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MONITORING OF SITES AND HABITAT FOR THREE ANNEX II SPECIES OF WHORL SNAIL (*VERTIGO*)

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Department of Culture, Heritage and the Gaeltacht

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Front cover, small photographs from top row:

Coastal heath, Howth Head, Co. Dublin, Maurice Eakin; **Red Squirrel** *Sciurus vulgaris*, Eddie Dunne, NPWS Image Library; **Marsh Fritillary** *Euphydryas aurinia*, Brian Nelson; **Puffin** *Fratercula arctica*, Mike Brown, NPWS Image Library; **Long Range and Upper Lake**, Killarney National Park, NPWS Image Library; **Limestone pavement**, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Barn Owl** *Tyto alba*, Mike Brown, NPWS Image Library; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Vertigo moulinsiana, Maria P. Long

Monitoring of sites and habitat for three Annex II species of whorl snail (*Vertigo*)

Version 1.1

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Executive Summary

All three *Vertigo* species listed under Annex II of the EU Habitats Directive and present in Ireland were surveyed over a four-year period (2014-2017) at a total of 60 sites around Ireland (21 for *Vertigo angustior*, 19 for *Vertigo geyeri* and 20 for *Vertigo moulinsiana*). Of these 60 sites, 54 had been subject to a monitoring survey in the period 2008-2010, while six were newly added sites.

Sites were surveyed using the previous survey methodology with some alterations. The survey involved taking spot samples across a site, recording a suite of data at each one, and repeating any transects to allow a direct comparison of habitat. Based on the amount of suitable habitat present in a defined habitat polygon, the suitability of the polygon for supporting the target species was assigned to a category on a 5-point scale running from Optimal to Unsuitable.

Of the 21 *V. angustior* sites visited, four had an Overall conservation assessment of Favourable (green), five were Unfavourable-Inadequate (amber) and 12 were Unfavourable-Bad (red). For the 19 *V. geyeri* sites, there were three Favourable (green), six Unfavourable-Inadequate (amber) and 10 Unfavourable-Bad (red). The result for *V. moulinsiana* was four Favourable (green), six Unfavourable-Inadequate (amber) and 10 Unfavourable-Bad (red). Where the calculated results, based on the assessment criteria of the baseline survey (2008-2010), seemed not to reflect the situation on the ground, expert judgement was employed to suggest an amendment to the conservation assessment status, and a review of the assessment criteria.

Overall, these results represent a substantial decline in the conservation status for all three species since the 2008-2010 survey. The cause of these changes in status was principally due to the result of the Population assessment or Habitat assessment. In some cases this can be linked to changes in habitat due to pressures acting on the site (e.g. grazing regime, hydrological changes), while in other cases the cause of the decline is not clear. Differing weather patterns between the two survey periods may have played a role, while overly stringent assessment criteria were also considered to have been a factor.

Management actions are suggested based on the results of the Future prospects assessment, in which pressures and threats acting on the site are identified. In recognition of the differing microhabitat requirements of the three species and the site-specific issues involved, an overly prescriptive approach was not taken in making management recommendations. Management plans are needed at most sites, and NPWS is best placed to take the lead in their development and implementation. Stakeholder engagement is vital in implementing meaningful action at *Vertigo* sites, rather than taking a solely top-down approach, and so landowners and land users should be involved at all stages. Particularly for grazing management, land users will be best placed to decide on stocking rates and timing, once the desired habitat outcome is clearly understood by them. While summary management action recommendations are presented in this report, the individual site reports should be read for site-specific information.

Recent changes to the reporting requirements for population under Article 17 of the Habitats Directive may allow scope for simplification of the survey and assessment methodologies in the future. Recommendations are made in this report that focus on ways of simplifying and streamlining the current system, as well as generating more data on populations in a shorter time.

The future of the three Annex II *Vertigo* species across Ireland depends on developing and implementing the necessary management plans, continued monitoring, and further research into aspects of the biology and ecology of the target species. Based on the results of this survey and on the site-based methodology employed, widespread decreases in both population and habitat quality are apparent. Furthermore, these pressures are acting on *Vertigo* sites against the backdrop of the threat of large-scale ecological change that may come with climate change. Without the implementation of management plans, and crucially, active management taking place on the ground, current declines are likely to continue on many of the sites. However, the fact that new sites are still being found, some existing sites have been

extended, and there are sites that still have healthy *Vertigo* populations, shows there is still reason to be optimistic about the future of these three species in Ireland.

