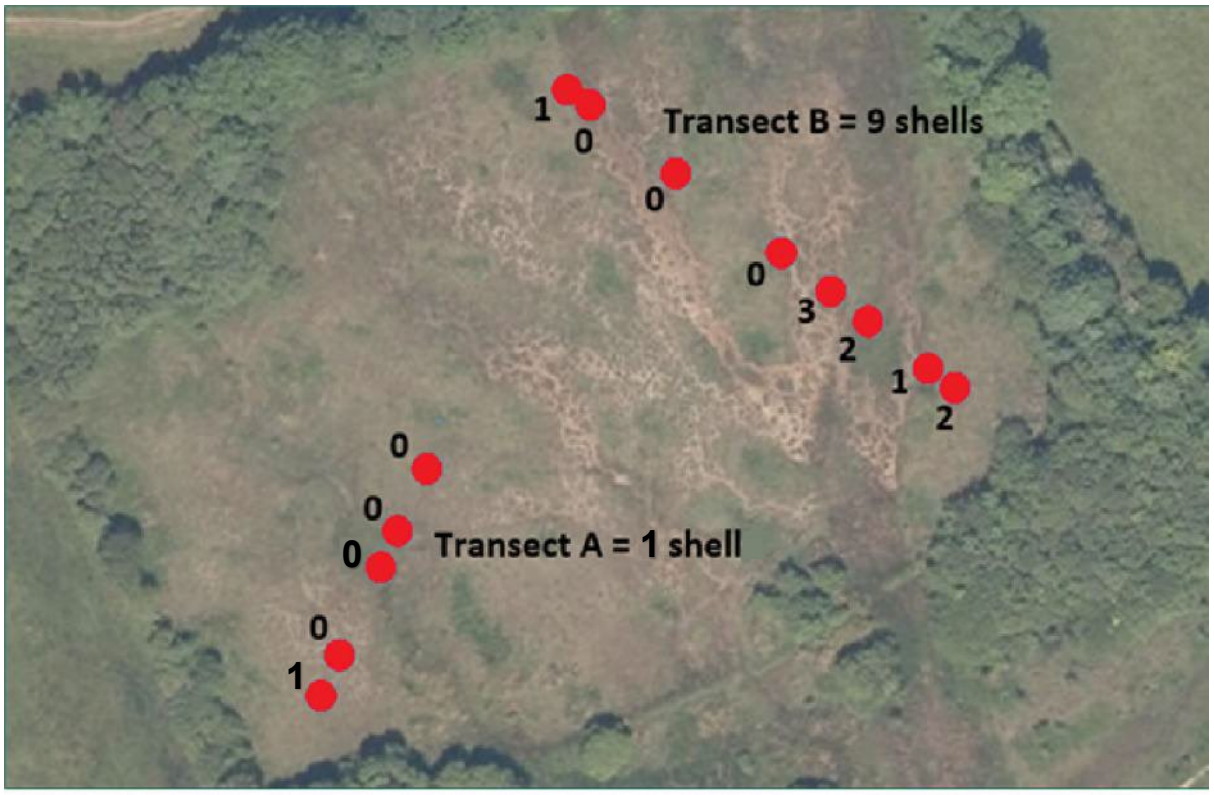

Figure 6. *Vertigo geyeri* transect results August 2007**.** Numbers at each point are *V. geyeri* counts.

Table 11. Numbers of *Vertigo geyeri* recorded from processed bulk samples on Waun Eurad Transect A in 2007 in relation to habitat condition.

Habitat type	No. of samples	No. of samples with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	2	1	1
Sub-optimal	3	0	0
Unsuitable	0	0	0

On 'Transect B', 8 samples (again **Optimal** and **Sub-optimal** only; Table 12) produced 9 snails compared to 61 *V. geyeri* found at 21 sample points in 2003. The reduced snail numbers in 2007 were believed to be due to the saturated field conditions and the snail population was therefore judged to be in an **Unfavourable Condition** in 2007. The extent and suitability of much of the habitat was considered good and the decline in snail numbers compared to 2003 was judged to be natural and due to, as yet, not fully understood population fluctuations. It was suggested that more regular monitoring of the site was required to fully understand population oscillations.

Table 12. Numbers of *Vertigo geyeri* recorded from processed bulk samples on Waun Eurad Transect B in 2007 in relation to habitat condition.

