Cyfoeth Naturiol Cymru
Natural Resources Wales

A survey for Desmoulin's Whorl Snail *Vertigo moulinsiana* on Cors Geirch NNR/SSSI and the Afon Penrhos floodplain in 2016

MJ Willing

NRW Evidence Report No. 210

Figure 1: *Vertigo moulinsiana* habitat at Afon Penrhos (mechanically cut and horse-grazed fen)

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Cynhaliwyd arolwg o Falwoden Droellog Desmoulin *Vertigo moulinsiana* ar GNG/SoDdGA Cors Geirch a gorlifdir Afon Penrhos ym mis Hydref 2016 i bennu ei statws a'i dosbarthiad cyfredol. Cafodd y lleoliadau a samplwyd eu seilio ar ganlyniadau arolygon blaenorol yng Nghors Geirch (1999-2008) ac ardal Afon Penrhos (2002-2008).

Cafwyd bod y boblogaeth yng Nghors Geirch wedi dirywio'n sylweddol, gyda'r falwoden wedi diflannu'n llwyr o ardaloedd a oedd yn gadarnleoedd yn flaenorol, a dim ond 17 cragen wedi'u cofnodi yn y ddwy ardal fach ym mhen deheuol y safle. Roedd asesiadau yn 2003 a 2008 yn ystyried bod y boblogaeth mewn cyflwr ffafriol. Gyda bwlch monitro o wyth mlynedd, mae achosion y dirywiad sydyn yn aneglur, ond mae'n debyg eu bod yn cynnwys lledaeniad ardaloedd drewllyd nad ydynt wedi cael eu torri na'u pori a llystyfiant ffen, wedi'u cyfuno â bedw a helyg. Roedd tyfiant y llystyfiant dwys ar y safle mor drwchus nes bod y llinellau ffosydd blaenorol, a ddefnyddir yn nodweddion ar gyfer monitro safleoedd, bron wedi'u cuddio'n llwyr ac yn anodd eu cyrraedd.

Yn ardal Afon Penrhos, cafwyd y falwoden mewn niferoedd mawr mewn 'dôl ffen' fer wedi'i thorri'n fecanyddol ac wedi'i phori'n ysgafn gan geffylau; roedd ffen dal nad oedd wedi'i dorri'n cynnal niferoedd sylweddol is. Ym mannau eraill y DU yn nodweddiadol mae'r falwoden yn cael ei chysylltu â ffen dal. Cofnodwyd *V. moulinsiana* ar tua 19 erw (wyth hectar) o'r safle, ond ni chafodd ffiniau'r boblogaeth eu sefydlu ar ffiniau dwyreiniol a de-ddwyreiniol yr ardal a arolygwyd. Amcangyfrifir bod tua 75 erw (30 hectar) o gynefin addas posibl yn bodoli, a dylid cynnal arolwg ohonynt i ganfod a ydynt yn cynnal y falwoden. Nid yn unig y mae poblogaeth ardal Afon Penrhos y fwyaf yng Nghymru, ond hefyd mae'n un o'r fwyaf ar dir mawr Prydain. Mae arwyddocâd y boblogaeth yma'n cael ei gynyddu ymhellach gan y colledion sylweddol i'r poblogaethau ar nifer o Ardaloedd Cadwraeth Arbennig yn ne Lloegr. Pan fydd cyrhaeddiad llawn y boblogaeth yn ardal Afon Penrhos wedi cael ei bennu, argymhellir y dylai'r safle gael ei ddynodi'n SoDdGA i leihau'r risg o golled neu ddifrod o ganlyniad i newidiadau i reolaeth y safle.

Yng ngoleuni cysylltiad y falwoden â'r 'ddôl ffen' fer yn ardal Afon Penrhos, argymhellir bod yr ardaloedd drewllyd a oedd yn cynnal *V. moulinsiana* ar Gors Geirch gynt yn cael eu hagor i ddarparu cynefin ffen byr i gynorthwyo adfywiad y boblogaeth sydd ar ôl.

2. Executive Summary

A survey for Desmoulin's Whorl Snail *Vertigo moulinsiana* on Cors Geirch NNR/SSSI and the Afon Penrhos floodplain was undertaken in October 2016 to determine its current status and distribution. Sampled locations were based upon the results of previous surveys at Cors Geirch (1999-2008) and Afon Penrhos (2002-2008).

The population at Cors Geirch was found to have declined considerably, with a complete loss of the snail from former stronghold areas and just 17 shells recorded from two small areas at the southern end of the site. Assessments in 2003 and 2008 had considered the population to be in favourable condition. With an eight-year monitoring hiatus, the causes of the sharp decline are unclear but are likely to include the spread of uncut and un-grazed rank, fen vegetation combined with encroaching birch and sallow. Dense vegetation growth at the site was such that the former ditch-lines, used as features for site monitoring, were almost completely obscured and difficult to reach.

At Afon Penrhos, the snail was found in large numbers in short, mechanically-cut and lightly horse-grazed 'fen-meadow'; tall uncut fen supported significantly lower numbers. Elsewhere in the UK, the snail is typically associated with tall fen. *V. moulinsiana* was recorded on about 19 acres (8 hectares) of the site, but population boundaries were not established on the eastern and south-east borders of the surveyed area. It is estimated that a further 75 acres (30 hectares) of potentially-suitable habitat exists which should be surveyed to determine if it supports the snail. The Afon Penrhos population is not only the largest in Wales, but also probably one of the largest in mainland Britain. The significance of the population here is further enhanced by recent considerable population losses at several SACs in southern England. Once the full extent of the population on Afon Penrhos is determined, it is recommended that the site should be notified as a SSSI to reduce any risk of loss or damage due to changes in site management.

In light of the snail's association with short 'fen-meadow' at Afon Penrhos, it is recommended that rank areas which previously supported *V. moulinsiana* on Cors Geirch are opened up to provide short fen habitat to assist the recovery of the remnant population.

3. Introduction

3.1 Background information

Desmoulin's Whorl Snail *Vertigo moulinsiana* (Dupuy, 1849) is a small snail found mostly in old or semi-natural open, calcareous fen and wetlands, usually adjacent or close to rivers, streams, lakes and ponds. In the UK, it is chiefly distributed in a broad band of country from central-southern England to East Anglia (Kerney, 1999). Outlying populations also exist in north and mid-Wales, the north-west English Midlands and north Cornwall. It was categorised as Rare (category 3) in the UK Red Data Books (Bratton, 1991), and more recently as Vulnerable on the IUCN-based UK red list status review (Seddon *et al.*, 2014). The snail is listed on Annex IIa of the European Community Habitats and Species Directive (92/43/EEC) and is also a Welsh Section 42 'Species of Principal Importance'.

V. moulinsiana is known from just three localities in Wales; Cors Geirch NNR/SSSI and Afon Penrhos near Pwllheli on the Llŷn peninsula, and Rhos Goch National Nature Reserve near Hay-on-Wye in Radnorshire, where a recent survey has highlighted a strong population (Willing, 2016). It is a feature of Corsydd Llŷn – Lleyn Fens SAC of which Cors Geirch is a part, but there is currently no statutory protection for the site at Afon Penrhos. All of the Welsh *V. moulinsiana* sites are isolated and do not closely resemble the lake and river-side base-rich fens typically associated with the snail at most of its English sites. The nearest English *V. moulinsiana* sites to Afon Penrhos and Cors Geirch lie in the north-west Midlands (meres in Shropshire) (Cousins, 2015; Kerney, 1999). Although very different habitats, the Afon Penrhos and Cors Geirch sites lie only about 2.5 km apart.