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We would like to thank Dr Roy Anderson, Dr Rory Hodd, Dr James Martin, Dr Fionnuala O'Neill, Dr Philip Perrin, Orla Daly and Emmi Virkki for their assistance on this project. Thank you also to the NPWS Conservation Rangers and District Conservation Officers for passing on their knowledge of sites, and all the landowners who facilitated our surveys. Thank you to Dr Evelyn Moorkens and Ian Killeen, whose extensive work on *Vertigo* in Ireland paved the way for this study. Thanks to Zoltan Fehér for sharing information on his work on *Vertigo* monitoring in Hungary and David Heaver for providing information on the UK *Vertigo moulinsiana* populations. Finally, we would like to thank Dr Brian Nelson (NPWS Project Officer) and Dr Deirdre Lynn for providing data and guidance on methodology and reporting.

1 Introduction

Of the eight species of whorl snail (*Vertigo*) found in Ireland, three are listed under Annex II of the EU Habitats Directive (92/43/EEC): *Vertigo angustior* Jeffreys, 1830 (species code 1014), *Vertigo geyeri* Lindholm, 1925 (species code 1013) and *Vertigo moulinsiana* (Dupuy, 1849) (species code 1016). As species of European interest, their protection requires the designation of Special Areas of Conservation (SACs) and, to date, there are 34 SACs in Ireland that list one or more *Vertigo* species as a qualifying interest. In addition, under Article 17 of the Habitats Directive, Ireland is obliged to report on the conservation status of these species every six years. For the previous cycle of reporting (2007-2012), a three-year monitoring project (2008-2010; Moorkens & Killeen 2011) was conducted covering 63 sites. The data gathered led to all three species being assessed as Unfavourable-Inadequate and declining in status for that reporting cycle (NPWS, 2013). The main pressures affecting these species are related to loss and degradation of habitat.

The current project aimed to carry out the monitoring recommendations of Moorkens & Killeen (2011) for 54 sites surveyed as part of the previous monitoring round and to survey six new sites in order to provide the necessary data for the current reporting cycle (2013-2018).

This report presents information on the survey methodologies (Section 2), summary of results (Section 3), discussion of results, management recommendations (Section 4) and recommendations on future monitoring (Section 5). This main report presents the summary results with all the individual site reports provided in three appendices (IV, V and VI) which are each available separately (Brophy & Long, 2019 a,b,c) and should be consulted for site-specific detail.

2 Methodology

2.1 Site selection

Fifty-four of the 63 sites surveyed as part of the previous monitoring round (Moorkens & Killeen, 2011) were selected by the National Parks and Wildlife Service (NPWS) for monitoring in the current survey, with six additional sites also included for which limited data existed. The sites surveyed as part of the current round of sampling are listed in Table 1 and the locations shown in Figure 1.

Table 1 List of *Vertigo* sites surveyed as part of the current monitoring in the period 2014-2017. Sites not included in the previous monitoring by Moorkens & Killeen (2011) are underlined.

Site code	Site name	County
Vertigo angustior		
VaCAM01	Beal Point	Kerry
VaCAM02	Derrynane	Kerry
VaCAM03	Dooaghtry	Mayo
VaCAM04	Glencolmcille	Donegal
VaCAM05	Kilshannig	Kerry
VaCAM06	Kinlackagh Bay	Donegal
VaCAM07	Maharees	Kerry
VaCAM08	Dog's Bay	Galway
VaCAM09	Fanore	Clare
VaCAM10	Killanley Glebe	Sligo
VaCAM11	Lahinch	Clare
VaCAM12	Malin Dunes	Donegal
VaCAM13	Pollardstown Fen	Kildare
VaCAM14	Streedagh Point Dunes	Sligo
VaCAM15	Bartraw	Mayo
VaCAM16	Inishmore Island	Galway
VaCAM17	Curragh Chase	Limerick
VaCAM19	Louisa Bridge	Kildare
VaCAM20	Ballysadare Bay	Sligo
VaCAM21	Strandhill Airport	Sligo
VaCAM22	Waterstown Lough	Westmeath
Vertigo geyeri		
VgCAM01	Meenaphuil	Leitrim
VgCAM02	Tievebaun	Leitrim
VgCAM03	Brackloon	Mayo
VgCAM04	Clonaslee Eskers	Laois
VgCAM05	Dooaghtry	Mayo
VgCAM06	Drimmon Lough	Roscommon
VgCAM08	Sheskinmore Lough	Donegal
VgCAM09	Annaghmore Lough	Roscommon
VgCAM10	Ballyness Bay	Donegal
VgCAM13	Easkey Valley	Sligo
VgCAM14	Polaguil Bay	Donegal
VgCAM15	Silver River	Laois