Habitat type	No. of samples	No. of samples with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	5	3	6
Sub-optimal	3	2	3
Unsuitable	0	0	0

Table 13. Habitat condition on Waun Eurad in 2003 and 2007.

Habitat type	Totals for both transects A & B: 2003	Totals for both transects A & B: 2007
*Optimal	80.75m	67.3m
*Sub-optimal	39.00m	55.8m
TOTAL suitable habitat (*optimal + *sub-optimal)	119.75m	123.1m
Unsuitable	45.25m	41.9m

Dylan Lloyd Survey 2014

Following a 7-year hiatus, the two Waun Eurad monitoring transects were resurveyed in September 2014 (Lloyd, 2014). As weather conditions were dry, *V. geyeri* sampling was undertaken solely by the field assessment of shaking plucked vegetation over a white tray. This entailed a 10-minute search in each section (and additional 10 minute slots in the larger sections). Searches were terminated as soon as the snail was detected so that habitat section was then recorded as supporting the snail. So, no quantitative data was recorded in 2014 just snail presence or absent in a particular vegetation band.

Table 14. Waun Eurad Transect A 2014 survey results.

Habitat type	No. of sections (samples)	No. of sections with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	1 continuous habitat section searched	0	0
Sub-optimal	1 continuous habitat section searched	0	0
Unsuitable	2 continuous habitat sections searched	0	0

Table 15. Waun Eurad Transect B 2014 survey results.

Habitat	No. of sections (samples)	No. of sections with *V. geyeri*	Total numbers of *V. geyeri*
Optimal	4 continuous habitat sections searched	4	8 total
Sub-optimal	No Sub-optimal	-	-
Unsuitable	5 continuous habitat sections searched	0	0