Following its discovery on Cors Geirch by Barry Colville in 1998, a survey in October 1999 highlighted that the population was confined to the south-east section of the site where more than 700 shells were associated with three permanently-wet ditches and an area of fen vegetation (Killeen, 2000). A survey in November 2003 led to the development of a 'common standards' condition assessment protocol for the site (Killeen, 2004; Killeen & Moorkens, 2003) and the snail population was assessed as being in Favourable condition, although some scrub encroachment was noted (Killeen, 2004). A repeat assessment in 2008, but with some modifications, found habitat in good condition and an increase in *V. moulinsiana* area of occupancy but a decline in total snail numbers from an average of 16 per sample in 2003 to five per sample in 2008, although the population was assessed to be in Favourable condition (Lloyd, 2008).

V. moulinsiana was first found on the Afon Penrhos floodplain by Dylan Lloyd in October 2002, who recorded it again in June 2003 when it was associated with emergent Meadowsweet *Filipendula ulmaria* and Yellow Flag *Iris pseudacorus* along a ditch-line. It was recorded in abundance at the same location in an area of open fen in 2008, although a wider search failed to find additional populations and the population boundaries were not delineated (Willing, 2008). It was recorded again in 2010 by John Bratton. A brief visit in October 2015 by Dylan Lloyd and Mike Howe of NRW highlighted major land management changes to the previously-occupied area, including drainage, ditch clearance, scrub removal and sheep grazing.

3.2. Objectives

This survey was undertaken to determine the current status and distribution of *V. moulinsiana* on Cors Geirch, the area of occupancy and current habitat condition in relation to data from the past three surveys. The survey on the Afon Penrhos floodplain was to determine if the snail had survived recent land management changes, and to delineate the full area of occupancy.

4. Methods

Surveys at Cors Geirch and Afon Penrhos were completed on 3rd and 5th October 2016 respectively. Survey days were selected to ensure the dry conditions needed to undertake sampling. Key survey locations are displayed in Figures 4 & 5 for Cors Geirch and Figures 9 & 10 for Afon Penrhos, with descriptions given in Appendix 1 Tables 3 to 5. Surveys focussed on locating and assessing populations of *Vertigo moulinsiana*.

Survey methodology broadly followed the 'level 1' survey techniques detailed in Killeen & Moorkens (2003). Consequently, searches for *V. moulinsiana* climbing upon wetland vegetation were carried out by the well-established technique of beating herbaceous fen vegetation onto a gridded white plastic tray.

1. Tray beating was undertaken in dry weather conditions. A gridded white beating tray measuring approximately 25cm x 33cm was used. At selected locations, this allowed approximate *V. moulinsiana* numbers per unit area to be estimated (6 trays being approximately equivalent to 0.5 m^2). Each beating tray went at the base of a fresh and undisturbed plot of vegetation, all within approximately 2m of a single sampling point. Material on the trays was combined and either counted in the field (if numbers of snails were low and easily seen amongst other vegetation detritus) or, in most cases, retained for later laboratory examination and snail counting (involving the inspection of samples microscopically using a x7 – x45 binocular microscope to count adult and juvenile *V. moulinsiana)*. Survey stations were selected as those judged most likely to produce *V. moulinsiana*. Tray beating was difficult in cut fen at Afon Penrhos because of the low vegetation height which prevented the estimation of snail area density.
2. Approximate area of occupancy was assessed with the use of a tray beating.
3. Degree of ground moisture (using a version of the '5 Point Wetness scale' of Killeen & Moorkens, 2003) was recorded at all survey sites;
    1. Ground dry: Possibly with cracks, and no evidence of surface moisture.
    2. Ground damp: Moisture observed on the surface but water does not rise under light pressure.
    3. Ground wet: No surface veneer, but water rises under light (foot) pressure.
    4. Ground wet: Surface veneer of water less than 1-2cm deep
    5. Ground very wet: Water depth greater than 2cm which may cover the sward and tussocks.

4. Dominant vegetation presence was recorded, noting particularly '+' and '-' *V. moulinsiana* 'suitability indicators' (e.g. *Carex* sp, *Glyceria maxima* as '+' indicators and *Epilobium* sp and *Urtica dioica* as '-').
5. Degree of site shading by overhead or over-hanging trees and bushes was recorded as a simple % canopy cover where appropriate (as shading can negatively affect the suitability of sites for *V. moulinsiana).*
6. Other potentially important site environmental and management details were recorded e.g. (i) grazing and/or ground poaching, (ii) recent cutting, (iii) human trampling;
7. Where *V. moulinsiana* was located (and vegetation height permitted), numbers were counted per 6-tray samples and then converted into approximate numbers m^2 with numbers of adult and juvenile snails recorded;
8. GPS 12 figure grid references and digital images were recorded for each 'main' sample point. In addition to these, tray beating was carried out as the surveyor walked around the site to try and locate *V. moulinsiana* 'pockets' that might otherwise be over looked.

5. Results

5.1. Cors Geirch NNR/SSSI

V. moulinsiana was not located during systematic sampling of habitat adjacent to the ditches used for condition monitoring of the snail in 2003 and 2008. Very small numbers were found at two sites towards the south of the site where the snail had also been reported during surveys in 1999 (Table 1 & Figure 2; see Killeen, 2000). The disappearance of the snail from these former strongholds may, at least partially, be due to the over-grown nature of these sites where rank herbaceous growth was accompanied by increasing ingress by sallow and birch. These increase shading and may also result in drier ground conditions, both factors that negatively impact upon *V. moulinsiana* populations. Appendix 1 provides more detailed descriptions of sample points and Appendix 4 provides site images.

Table 1. Locations for *Vertigo moulinsiana* on Cors Geirch in 2016.

Vertigo moulinsiana site (locations in this report) & Grid. Ref	Approx. *V. moulinsiana* (m^{-2})
E SH3300935427	1 juvenile in 20 minutes tray beating in potentially suitable *Carex, Juncus, Schoenus* in damp ground on stream margins. < 1 m^{-2}
F SH3305235259	16 m^{-2} (1:1 - juvenile: adult ratio) 20 minutes of additional beating mostly < 6 m^{-2} extending approx. 20 m either side (east – west) of grid ref.

Figure 2: Locations for *Vertigo moulinsiana* on Cors Geirch in 2016.

5.2. Afon Penrhos floodplain

Despite the recent cutting of some areas of fen, *V. moulinsiana* presence was re-confirmed. The snail was found to be plentiful and widespread in short *Juncus*-dominated vegetation in recently mechanically-cut (and lightly horse-grazed) fields (Table 2 & Figure 3). Noticeably more *V. moulinsiana* were recovered from the cut fen than in areas of uncut fen. It is estimated that *V. moulinsiana* presence was confirmed from about 19.3 acres (7.82 hectares) of habitat. There was insufficient time to complete survey work in the south-eastern areas of the access-permitted land. Additionally, more potentially-suitable *V. moulinsiana* habitat was observed (both in the field and from studies of Google Earth footage) lying to the east of the survey area, the survey of which will require further access permission. It is estimated that this may equal about 75 acres (30.4 hectares). Appendix 1 provides more detailed descriptions of sample points and Appendix 4 provides site images.

Table 2. Locations for *Vertigo moulinsiana* on Afon Penrhos in 2016.