Site code	Site name	County
VgCAM16	Fermoyle	Mayo
VgCAM18	Fin Lough (Offaly)	Offaly
VgCAM20	Lisduff Fen	Offaly
VgCAM21	Ox Mountains	Sligo
VgCAM22	Pollardstown Fen	Kildare
VgCAM23	Waterstown Lough	Westmeath
VgCAM24	Duleek Commons	Meath
Vertigo moulinsiana		
VmCAM01	Borris	Carlow
VmCAM02	Fin Lough (Offaly)	Offaly
VmCAM03	Lough Owel	Westmeath
VmCAM04	Mountmellick	Laois
VmCAM05	Louisa Bridge	Kildare
VmCAM06	Ballybeg Lough	Clare
VmCAM08	Cappankelly	Westmeath
VmCAM09	Waterstown Lough	Westmeath
VmCAM10	Ballynafagh Lake	Kildare
VmCAM11	Charleville Lake	Offaly
VmCAM12	Curragh Chase	Limerick
VmCAM14	Kildallan Bridge	Westmeath
VmCAM15	Lisbigney Bog	Laois
VmCAM16	Lisduff Fen	Offaly
VmCAM17	The Murrough	Wicklow
VmCAM18	Pollardstown Fen	Kildare
VmCAM19	Portumna	Galway
VmCAM21	Royal Canal, Longford Branch	Longford
VmCAM22	Fiagh Bog	Tipperary
VmCAM23	Castletown	Waterford