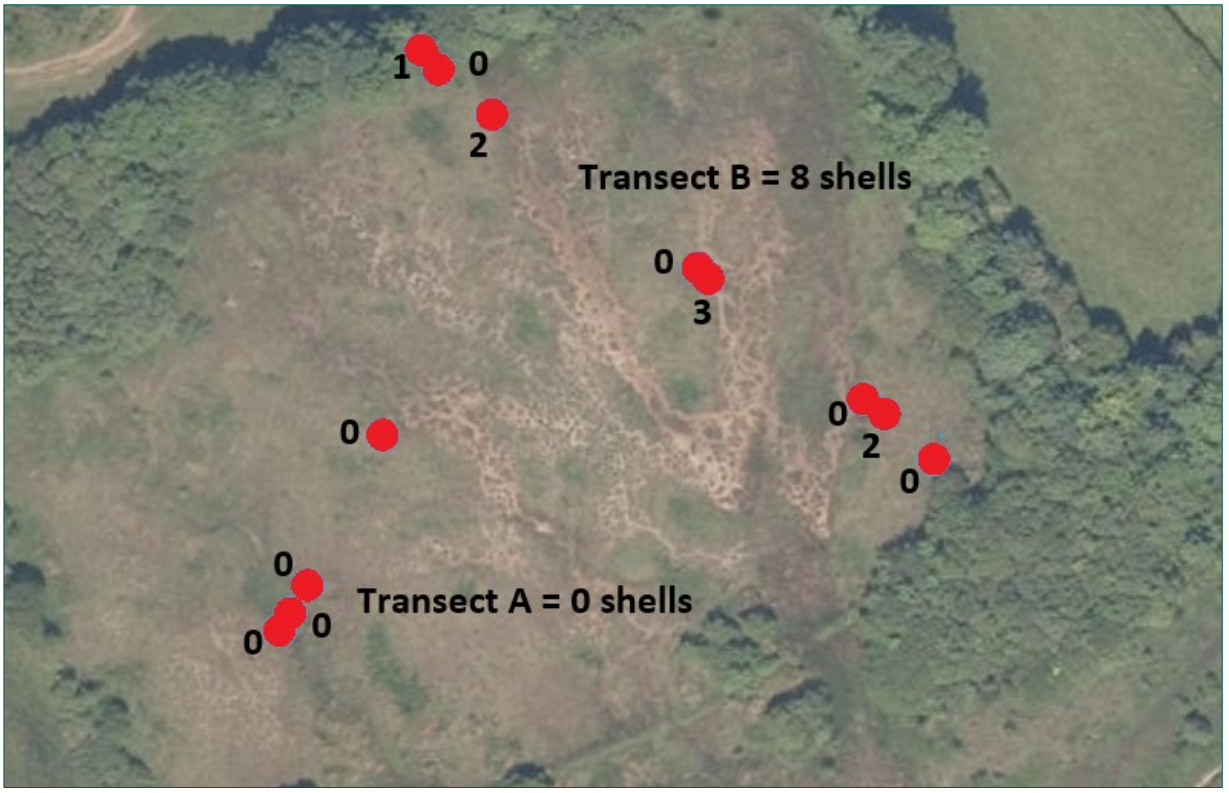

Figure 7. *Vertigo geyeri* transect results September 2014**.** Numbers at each point are *V. geyeri* counts based upon field assessment only.

Table 16. Proportions of habitat types on 2014 transect surveys.

Transect	Optimal Habitat	Sub-optimal Habitat	Suitable habitat (Optimal + Sub-optimal)	Unsuitable habitat
A (64m)	30m (monitoring target 35m)	4.8m	34.9m (monitoring target 45m)	29.1m
B (105m)	87.2m (monitoring target 35m)	0m	87.2m (monitoring target 60m)	17.8m

Searches along Transect A in the southwest section of the site found no *V. geyeri* (Table 14; Figure 7), producing results similar to 2007 when only a single snail was found at the lowest transect point. **Optimal** habitat was judged to have declined slightly (Table 16) although more than a third was still considered to provide suitable habitat. The 2014 survey for the snail relied solely upon short periods of field assessment; it is possible that the use of bulk samples might have produced some snails. This is considered the more reliable way to detect the snail. Thus, on Transect B in 2007 12 shake samples only produced a single *V. geyeri* whereas bulk samples taken at only 8 stations gave 9 specimens. It is not understood why the snail seems to have gone from Transect A when a reasonable amount of suitable habitat was present. Perhaps this area of Waun Eurad had not been recolonised by the snail following a period of intensified (now reduced) grazing in previous years. The extent of suitable habitat on Transect B had increased since 2007 (Table 16) and *V. geyeri* was found in all suitable habitat. The relatively low numbers of snails recorded on Transect B (Table 15; Figure 7) may be a consequence of the sampling as no bulk samples were removed which would probably have produced higher counts. *V. geyeri* was assessed as being in **Unfavourable Condition** on Waun Eurad in 2024 due to the snail's absence from transect A and also a decline in favourable habitat there.

Appendix 3. Previous *Vertigo geyeri* surveys on Cors Erddreiniog and Cors Geirch (simplified chronologies)

Cors Erddreiniog

1. **1985**: *V. geyeri* found as a dead shell of uncertain age (Willing, unpublished).
2. **1988**: The first live specimen found in pitfall trap but initially incorrectly identified as *Vertigo lillljeborgi* ((Boyce *et al*., 1992; Holmes *et al*., 1995).
3. **1994**: Barry Colville (Colville, 1994) is first to identify *V. geyeri* on Cors Erddreiniog at a site on the eastern side of the reserve; sloping ground with calcareous springs known as Nant Isaf.
4. **1994 – 1997**: Further finds of the snail by R. Marriott, A.P. Fowles, E.A.Howe and M. Sutton.
5. **2003**: The first detailed survey of the site was undertaken in summer 2003 (Killeen & Moorkens, 2004) when 9 reserve compartments situated on the northern and eastern margins (11a, 11b, 13c, 15a, 15b, 20, 21, 22f & 22h) were surveyed. *V. geyeri* was confirmed in 4 of these (13c, 15a, 15b & 20). The key 'hotspot site was 13c, Nant Isaf, a series of spring-fed calcareous flushes on the centre-east of the site which was further subdivided into 11 habitat cells, 9 of which supported the snail. The project formulated a 'Conservation Objective' for future monitoring of the site which for assessment of the snail to be in 'favourable condition' required *V. geyeri* presence in 4 of the compartments (13c, 15a & b, 20). In 13c, the future use of transects are proposed to monitor prescribed levels of presence of the snail together with certain habitat attributed (vegetation type and water table).
6. **2007**: Following a 4-year hiatus, the site was resurveyed in September 2007 (Killeen & Moorkens, 2008). At the key Nant Isaf site (13c), three transects were used to monitor conditions. Out of a total of 13 sample points on these transects, only three *V. geyeri* were located at just one sample point marking a huge decline in presence of the snail which was attributed to a lack of grazing causing the growth of rank shading vegetation first noted in 2003. Elsewhere, *V. geyeri* was detected at only one (of 6) survey points in the combined 15a/b, one snail in 19b (mislabelled as 20 in the 2003 report), in the north-west corner the snail was found in large numbers (175) in a small area of 21 (not recorded here in 2003) and in low numbers in 22f and 22h (again not found in these in 2003) but not in 22c and 22e.
7. **2016**: Following a 9-year survey hiatus, many sites previously supporting the snail were resurveyed in 2016 (Willing, 2017). *V. geyeri* was not located from samples removed from 13c, 15a and 15b and 21. The former key Nant Isaf site (13c) was found to be