Vertigo moulinsiana site (locations in this report) & Grid. Ref	*V. moulinsiana* (*Vm*) presence and where appropriate m^{-2}
B SH3438333655	Frequent presence of *Vm;* estimated @ approximately 100 m^{-2}. (approximately 4:1 adult:juvenile ratio)
C SH3432733631	*Vm* present (several specimens in < 5 minutes low-tray beating)
D SH3430133659	*Vm* present (several specimens in < 5 minutes low-tray beating)
E SH3436133620	*Vm* present (several specimens in < 5 minutes low-tray beating)
F SH3441333565	*Vm* present (several specimens in < 5 minutes low-tray beating)
G SH3446433590	*Vm* present (several specimens in < 5 minutes low-tray beating)
H SH3450533590	*Vm* present (several specimens in < 5 minutes low-tray beating)
I SH3447433634	Very low numbers of *Vm;* 1 adult 1.25 m^{-2} (= 15 sampling trays; see methods above)
J SH3453733649	*Vm* present (several specimens in < 5 minutes low-tray beating)
K SH3441533706	*Vm* present (several specimens in < 5 minutes low-tray beating)
L SH3434933706	*Vm* present (several specimens in < 5 minutes low-tray beating)
N SH3454933781	Low numbers of *Vm;* 4 - 5 m^{-2} Juveniles estimated < 25%
O SH3464533849	*Vm* present (several specimens in < 5 minutes low-tray beating)
P SH3473033912	*Vm* present (several specimens in < 5 minutes low-tray beating)

Figure 3: Locations of *Vertigo moulinsiana* on Afon Penrhos in 2016. Red stars displaye positive *V. moulinsiana* survey locations.

6. Discussion

6.1. Cors Geirch NNR/SSSI

During the first systematic survey of Cors Geirch in October 1999, Killeen (2000) located the snail only in and immediately adjacent to a number of permanently-wet ditches at the southern end of the site, just north of Rhyd-y-clafdy, although he noted potentially-suitable habitat in both northern and central areas. He produced a sketch map summarising the main ditches and areas of fen. That map has been adapted and included here (Figure 4) as it shows not only the results of Killeen's original baseline, but habitat blocks visited and surveyed in all of the more recent surveys including the 2016 survey.

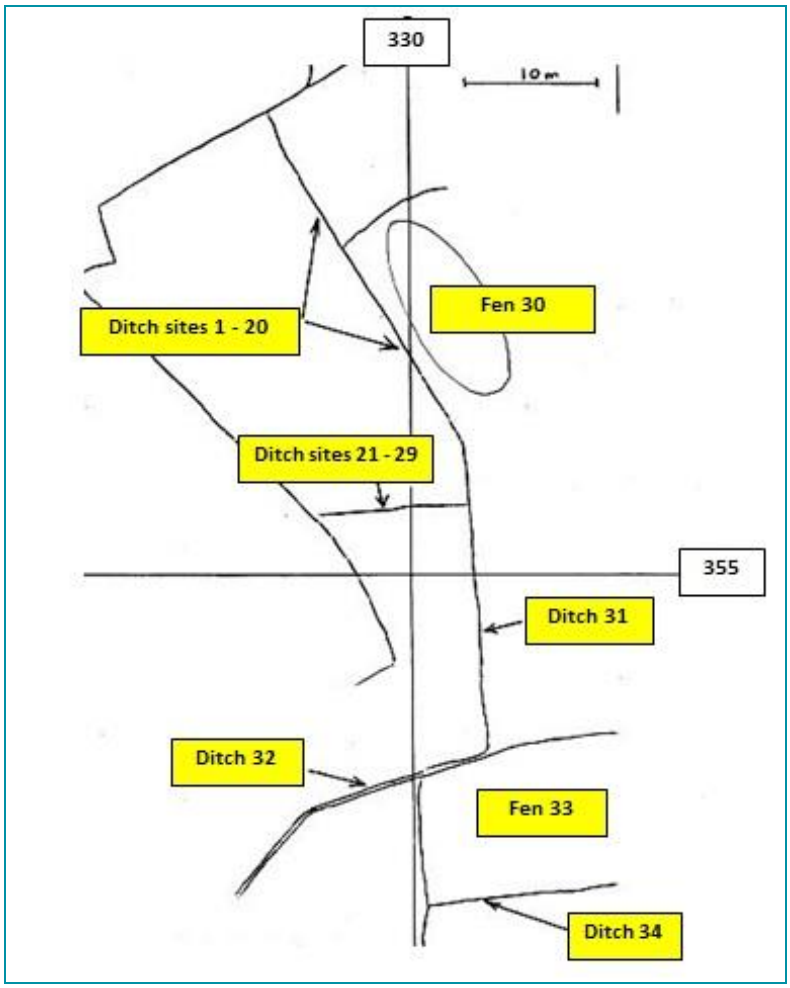

Figure 4: Sketch map of survey areas at Cors Geirch (adapted from map in Killeen, 2000).

The 2003 survey focussed solely on the occupied southern area of the site (Killeen, 2004). Transect surveys of the 'dogleg' ditches (a) 1 – 20 and (b) 21 – 29 of the 1999 survey were established, confirming 77% *V. moulinsiana* presence (from 31 samples) on the former ditch and 89% presence (from 9 samples) on the latter ditch. Additionally, a further set of randomly-located samples (lying approximately parallel to the longer ditch) located *V. moulinsiana* in 68% of 19 samples from these ditches (Figure 5).

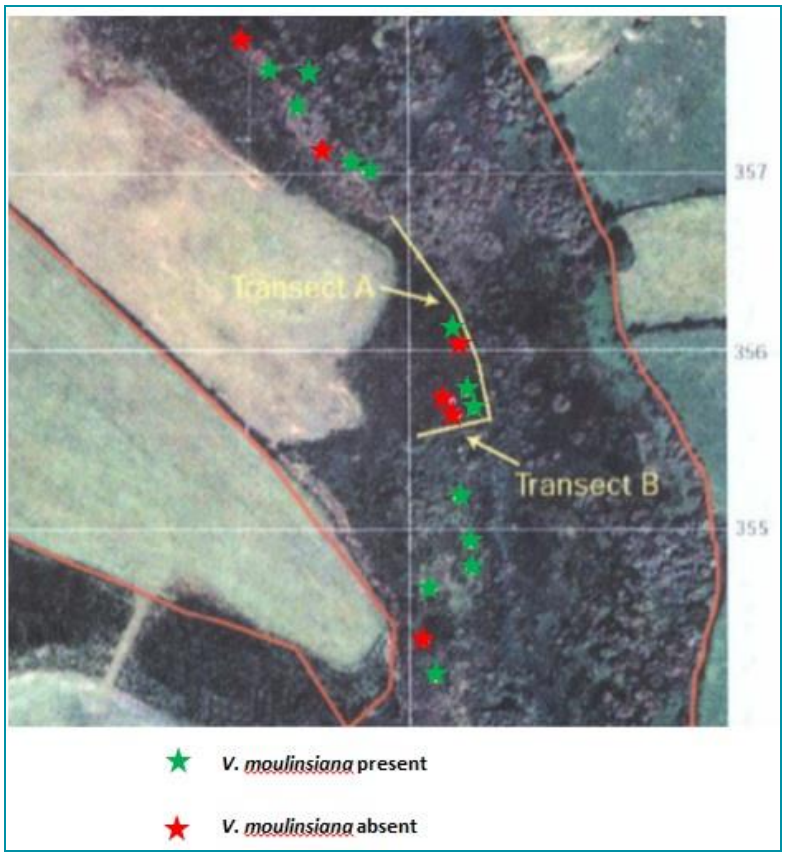

Figure 5: Sketch map of survey locations and non-transect populations of *Vertigo moulinsiana* at Cors Geirch (adapted from Killeen, 2004).

Killeen (2004) also developed a 'common standards' framework for assessing the status of *V. moulinsiana* on the site, using four criteria with 'threshold' measurements to judge favourable condition:

(1) area of *V. moulinsiana* occupancy;
(2) *V. moulinsiana* population density;
(3) vegetation species/community structure and
(4) ground moisture levels.

On this basis, the population of *V. moulinsiana* on Cors Geirch was judged to be in favourable condition in 2003. The report notes that no grazing was recorded, and there was a small amount of scrub encroachment from the eastern side of the site. Further monitoring was undertaken in October 2008, adopting the two transects following the ditch lines previously suggested (Lloyd, 2008). Thirty samples were taken on the long ditch line transect ('1 – 20') and nine samples on the shorter length ('21 – 29'). *V. moulinsiana* was recorded in 100% of samples. Lloyd applied the four protocol criteria to make a condition assessment of *V. moulinsiana*. Three of these - area of occupancy, vegetation species composition and ground moisture - were judged to be in favourable condition. The fourth criterion, population density, failed as mean snail numbers were below the protocol threshold. However, this was considered to be a sampling artefact and, because the snail was found in all 40 samples and the area of occupancy was greater than in 2003, the overall assessment was made as Favourable. This is discussed in more detail in Appendix 3.