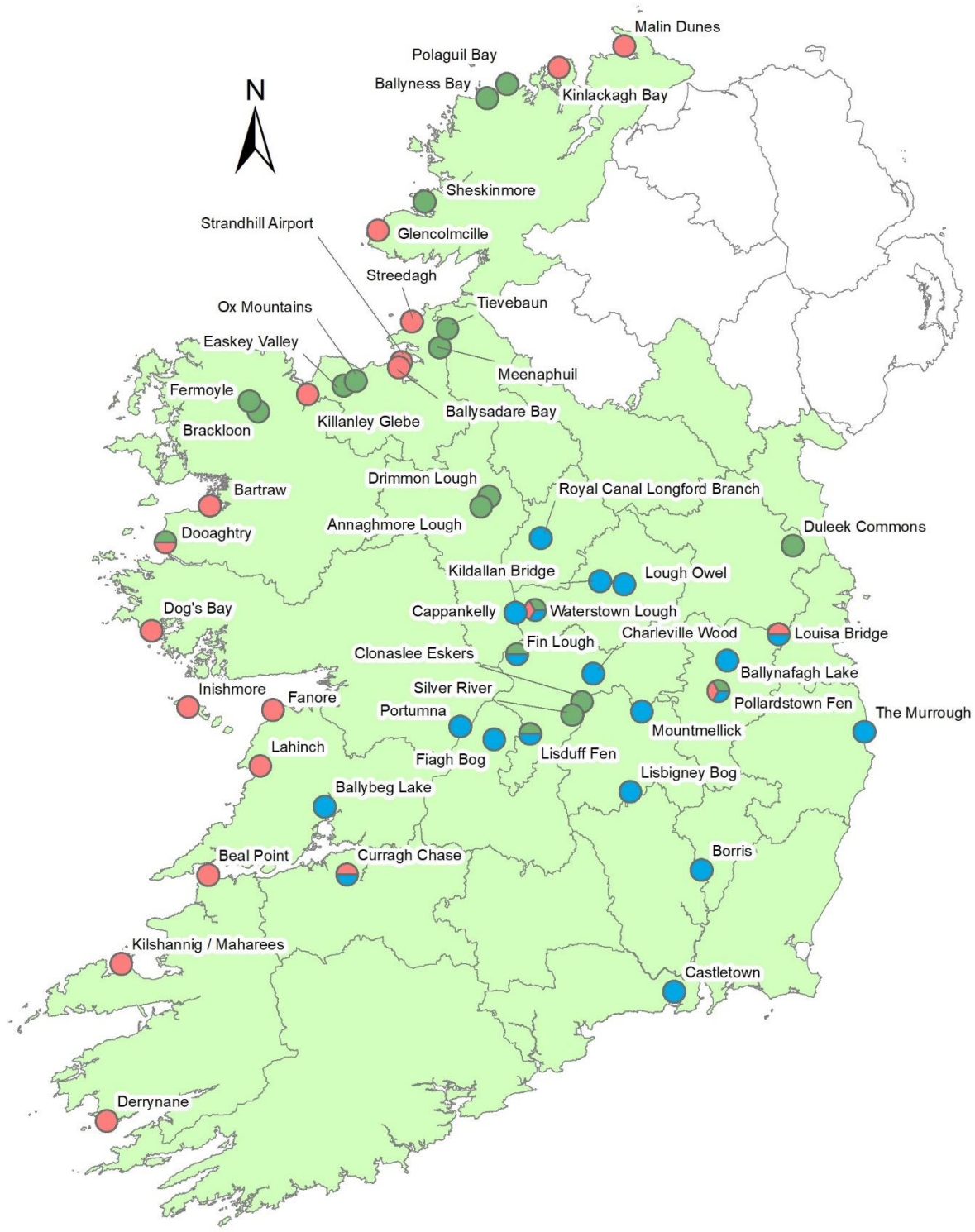

Figure 1 Distribution of survey sites for the 2014-2017 survey. Red indicates *Vertigo angustior* sites, green indicates *Vertigo geyeri* sites and blue indicates *Vertigo moulinsiana* sites. Note that some sites support more than one species.

2.2 Introduction to *Vertigo* species monitoring methodology

The methodology used in this survey is a modified version of that presented in Moorkens & Killeen (2011), which was adapted by Long & Brophy (2013) and during this project. The term 'baseline survey' or '2008-2010 survey' is frequently used when referring to the Moorkens & Killeen survey that took place between 2008 and 2010 and was reported in Moorkens & Killeen (2011). The term 'current survey' or '2014-2017 survey' is used when referring to the survey reported on in this volume. Changes were made to the original methodology to add clarification where it was required, to reduce subjectivity, and to allow the methodology to be utilised more readily by multiple ecologists over multiple recording years. Some of the main changes made include:

- introduction of a 5-point scale (replacing the 3-point scale) for describing habitat suitability of transect zones and spot samples, and a standardisation of the use of these terms when referring to polygons (see individual species methodology Sections 2.3-2.5)
- changing from measuring transect zones to the nearest 10 cm, to, in general, the nearest 1m, due to the difficulty in precisely relocating the transect start and end points
- changing (or adding) some assessment criteria to take account of issues such as a re-mapped polygon, a significant polygon for which no criterion existed, or a previous error (full list of changes in Appendix I).

The monitoring methodologies for the three species share many similarities, but because there are differences, and in order to allow practitioners to easily access a species-specific methodology, it was decided to present the complete methodology for *V. angustior*, *V. geyeri* and *V. moulinsiana* separately. In addition to the monitoring methodology for each of the three *Vertigo* species, introductory information modified from Moorkens & Killeen (2011) and Long & Brophy (2013) is included as it provides important context.

2.2.1 Note on terminology

The terminology used in Moorkens & Killeen (2011) to describe habitat suitability varied at times. In the current study a standardised terminology was used. The general relationship of the terms across the two studies is presented in Table 2. The precise definitions of the suitability classes for each species in the current and previous studies are presented in the respective methodology sections (Sections 2.3-2.5).