very heavily overgrown by rank, shading *Schoenus nigricans* tussocks following a lack of grazing over many years possibly also a reason for the snail's absence from 15a and 15b. Reasons for the snails absence from 21 were unclear. Additionally, the further two potential V. *geyeri* compartments 10 and 11a were also unsuccessfully sampled for the snail.

8. **2019**: After a further three-year break, selected sites were resurveyed (Willing, 2020). The Nant Isaf spring field site (13c) had been grazed in the period since the previous survey which had removed much of the rank shading tussock growth and there were early signs of a restoration of short '*Carex*-lawn' habitat favoured by *V. geyeri*. As the snail was not detected in the samples taken, it was concluded that the years of shading growth had probably eliminated any remaining *V. geyeri* population pockets. The snail was also not recovered in the formerly occupied 21, 22f, 22h and 19a/b compartments. The snail was not detected in potentially suitable habitat in compartments 11a, 22e and 22f. The survey report concluded that it was probable that *V. geyeri* had become extinct on Cors Erddreiniog but that if conditions continued to improve in the Nant Isaf compartment with continued managed grazing, then there might be a *V. geyeri* reintroduction opportunity in future years (possibly from Waun Eurad if 'healthy' populations of the snail remain there).

Cors Geirch

1. **1996**: A.P. Fowles discovers two *Vertigo geyeri* specimens in an area of wet valley fen supporting *Schoenus nigricans* (these voucher specimens had confirmed ID).
2. **1998**: As part of a NRW supported survey Barry Colville finds a further 3 specimens of the snail close to the site of the original find and additionally a single specimen in a different non-*S. nigricans* part of the reserve (Colville, 1999).
3. **2005**: Dylan Lloyd undertook surveys and established 4 new monitoring sites labelled A, B, C & D (but no grid references are provided) in Lloyd (2005). Only one of these (Area C) appears to be approximately near the site of the Fowles and Colville finds in 1996 and 1998 respectively. The sites were proposed based upon their assumed *V. geyeri* suitability rather than (possibly except in Area C) a demonstration of *V. geyeri* presence. Two *V. geyeri* specimens (ID later confirmed) were located from field sampling at the newly designated 'Area A' - these being the only specimens of the snail found during the 2005 programme. It is unclear if the sites of the 1996 and 1998 finds were re-surveyed.
4. **2008**: Lloyd (2008) undertook transects in the 4 monitoring blocks; 1 in Area A, 1 in area B, two in Area C (which are shown as two separate 'sub -blocks') and two in Area D (again shown as two separate 'sub -blocks'). The only reported *V. geyeri* were 4 specimens from Area D (not a previous *V. geyeri* site). These specimens were not independently verified (and are not available to study) and it is considered that they are

likely to have been the superficially similar *V. pygmaea*. Four subsequent surveys of this area in 2015, 2016 and 2019 (see below) also failed to find *V. geyeri* but did record *V. pygmaea*, reinforcing the initial doubts about the accuracy of the 2008 finds.