The 2016 survey was undertaken by MJW and Mike Howe (NRW Invertebrate Ecologist). The main north-south orientated ditch-line (designated as one of the monitoring transects: '1 – 20') was almost totally obscured by dense, uncut and un-grazed *Phragmites australis, Cladium mariscus* and *Carex riparia* at the northern end (Figure 6). The assumed line of the ditch was progressively over-shaded by birch and sallow toward the central and southern sections, becoming increasingly obscured and impenetrable. The east-west ditch ('21 – 29') was similarly shaded except at the western end.

Despite systematic tray beat sampling both within and along the outer margins of these transect zones, no *V. moulinsiana* were recorded. Survey was continued southward to sample areas approximately adjacent to 'Ditch 31'.

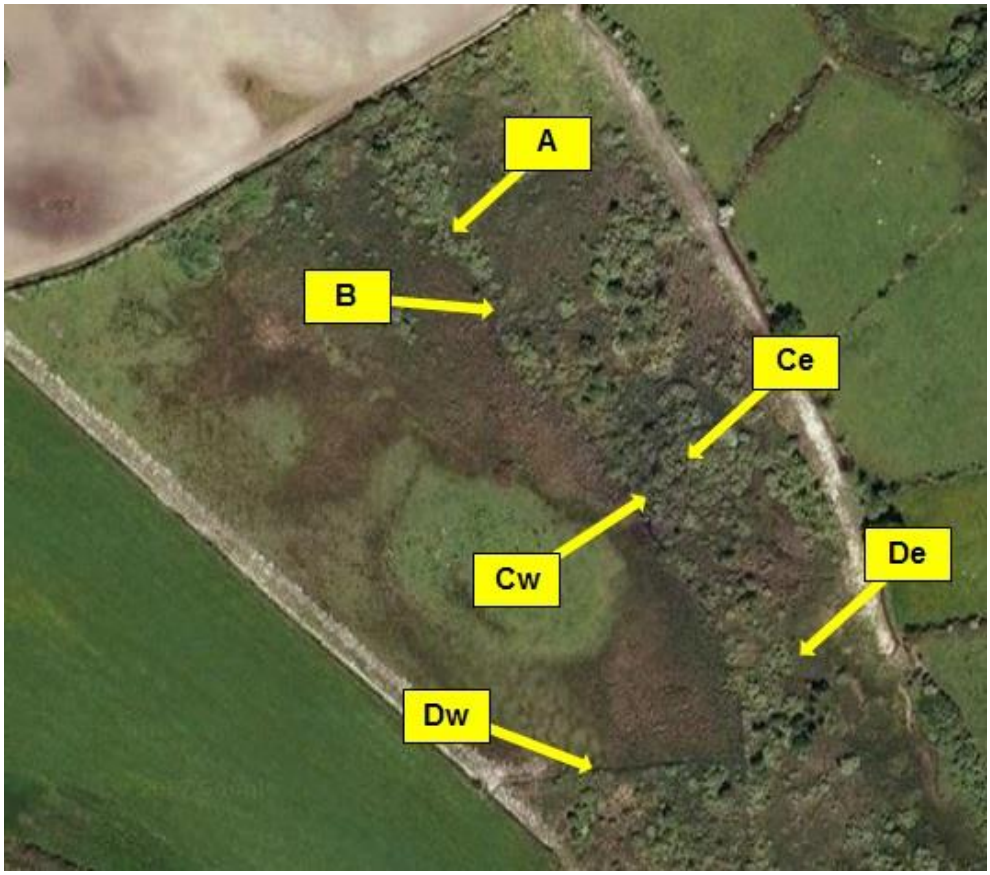

Figure 6: Survey locations at Cors Geirch (northern sector). Ce = C East; Cw = C West.

Little potentially-suitable *V. moulinsiana* habitat was found, with only a single juvenile snail (retained as a voucher specimen) recorded (E in Figure 7). *V. moulinsiana* was only recorded at one further site, with small numbers at the central point of 'Ditch 34' (F in Figure 7). Killeen (2000) noted that *V. moulinsiana* was 'occasional' at 'Ditch 31' and 'locally frequent' at 'Ditch 34'. No *V. moulinsiana* were recorded in 'Fen 33' (lying between Gs – Gn), where the snail was described as 'occasional' in 1999, despite the presence of a large block of mostly un-shaded *Cladium mariscus*, *Carex riparia* and other *Carex* spp and with favourable ground moisture conditions (levels 3 to 4).

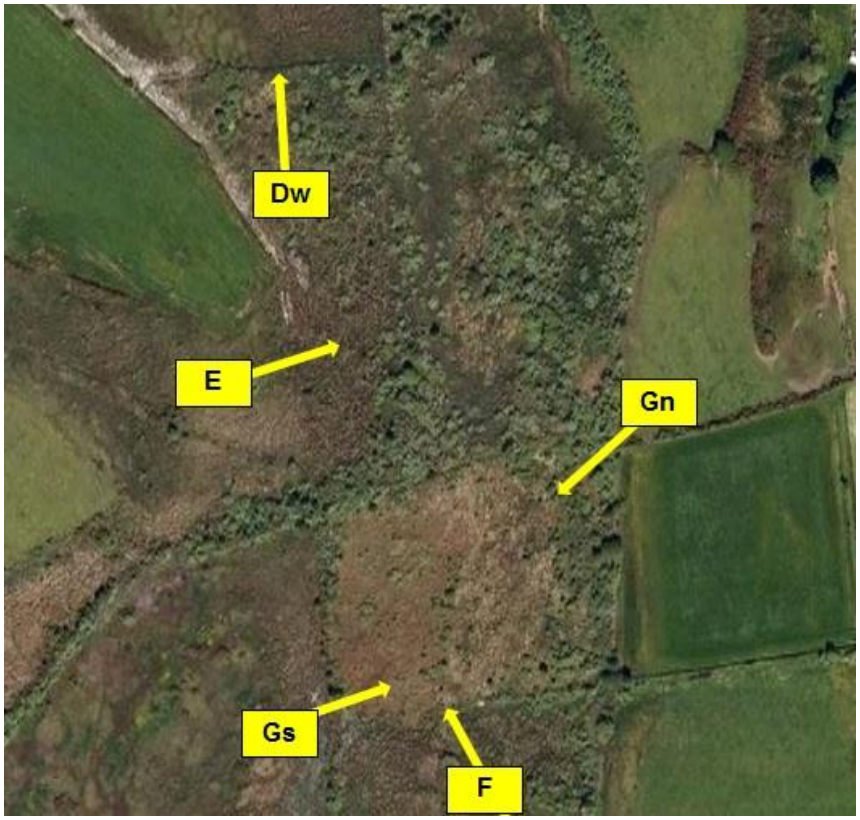

Figure 7: Survey locations at Cors Geirch (southern sector). Note overlap with ditch 'Dw' on northern map. Gn = G North; Gs = G South.