Table 2 Terminology for habitat suitability description used in Moorkens & Killeen (2011) and the current study.

Moorkens & Killen (2011), some commonly used terminology	Current study, standardised terminology
Optimal	Optimal
Optimal and sub-optimal, Sub-optimal with Optimal	Optimal-Suboptimal
Sub-optimal	Suboptimal
Sub-optimal and unsuitable, Unsuitable with areas of Sub-optimal	Suboptimal-Unsuitable
Unsuitable	Unsuitable

2.2.2 Summary of monitoring methodology

Each *Vertigo* population was assessed using specific assessment criteria based on those outlined in Moorkens & Killeen (2011) and Long & Brophy (2013). The monitoring for all three species had two main components: first, the use of repeatable transects and/or stratified spot sampling to record the presence of the target species and habitat suitability; and second, the broad-scale mapping of habitat quality at each site within polygons. The positioning of transects, the number of samples along each transect and the number of spot samples at each site generally followed the monitoring prescriptions laid out in the baseline survey, but changes were made where deemed appropriate (changes are listed in Appendix I). Threats, pressures and activities were also recorded at all sites, and these were used to inform the Future prospects assessment.

Overall conservation assessments were based on the results of Population, Habitat and Future prospects assessments[1]. In some instances, expert judgement was used during the current project to make recommendations with regard to the overall conservation assessment where it was felt that the calculated result did not accurately reflect the situation on site.

2.2.3 *Vertigo* habitat – general

The three *Vertigo* species being monitored require quite stable overall hydrological conditions. For these species to survive prolonged periods of wetter or drier weather, the snails require habitat heterogeneity that provides a gradient along which they can move as conditions become wetter or drier. The surveyor must take account of the type of habitat the snail will require during extreme weather events (e.g. 1 in 30-year droughts, 1 in 30-year floods). Thus there are microhabitat niches that are sub-optimal during normal conditions, but essential for survival during extreme conditions. Although it seems logical to assume that every site would benefit from being of consistent optimal habitat, some areas of apparently sub-optimal habitat are essential in order to provide refugia for the snail during extreme conditions.

Another factor to be considered is that because these snails are so small (2 mm or less), what appear to us to be minor topographical changes and slight fluctuations in groundwater levels can have substantial effects on them. Therefore, optimal, sub-optimal and unsuitable habitat can all be present within one square metre of habitat. Because mapping out patches of suitable habitat which might only be centimetres wide is not practical, the surveyor bases the assessment of habitat suitability on the overall suitability of a polygon and carries out mapping at a scale that is practicable. Therefore, some mapped polygons may be somewhat heterogeneous in terms of suitability for a species.

Further information on the ecology and habitat requirements of *Vertigo* species can be found in Speight, Moorkens & Falkner (2003) and Mzyzk (2011), and further detail is provided in the species-specific sections (Sections 2.3.1, 2.4.1 and 2.5.1). In addition, there has been considerable work carried out on the ecology of *Vertigo* species in recent years in some continental European countries in particular. For a gateway to some of this work, and featuring some of the key researchers, the following references may be useful. For *V. geyeri*, work by Michal Horsák and Michal Hájek is important (e.g. Horsák & Hájek, 2005, Schenková *et al*., 2012). There are a number of active researchers in Poland also, where a number of studies have focused on *V. angustior* and *V. moulinsiana*. Work by Książkiewicz in particular is relevant, and again, will provide a useful starting point for further reading (e.g. Książkiewicz *et al*., 2013, Książkiewicz & Goldyn, 2015, Książkiewicz-Parulska & Ablett, 2017).

[1] Following the convention used in the Article 17 reporting, where these words are capitalised, they refer to the Article 17 assessment parameters, otherwise they are used in the general meaning of the word.

2.2.4 Data collection and storage

For the mapping of *Vertigo* sites during the 2014-2017 survey, baseline survey mapping data (polygons, transects and sample points), checked and corrected as necessary during a 2014 data audit, and recent aerial imagery were displayed within an ArcPad GIS project on Trimble Nomad hand-held devices. The inbuilt GPS of the Trimble Nomad facilitates real-time navigation in the field in relation to polygon boundaries and location of transects, greatly improving efficiency and accuracy.