5. **2015**: A site visit by Dylan Lloyd and Mike Howe to the Lloyd Area D removed four samples but did not locate any *V. geyeri* instead only finding the superficially similar *V. pygmaea* (Mike Howe, pers.comm.).
6. **2016**: In October 2016, all previous *V. geyeri* survey stations (including all where the snail was reported) were re-surveyed (Willing, 2017). Thus, 2016 sites S1a/1b & S2a/2b were equivalent to Lloyd D; S3a/3b/3c approximately close to both Fowles 1996 / Colville 1998 sites and including Lloyd Areas B and C; S4 to Lloyds Area A. Sites S2d and 5 were new areas surveyed as potential *V. geyeri* sites. No *V. geyeri* were found at any of the 2016 sites.
7. **2017**: The short horse-grazed lawn flushes lying in the centre of the site and situated a short distance north of the second 1998 Colville site were bulk sampled and although large numbers of three other *Vertigo* species were found, no *V. geyeri* were recovered despite the seeming suitability of this area (Willing, 2018).
8. **2019**: A return in 2019 (Willing, 2020) resurveyed further areas in the central short horse-grazed lawn flushed and the Lloyd Area D block where he had reported 4 *V. geyeri* in 2008. The survey report concluded that it was probable that *V. geyeri* was extinct on Cors Geirch. It may be that the site was always very marginally suitable for the snail; only 8 confirmed specimens were found at the site over the nine-year period 1996 to 2005. The two other *V. geyeri* sites in North Wales, Waud Eurad and Cors Erddreiniog, both produced far larger numbers of specimens over more extensive areas.

Appendix 4. Site locations and summary habitat descriptions on Waun Eurad in 2021

Note: All sites were selected to lie within or close to *Schoenus nigricans* and so were judged to be potentially '**Optimal**' or '**Sub-optimal**' for *Vertigo geyeri*.

Location 1. SH 50607 80506. Relatively short (ca. 30cm). *Schoenus nigricans* present.

Location 2. SH 50618 80482. Relatively short (ca. 30cm). *Schoenus nigricans* present.

Location 3. SH 50630 80473. Relatively short (ca. 35cm). *Schoenus nigricans* and *Vertigo geyeri* present.

Location 4. SH 50632 80483. Relatively short (ca. 35cm). *Schoenus nigricans* and *Vertigo g*eyeri present.

Location 5. SH 50637 80488. Relatively short (ca. 35cm). *Schoenus nigricans* and *Vertigo g*eyeri present.

Location 6. SH 50635 80500. Relatively short (ca. 30cm). *Schoenus nigricans* present.

Location 7. SH 50623 80500. Relatively short (ca. 40cm). *Schoenus nigricans* present.

Location 8. SH 50650 80505. Relatively short (ca. 35cm). *Schoenus nigricans* and *Vertigo g*eyeri present.

Location 9. SH 50714 80532. Occasional *Schoenus nigricans* but extensive areas of short, grazed '*Carex* lawn'. *Vertigo g*eyeri present.

Location 10. SH 50709 80545. Occasional *Schoenus nigricans* but extensive areas of short, grazed '*Carex* lawn'. *Vertigo g*eyeri present.

Location 11. SH 50696 80545. Occasional *Schoenus nigricans* but extensive areas of short, grazed '*Carex* lawn'. *Vertigo g*eyeri present. Ground saturated.

Location 12. SH 50690 80543. Occasional *Schoenus nigricans* but extensive areas of short, grazed '*Carex* lawn'. *Vertigo g*eyeri present. Ground saturated.

Location 13. SH 50684 80551. Rather ranker than Location 12; of short, grazed '*Carex* lawn' between *Schoenus nigricans* tussocks (ca. 45 cm.). *Vertigo g*eyeri present.

Location 14. SH 50684 80551. Rather ranker than Location 12; of short, grazed '*Carex* lawn' between *Schoenus nigricans* tussocks (ca. 45 cm.). *Vertigo g*eyeri present.

Location 15. SH 50697 80569. Occasional *Schoenus nigricans* but extensive areas of short, grazed '*Carex* lawn'. *Vertigo g*eyeri present.

Location 16. SH 50671 80517. Relatively short (ca. 35cm). *Schoenus nigricans* and *Vertigo g*eyeri present.

Location 17. SH 50660 80509. Relatively short (ca. 35cm). *Schoenus nigricans* and *Vertigo g*eyeri present.

Data Archive Appendix

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

~~[B] A full set of maps produced in JPEG format~~.

~~[C] A series of GIS layers on which the maps in the report are based with a series of word documents detailing the data processing and structure of the GIS layers~~.

~~[D] A set of raster files in ESRI and ASCII grid formats~~.

~~[E] A database named [name] in Microsoft Access 2000 format with metadata described in a Microsoft Word document [name.doc]~~.

~~[F] A full set of images produced in [jpg/tiff].~~

[G] Species records held in Welsh Invertebrate Database (WID).

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service https://metadata.naturalresources.wales/geonetwork/srv (English version) and https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/ (Welsh Version). The metadata is held as record no. NRW_DS161386.