Populations of *V. moulinsiana* have virtually disappeared from Cors Geirch since 2008. No specimens were recorded in the vicinity of the transect ditch-lines. As already highlighted, this feature is now almost impossible to access and not readily discernible (due to dense vegetation growth). As no surveys have been undertaken for the snail for eight years, it is very difficult to determine the precise cause or causes of *V.moulinsiana* losses. During this period, the site will have experienced potentially significant natural events such as flooding, periods of drought, high summer and low winter temperatures and the effects of these will have inter-related with possibly changing site management routines (especially routine mechanical cutting and levels of grazing and stock species used). A likely contributory cause along the ditch-lines is shading caused by the rank growth of *Phragmites, Carex* spp and invasive woody species including sallow and birch. *V. moulinsiana* is intolerant of shading and even slight lateral effects can depress snail numbers (Drake, 1999; Killeen, 2003; Killeen & Moorkens, 2003; Willing 2011, 2016). In addition to shading, the increase in *Phragmites*, sallow and birch in this area may have contributed to a reduction of ground moisture levels. If these remain at much less than 'Level 3' (water rises under light pressure) for extended periods, this will also reduce *V. moulinsiana* numbers (Killeen, 2003). It is difficult to know why the snail was not recorded in Fen 33 as ground moisture levels appeared suitable and there was a lack of shading. The habitat at Cors Geirch was un-grazed and showed no signs of recent mechanical cutting. It is interesting to compare the lack of management and progressive spread of scrub over much of the site with the managed, short-cut fen at Afon Penrhos where *V. moulinsiana* is abundant (see Section 6.2. below).

Given the large population at Afon Penrhos, it is suggested that trial habitat clearance takes place at a number of localities on Cors Geirch to create some 'short fen' habitat to allow any remnant *V. moulinsiana* population within the *Cladium* areas to recover. The scrub and high fen that is currently largely obscuring the monitoring ditch-line could be reduced in a staggered way to leave a mosaic of different fen heights. Additionally, a quick 'walk-over' tray-beat survey would either confirm snail loss or detect any remaining population pockets.

6.2. Afon Penrhos floodplain

Following the discovery of *V. moulinsiana* here in 2002 and 2003, a more detailed survey was undertaken in July 2008 (Willing, 2008) when the snail was easily located in un-grazed and mostly open fen in an area extending for about 35 – 40m west and about 100m east of the public footpath running south from Tan-y-fron and crossing the Afon Penrhos stream at SH3462133632 (Figures 8 & 9). The search lasted about one hour and was undertaken in heavy rain. The eastern and western limits of *V. moulinsiana* distribution were not established. Potentially-suitable fen habit was also surveyed to the south of Afon Penrhos from a fen on the margins of a golf club at SH3553133911 running west to SH3462133632 (Figure 10).

A brief visit to the original locality in October 2015 by NRW staff (Dylan Lloyd and Mike Howe) noted that the fen had been cut and it was feared that *V. moulinsiana* may have been lost.

Figure 8: Afon Penrhos – habitat supporting *V. moulinsiana* looking west from public footpath, July 2008.

Figure 9: Afon Penrhos – habitat supporting *V. moulinsiana* looking east from public footpath, July 2008.

Figure 10: Afon Penrhos floodplain west of Pwllheli - areas surveyed for *Vertigo moulinsiana* July 2008. Light yellow: positive for *V. moulinsiana* (all north of Afon Penrhos). Light blue: negative for *V. moulinsiana* (all south of Afon Penrhos).

The survey in October 2016 focussed initially on the fields lying to the west of the public footpath (beyond a narrow fenced strip) and lying north of Afon Penrhos. Most of the fields in this sector had recently been mechanically cut and were lightly horse-grazed. As a consequence, searches (extending westwards to a boundary fence at SH3431833610) concentrated upon sampling the remaining uncut fen (*Carex, Juncus, Iris*) infilling many of the drainage ditches (Figure 11). Twenty to thirty minutes of tray-beat sampling produced no *V. moulinsiana*.

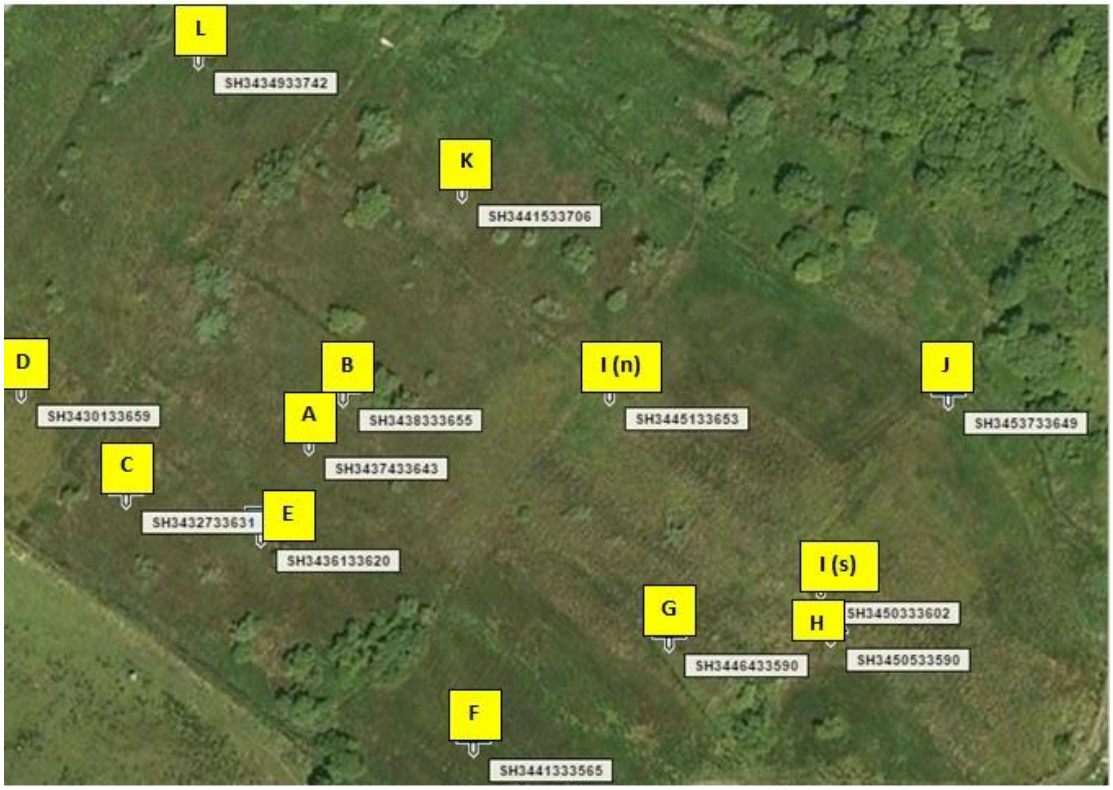

Figure 11: Afon Penrhos – 2016 survey locations west of public footpath.

Although not expecting success, the cut vegetation in the fields was also sampled. It was soon apparent that the snail was abundant, climbing the short vegetation (chiefly *Juncus* sp with an underlying matt *of Festuca ovina*), the maximum height rarely exceeding 15 cm. It was not possible due to the low height of the vegetation to estimate snail numbers per unit area as it was not possible to 'bend' a height of vegetation equivalent to the width of the sampling tray. Use of the tray nevertheless permitted sampling to establish the presence of the snail over all of the cut field surfaces. One relatively small area of uncut fen (Site I: see Appendix 4, Figure 27) was sampled and produced very few *V. moulinsiana* (Table 2), estimated to be <10% of the numbers being recorded from the cut field surfaces.

To the east of the fenced path, further tray beating confirmed the presence of the snail across three more fields, the central one being recently cut (Sites N, O & P; Figure 12). Although survey stopped at a ditch marking the eastern boundary of the access permission area, seemingly suitable areas of 'fen-meadow' lay beyond - these need to be surveyed to establish the eastern limit of *V. moulinsiana* presence. Time did not allow all areas lying immediately south of Site P and north of Afon

Penrhos to be assessed, but fen seemingly suitable for the snail is present and also needs to be surveyed.