The Trimble Nomads were set up with a series of custom forms and tables in ArcPad and Turboveg to facilitate digital recording in the field. This reduced the time spent entering and checking data and also, through established file backup protocols, reduced the risk of data loss. Furthermore, the forms and tables were designed so that data could be entered in a format compatible with the Microsoft Access project database.

2.2.5 Digital mapping

ArcGIS-compatible polygon and point shapefiles produced as part of the baseline survey formed the basis of the GIS outputs for the current project. Hard copy aerial photographs with polygon boundaries were taken into the field to allow polygon boundary changes to be recorded for later digitisation. Each polygon was assigned to a habitat suitability class on the 5-point scale ranging from Optimal to Unsuitable and the reason for any changes since previous surveys recorded. Reference was made to the site-specific habitat suitability definitions of Moorkens & Killeen, as well as to the overall habitat definitions for the species in question.

Details of the shapefiles submitted as part of this project are presented in Appendix II.

2.2.6 Snail sample identification

Vertigo species were identified using Cameron (2003), Kerney & Cameron (1979) and other relevant works (e.g. Cameron *et al*., 2003), and specimens were recorded as either adult (a), juvenile (j) or dead (d). 'Dead' signifies specimens which were clearly long-dead, evidenced by broken or very worn/bleached shells, or clearly empty shells. Note that, as dead mollusc shells may persist for many years (in the right conditions, many hundreds of years), they cannot be counted as a positive result.

All snail samples were retained for the duration of the 2014-2017 monitoring project. Voucher specimens will be deposited with the National Museum, Dublin.

2.3 Monitoring methodology for *Vertigo angustior*

2.3.1 Background to the species

The Narrow-mouthed Whorl Snail, *Vertigo angustior*, grows to less than 2 mm in height. It has a narrow, yellowish-brown shell with its mouth opening to the left (i.e. sinistral), and with an easily identifiable set of teeth (Figure 2). Full descriptions and illustrations can be found in Kerney & Cameron (1979) and Pokryszko (1990). In April 2002, European experts on *Vertigo* species gathered together for a workshop that culminated in the production of species accounts and relevant papers on the four *Vertigo* species listed in the EU Habitats Directive. The publication from this workshop (Speight *et al.*, 2003) is recommended for a more detailed understanding of *V. angustior* in Europe, along with Moorkens & Gaynor (2003), Myzyk (2011) and Moorkens *et al.* (2012). Further avenues for relevant literature sources have been provided in Section 2.2.3.

Figure 2 *Vertigo angustior.* Photograph by M.P. Long. © M.P. Long.

At a broad level, this species can be present in a wide range of habitat categories such as dune grassland, fen, marsh, saltmarsh and floodplain. However, within these, it is restricted to a particular microhabitat, with the result that the exact conditions demanded by *V. angustior* are rare. The largest areas of occupancy in Ireland are damp sand dune systems in the west of the country. At other sites in Ireland it is restricted to a narrow band, sometimes only a few metres wide (but of variable length), where there is an appropriate transition zone between wetland and terrestrial habitats. Sites where the species is widespread, especially those with a variety of suitable habitats and wetness conditions occurring together, are of high conservation importance.

In wetlands, the snail is associated with decaying vegetation in the litter layer or damp moss in open unshaded habitats, where the openness is maintained by wetness or grazing levels. Generally it occurs in open-structured, humid litter, but in very wet conditions can climb 10-15 cm up the stems of plants or onto damp decaying timber. In dry conditions it may be found in the soil, just below the litter layer. In dune grassland it occurs at the base of tussocks of vegetation and among moss patches at the edge of dune slacks. In dunes that have a naturally high water table or are subject to high levels of precipitation, it can be found higher up on the tussocky vegetation and more generally throughout the habitat. *V. angustior* may also be found in and under flood debris.

This species requires friable soil and permanently moist litter providing humid conditions, shaded by moderately tall herbaceous or grassy vegetation, but in overall open conditions. It normally occurs in association with permanently moist but free-draining soil, not subject to inundation. It is the latter requirement that makes seemingly suitable and widespread habitat unable to sustain a population of *V. angustior*.