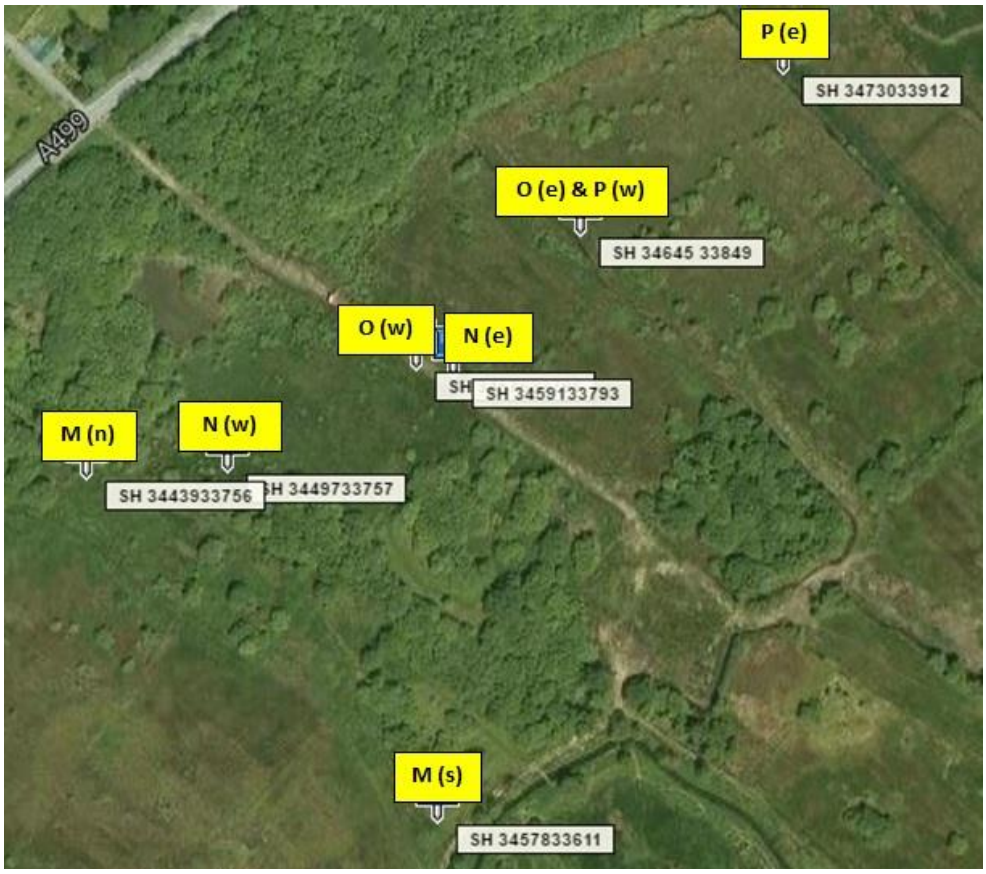

Figure 12: Afon Penrhos – 2016 survey locations east of public footpath.

The results at Afon Penrhos seem to be at odds with the widely-held understanding that the snail requires tall 'reedswamp' dominated by narrow-leaved monocotyledons (*Carex* spp, *Glyceria maxima*, *Cladium mariscus*, *Phragmites*, *Phalaris, Typha, Iris;* see Appendix 2) (Drake, 1999; Killeen 2003). Most accounts of the snail relate to habitat descriptions of localities in southern and eastern England. However, a study of *V. moulinsiana* at Penhale in Cornwall does show similar results, where *V. moulinsiana* was studied in a series of vegetation zones grading from very short into tall fen (Holyoak, 2003). There, the snail was found to be abundant in short, grassy herb rich fen with *Festuca rubra* and *Salix repens* where the mean vegetation height was only 20 cm. By contrast, it was scarce in taller fen dominated by *Carex paniculata. V. moulinsiana* was found in a ratio of 1:18 for tall fen/short fen respectively. The results from Afon Penrhos match these closely. The sites both lie close to the sea in western Britain and, when compared to sites in southern and eastern England, will typically have higher mean humidity, higher rainfall and lower mean summer temperatures. It is possible that *V. moulinsiana* favours shorter vegetation in western, oceanic Britain, although it should be noted that the population at Cors Geirch did occur historically in more typical habitat. It was noted that all of the cut fen fields at Afon Penrhos had ground water at or near to the ground surface (Figure 1). If vegetation was cut and then maintained at a much lower level at Cors Geirch, then possibly the snail population might recover there.

The *V. moulinsiana* population at Afon Penrhos covers an extensive area (Figure 3). Most of the snail's English sites are quite different in that they occupy habitat in relatively narrow strips of base-rich fen lying alongside rivers, in abandoned water-meadow channels or around the margins of ponds, meres, broads or lakes; the overall occupied areas may be relatively small. An unusual feature of the Afon Penrhos site is that *V. moulinsiana* habitat is not a linear feature running in narrow bands, but occurs in large blocks. It is estimated (using 'Grid Reference Finder') that *V. moulinsiana* was recorded in an area of 19.3 acres (7.82 hectares). As the southern and south-eastern population limits were not established, it is suggested that the full area of occupancy is considerably greater (than this already large area) and may include an additional 67.4 acres (27.3 hectares) (Figure 13). This makes the Afon Penrhos population not only the largest in Wales, but possibly one of the most extensive in mainland Britain. It is of considerable concern that this nationally important site has no statutory protection; SSSI status would seem to be urgently required. The significance of the Afon Penrhos population is perhaps further enhanced by the declines in *V. moulinsiana* populations elsewhere in Britain. Studies over the last 18 years have demonstrated *at least* an 85% decline in the formerly numerous populations of the snail in the Hampshire/Wiltshire River Avon SAC (Willing 2015, 2017). Similar extensive losses have been recorded in another SAC, that of the Rivers Kennet and Lambourn (Tattersfield & Killeen, 2006; Killeen, pers. comm.).

Figure 13: Approximate area of potential *Vertigo moulinsiana* habitat on Afon Penrhos suggested for further survey.

7. Conclusions & Recommendations

The population at **Cors Geirch** was found to have declined considerably, with a complete loss of the snail from former stronghold areas and just 17 shells recorded from two small areas at the southern end of the site in October 2016. Assessments in 2003 (Killeen, 2004) and 2008 (Lloyd, 2008) had considered the population to be in favourable condition. With an eight-year monitoring hiatus, the causes of the sharp decline are unclear but are likely to include the spread of uncut and un-grazed rank, fen vegetation combined with encroaching birch and sallow. Dense vegetation growth at the site was such that the former ditch-lines, used as features for site monitoring, were almost completely obscured and difficult to reach. Further survey work is required to determine if the visit coincided with a population trough. It may be necessary to re-establish the monitoring transect and undertake surveillance on a more regular basis. However, transects are hard to replicate, tend to ignore the 'bigger picture' of distribution across a site, and don't cater for dynamic changes to habitat conditions. As such, more regulat sampling by tray-beating may be preferable. If the population has indeed crashed, them remedial management is required to open up the *Cladium* beds and reduce the amount of encroaching scrub.

By contrast, the snail was found in large numbers on the **Afon Penrhos** floodplain where it is associated with atypical habitat - short, mechanically-cut and lightly horse-grazed 'fen-meadow'. Tall uncut fen supported significantly lower numbers. *V. moulinsiana* was recorded on about 19 acres (8 hectares) of the site, but population boundaries were not established on the eastern and south-east borders of the surveyed area. It is estimated that a further 75 acres (30 hectares) of potentially-suitable habitat exists which should be surveyed to determine if it supports the snail. The Afon Penrhos population is not only the largest in Wales, but also probably one of the largest in mainland Britain. The significance of the population here is further enhanced by recent considerable population losses at several SACs in southern England.

Further survey work at Afon Penrhos is required to establish the full extent of the snail population, particularly towards the east of the land boundary main ditch and also to the south of sites O and P (see Figure 13). Only areas north of the Afon Penrhos stream need to be visited because all potentially-suitable fen lying south of it were surveyed in 2008. A more detailed botanical study (to determine NVC communities) is required of the short 'fen-meadow' favoured by *V. moulinsiana* to help identify management requirements. Once the full extent of the population on Afon Penrhos is determined, **it is recommended that the site should be notified as a SSSI** to reduce any risk of loss or damage due to changes in site management, and to acknowledge its importance as a key site in the UK and in Europe.

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10. Appendices

Appendix 1: Site locations, brief habitat details, molluscan presence.

Table 3. Site locations and habitat descriptions at Cors Geirch.

Location point (LP) : with Grid Ref	Ground moisture (1 – 5)	Shading	General vegetation/ dominant species / site management	Figs.
A SH3294635776	4 - 5	Some occasional birch	Northern head of map-marked ditch line but this feature was not readily visible due to un-grazed, rank growth of *Phragmites australis*, *Cladium mariscus.* Away from ditch to east & west ranks *Myrica gale*, *Calluna vulgaris*, occasional *Betula*	Fig.14
B SH3925235721	5	Some occasional birch	Much as LP 'A': with rank growth of *Phragmites australis*, *Cladium mariscus.*	Fig.15
C SH3302435681 (Ce = east) SH3300935663 (Cw = west)	4 - 5	Moderate from young sallow & birch	Rank growth of *Phragmites australis*, *Cladium mariscus* with abundant birch and sallow (some recently bulldozed in a cut through this 'scubby-fen'	Fig.17
D SH3299635556 (Dw = west) SH3306835623 (De = east)	4 - 5	Moderate from young sallow & birch	ditch running east – west to join the former ditch running north – south (A – C); *Phragmites australis* & some marginal Myrica gale shaded by birch & sallow	Fig.18 Fig. 19
E SH3300935427	2 - 4	Nil	*Schoenus nigricans* tussocks on margins of small stream in association with *Myrica gale*, *Phragmites australis* (*Vertigo moulinsiana* recorded)	Fig.20
F SH3305235259	5	Nil	A ditch supporting emergent and marginal fen vegetation; *Juncus subnodulosus*, *Phragmites australis* (*Vertigo moulinsiana* recorded)	Fig. 21
G SH3303535265 (south) SH3310535364 (north)	3 - 4	Nil	Dense, ungrazed *Cladium mariscus* fen with occasional areas of *Phragmites australis*	Fig. 22

Table 4. Site locations and habitat descriptions at Afon Penrhos (west of central footpath).

Location point (LP) : with Grid Ref	Site wetness (1 – 5)	Shading	General vegetation/ dominant species / site management	Figs.
A SH3437433643	3 - 5	Nil	A ditch line infilled with emergent and marginal *Juncus* spp with some *Iris pseudacorus* (similar to other ditches in immediate vicinity).	Fig. 23, 24
B SH3438333655	4 - 5	Nil	Recently mechanically cut & lightly horse-grazed at time of survey *Juncus* spp, *Iris* sp, *Festuca ovina*, *Filipendula ulmaria, Potentilla palustris*. Vegetation height mostly <20cm. (*Vertigo moulinsiana* recorded)	Fig. 1
C SH3432733631	4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	Fig. 25

D SH3430133659	4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	-
E SH3436133620	4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	-
F SH3441333565	4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	Fig. 26
G SH3446433590	4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	-
H SH3450533590	3 - 4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	-
I SH3450333602 (south) SH3445133653 (north)	3 - 4	Nil	Rank uncut fen *Juncus* spp, *Filipendula ulmaria, Carex spp.* (*Vertigo moulinsiana* recorded @ SH 34474 33634)	Fig. 27
J SH3453733649	3 - 4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	Fig. 28
K SH3441533706	3 - 4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	-
L SH3434933742	3 - 4	Nil	Much as LP 'B' (*Vertigo moulinsiana* recorded)	-

Table 5. Site locations and habitat descriptions at Afon Penrhos (fenced footpath area & east of footpath).

Location point (LP) : with Grid Ref	Site wetness (1 – 5)	Shading	General vegetation/ dominant species / site management	Figs.
M SH3443933756 (n) SH3457833611 (s)	3- 5	Variable; most surveyed areas nil	Lightly horse-grazed fen in fenced area to west of footpath and on margins of and in channel of small stream (*Juncus* spp, *Carex* sp, *Iris pseudacorus*, *Filipendula ulmaria.* Beyond footpath and up to fence *Alnus* dominated woodland	Fig. 29
N SH3449733757 (w) SH3457633796 (e)	3	Nil	Uncut rank fen with *Juncus* spp*, Iris* sp, *Filipendula ulmaria, Potentilla palustris*, *Lycopus europaeus, Hydrocotyle vulgaris*, (bordered on western margin by fenced alder woodland and east by ditch and farm track). (*Vertigo moulinsiana* recorded - SH34549 33781)	Fig. 30
O SH3459133793 (w) SH3464533849 (e)	(3) - 4	Nil	Recently mechanically cut fen (dominant plant mix as J & K) to ditch *Vertigo moulinsiana* recorded.	Fig. 31
P SH3464533849 (w) SH3473033912 (e)	3 - 4	Nil	Uncut rank fen (dominant plant mix as J & K) with running from eastern ditch to deep boundary drain (marking end of land ownership & access permissions during survey). Similar grazing fen lying to east was not surveyed but appeared potentially suitable for *V. moulinsiana*.	Fig. 32

Appendix 2: Vegetation classes widely used to assess site habitat condition for *Vertigo moulinsiana.*

At many sites in southern and eastern England, *V. moulinsiana* displays a 'hierarchy of preference' for certain plant species. Table 6 (extracted from Killeen & Moorkens, 2003) displays such a hierarchy with a decreasing order of suitability decreasing from 'class I' (most suitable) to 'class IV' (least suitable).

Table 6. Classification of plant species in *Vertigo moulinsiana* habitats.

Class I	**Class II**
Reed sweet-grass (*Glyceria maxima*) Lesser pond-sedge (*Carex acutiformis*) Tufted sedge (*Carex elata*) Greater tussock-sedge (*Carex paniculata*) Greater pond-sedge (*Carex riparia*) Great fen-sedge (*Cladium mariscus*)	Reed canary-grass (*Phalaris arundinacea*) Common reed (*Phragmites australis*) Branched bur-reed (*Sparganium erectum*) Meadowsweet (*Filipendula ulmaria*) Stinging nettle (*Urtica dioica*)
Class III	**Class IV**
Water-mint (*Mentha aquatica*) Ambibious bistort (*Persicaria amphibium*) Willowherbs (*Epilobium* spp.)	*All other species*

Appendix 3: Short critique of condition assessment criteria for *Vertigo moulinsiana* at Cors Geirch.

A status condition objective was proposed for *V. moulinsiana* at Cors Geirch (Killeen, 2004). This was based upon the assessment of four attributes (see 6.1.1 above) each of which need to reach or exceed a particular threshold for the snail to be judged in favourable condition. In the light of this study and other factors, it is suggested that these criteria may need to be revised. Criteria considerations include:

Ground moisture levels

Advice on these are sound advising that *V. moulinsiana* sites should have ground moisture levels 2 – 4 (see Section 4: Methods) but ideally between 3 – 4.

Vegetation

Plant species assemblages: The prolific *V. moulinsiana* populations at Afon Penrhos were found in short-cut fen where the dominant plants were *Juncus* spp., *Festuca ovina*, *Potentilla palustris Iris pseudacorus* and *Filipendula ulmaria.* None of these species appears in the 'Class 1' listing of key 'most suitable' plants (see Appendix 2 above) for the snail as given in Killeen & Moorkens (2003) for sites in England and only one, *F. ulmaria,* appears in the 'Class II' list. It is therefore suggested that additional plant species be added to any similar protocol devised for Afon Penrhos. It is also possible that these plant classes may not be wholly appropriate for the very different conditions in West Wales (compared to the lowland English sites for which they were developed).