The protection of *V. angustior* under the EU Habitats Directive has resulted in the designation of SACs for the snail both in Ireland and in other EU countries. The maintenance of this species at favourable conservation status is a challenge given its patchy distribution, often amongst larger sites, many of which may have conflicting conservation and other management requirements.

2.3.2 Survey methodology

2.3.2.1 Timing of the survey

Although *V. angustior* can be found at any time during the year, there are optimum periods in which to survey. *V. angustior* can live for 12-18 months and are opportunistic breeders, particularly in humid weather. They lay small numbers of eggs, perhaps multiple times, during periods when conditions are favourable (Myzyk, 2011). Therefore, reproduction most often happens during spring or autumn, but sometimes during summer. Accordingly, surveys for this species should take place between April and October inclusive, in conditions that are not excessively wet. This was the timing followed in the current survey, as it offers the best chance of confirming the presence of the species in the field.

2.3.2.2 Sampling for Vertigo angustior

When weather conditions allow (dry conditions, low wind) it is best and easiest to process the samples taken for *V. angustior* in the field. Handfuls of *Festuca rubra* litter, moss and other material were shaken over a white tray, which was then searched by eye or using a headband magnifier. To ensure constancy of effort, the litter (collected over an area of approximately 5 m x 5 m) was first amalgamated into three-litre muslin bags.

If the weather was wet or too windy, or if the samples were from a wet habitat (e.g. an inland marsh), samples were bagged for drying and sorting in the lab. The samples were air-dried by spreading out each sample in a newspaper-lined cardboard box in a warm, ventilated room. The newspaper was changed and the samples turned frequently to aid drying. Once dry, the samples were either sorted and identified or were transferred to labelled zip-lock bags for later analysis. To aid the process of sorting, samples were passed through a series of sieves (mesh sizes: 0.5 mm, 1 mm and 5 mm). Material that passed through the 0.5 mm sieve was discarded, while the fractions retained in the 0.5 mm and 1 mm sieves were processed. Samples were emptied into shallow white trays and searched for molluscs under good light. All putative *Vertigo* specimens were identified and counted, or transferred to labelled glass vials for later work.

2.3.2.3 Mapping of polygons

Within each survey site, the polygons that had been mapped and assessed during the baseline survey were re-visited. Habitat suitability for the species was re-assessed and any changes in the polygon were mapped. Notes were made to account for any differences between the two survey periods. To assist in the practical application of polygon mapping, generally only changes in area greater than a minimum mapping unit of 100 m^2 were mapped. Given the small/linear nature of some areas of *Vertigo* habitat, however, this rule was applied with a degree of flexibility. Any mapped changes were denoted as either **ecological change** – where either natural factors or human activities (e.g. development, drainage, afforestation, changes in management) had brought about the change; or **interpreted change** – where the re-mapping of the polygon was due to differences in how the mapping methodology was applied between the 2014-2017 survey and the 2008-2010 baseline survey, or due to issues relating to mapping accuracy, or where the current assessment differed from the previous but no change was evident.

During the baseline survey the polygon boundaries were sometimes delineated by physical barriers, such as fences and hard-surfaced paths, or ecological boundaries such as a fen-grassland interface. In some cases, it was difficult to ascertain how the boundary was defined and here, the 2014-2017 survey confirmed or redrew improved the boundaries of polygons necessary. Any new areas of suitable habitat found within a site were also mapped.

2.3.2.4 Habitat suitability classifications

During the baseline survey, *V. angustior* habitat was divided into areas suitable for the species at the time of the survey, i.e. optimal and sub-optimal, and habitat unsuitable for the species. Moorkens & Killeen (2011) provided site-specific definitions of optimal and sub-optimal habitat for every site

surveyed, and these definitions were referred to when assessing polygons, transects and spot samples at individual sites during the 2014-2017 survey. The general or over-arching definitions of habitat suitability for *V. angustior* from Moorkens & Killeen (2011) are provided in Table 3.