Vegetation height: In relation to Cors Geirch Killeen (2004, p.12) suggests that "the average height of vegetation should not be less than 70 cm as measured in August". The results at Afon Penrhos suggest that at this site (and possibly others in maritime West Wales) there is a negative correlation with increased vegetation height mirroring observations made by Holyoak at Penhale in Cornwall (Section 6.2. above).

Population density thresholds

For *V. moulinsiana* to achieve favourable status at Cors Geirch, population density thresholds were set thus: the snail to be present at 25/40 samples (62.5%) and that 15/40 (37.5%) of the samples equal or exceed 10 of the adult snails. These measures seem rather arbitrary considering they were based upon population counts from only two single day visits in October 1999 and November 2003. In his 2LL008 survey Lloyd found *V. moulinsiana* in all 40 samples whereas in 2003 Killeen only recorded the snail at 33 sites (83%). In terms of numbers of snails Lloyd recorded a mean adult count of 5.94 per sample with only 7 samples exceeding the protocol threshold. On the basis of this population density thresholds would have meant that the condition was assessed as unfavourable for the snail (although it met or exceeded the other 3 condition assessment criteria (for ground moisture, vegetation and area of occupancy). Lloyd judged that the snail number criteria to be over-presccriptive and failed to take account of natural fluctuations in snail numbers. He stated (2008), "*As a result of this re-appraisal it is considered appropriate to suspend the requirement for snail abundance as a performance indicator for this feature on*

*this site. The principle reasons underpinning suspension are that snail numbers on vegetation above the litter layer are highly variable and subject to numerous impacts such as rainfall, temperature and humidity".*This position reflects the JNCC 'Site Condition Monitoring' (SCM) (Guidance version March 2008 ISSN 1743-8160 online. The *Vertigo* species assessed at Cors Geirch conform to JNCC 'Option 2' species; i.e. ones where species presence or absence is linked to habitat attributes and quality and / or extent. To quote an adapted passage from the JNCC guidelines: "*Numbers of Vertigo species fluctuate wildly between years. It is unclear whether this represents fluctuations in the strength of the population or the detectability of the species dependent on ambient conditions. Setting a direct attribute for the numbers of individuals of the species would, therefore, appear to be impractical. However, the habitat conditions within which good populations of the species are found are now well known and hence an indirect attribute based on extent of suitable habitat can be utilised*". It is therefore suggested, in the absence of any robust population data, that presence or absence of *V. moulinsiana* should be the main focus of future condition assessment at Cors Geirch linked to whatever is deemed to be suitable habitat (and that may, as discussed earlier, be different in west Wales and Cornwall than in southern and eastern England.

Area of occupancy

The protocol assesses area of snail occupancy as presence in 25/40 samples (62.5%) based upon sampling along two transect lines. This fails to establish the overall site area occupied. This might instead be achieved by tray-beat sampling across the site to determine the true area of snail presence. Locating boundary points might be especially useful in determining range contraction or expansion.

Appendix 4: Site images of Cors Geirch and Afon Penrhos.

Figure 14: Cors Geirch - uncut fen near site A.

Figure 15: Cors Geirch - uncut fen near site B.

Figure 16: Cors Geirch – General view looking east showing over-grown condition of 'Ditch line 1 – 20' (lying where *Phragmites* meets birch / sallow).

Figure 17: Cors Geirch - uncut fen and encroaching sallow scrub near site Ce.

Figure 18: Cors Geirch - uncut fen and encroaching sallow & birch near site Dw.

Figure 19: Cors Geirch - uncut fen & encroaching scrub near site De.

Figure 20: Cors Geirch – sampling site E (*Vertigo moulinsiana* found by ditch).

Figure 21: Cors Geirch – site F (*Vertigo moulinsiana* on emergent *Juncus* spp/ *Phragmites* in ditch).

Figure 22: Cors Geirch – sampling location Gs.

Figure 23: Afon Penrhos point A (fen-filled ditch with cut meadows between).

Figure 24: Afon Penrhos near point A.

Figure 25: Afon Penrhos cut meadow at Point C (*Vertigo moulinsiana* present).

Figure 26: Afon Penrhos point F (*Vertigo moulinsiana* present).

Figure 27: Afon Penrhos point I - an area of uncut fen. (*Vertigo moulinsiana* present in very low numbers).

Figure 28: Afon Penrhos point J (*Vertigo moulinsiana* present in cut fen).

Figure 29: Afon Penrhos point M(n) (fence line on eastern margin of western block; *Vertigo moulinsiana* to right of fence in meadow but not in ~~to~~ dry heavily grazed land to left).

Figure 30: Afon Penrhos uncut fen at point N (*Vertigo moulinsiana* present).

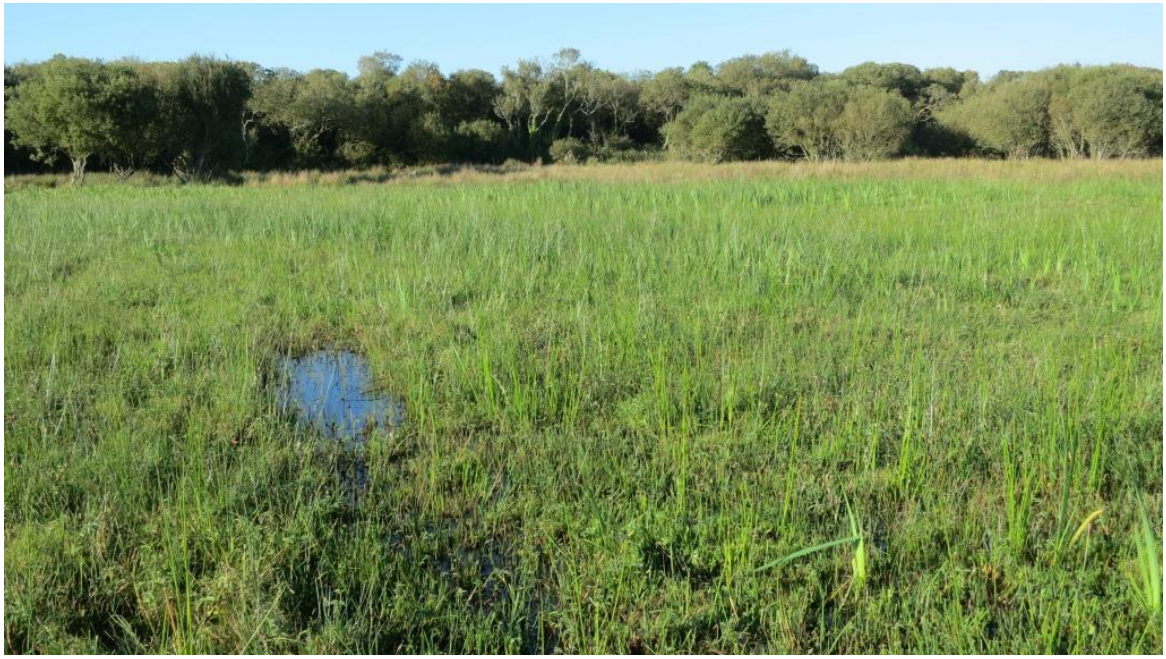

Figure 31: Afon Penrhos cut fen at point O (*Vertigo moulinsiana* present).

Figure 32: Afon Penrhos point P(e) (*Vertigo moulinsiana* present). Fen to left of ditch not surveyed but is potential *V. moulinsiana* habitat.

11. Data Archive Appendix

The data archive contains:

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

[B] Species records, which are held on the NRW Recorder 6 database.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://libcat.naturalresources.wales or http://catllyfr.cyfoethnaturiol.cymru by searching 'Dataset Titles'. The metadata is held as record no. 118898.

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