Table 3 Over-arching habitat suitability definitions for *V. angustior* taken verbatim from Moorkens & Killeen (2011)

Habitat suitability class	**Definitions from Moorkens & Killeen (2011)**
Optimal	Where *V. angustior* could survive in a high proportion (at least 50%) of the habitat. This allows for areas that have, for example, *Iris pseudacorus* tussocks within cropped wet grassland. The snail cannot be found high in a tussock, but the structure of the tussock provides the variation that sustains the snail within the first 5–6 cm of its base, depending on the hydrological conditions on the day. Thus to provide this amplitude of habitat variation to cover annual variation, the growth of unsuitable microhabitat is necessary. Another example of optimal habitat is fixed narrow grass (principally *Festuca rubra*) grey dune habitat, where natural topographic differences will place some areas outside the humidity conditions required by the snail. The topographical changes also provide the niches for wet and dry extremes; therefore by their provision for these extremes, there will always be some habitat within them that is at least temporarily unsuitable.
Sub-optimal habitat	Where there are patches of vegetation and conditions that support *V. angustior*, but the majority of the habitat cannot (average 5% of the habitat). An example would be in terrain that is generally too wet, but with small areas of sloping transition edges.
Unsuitable habitat	Where the combination of vegetation and hydrological influence is outside the snail's range of tolerance. This may be natural unsuitability, e.g. due to proximity of bedrock or alternatively the snail may be restricted by excessive grazing or fertilisation of flat areas of dune grassland, or by patches of weeds arising due to enrichment, sometimes in the distant past. The exact cause of unsuitability cannot always be accurately assessed.

Within any polygon, combinations of the three categories listed above can be found. For that reason, to allow flexibility when assessing and to provide a guide to future surveyors, polygons were listed on a 5-point habitat suitability scale as shown in Table 4. This was developed as part of the current project in conjunction with NPWS, and while it aims to provide more detail to prospective *Vertigo* surveyors, it should be remembered that sites will vary, and expertise and experience is needed in deciding which point on the scale to apply to a polygon, point or transect zone.

For the 2014-2017 survey, the starting point for re-assessing the habitat suitability category of a polygon was to consider the classification provided by the 2008-2010 baseline survey. Expert judgement was then applied to decide if that suitability category was still appropriate for the polygon, in conjunction with the definitions of optimal and sub-optimal habitat for that specific site, and the 5-point habitat suitability scale listed above. As already noted, where the suitability category of a polygon was different in 2014-2017 compared to the baseline, notes were taken as to why, as well as identifying it as either an ecological change or one due to interpretation.

Photographs of examples of *V. angustior* habitat from the current survey are presented in Figure 3 (dune habitat close-up), Figure 4 (general view of dune habitat), Figure 5 (marsh habitat close-up) and Figure 6 (general view of marsh habitat).

Table 4 Five-point scale used for *V. angustior* habitat in the current survey, developed from Moorkens & Killeen (2011)

Habitat suitability class	Definition
1 Optimal	*V. angustio*r could survive in >50% of the habitat.
2 Optimal-Suboptimal	*V. angustior* could survive in 10-49% of the habitat.
3 Suboptimal	As used in Moorkens & Killeen (2011), *V. angustior* could survive in, on average, approximately 5% of the habitat. For the purposes of having an explicit definition, this definition was expanded to cover the range from 2% up to 9% of the habitat.
4 Suboptimal-Unsuitable	*V. angustior* could survive in only a very small section of the habitat (<2%). Moorkens & Killeen (2011) state that the habitat area should be "at least a number of metres square".
5 Unsuitable	There are no areas of suitable habitat i.e. the combination of vegetation and hydrological influence is outside the snail's typical range of tolerance.

Figure 3 Close-up of Optimal *Vertigo angustior* dune habitat at Bartraw (VaCAM15), Co. Mayo. Photograph by J.T. Brophy © NPWS

Figure 4 General view of Optimal *Vertigo angustior* dune habitat at Bartraw (VaCAM15), Co. Mayo. Photograph by J.T. Brophy © NPWS

Figure 5 Close-up of Optimal *Vertigo angustior* marsh habitat at Killanley Glebe (VaCAM10), Co. Sligo. Photograph by J.T. Brophy © NPWS

Figure 6 General view of Optimal *Vertigo angustior* marsh habitat at Killanley Glebe (VaCAM10), Co. Sligo. Photograph by J.T. Brophy © NPWS

2.3.2.5 Monitoring permanent transects

During the baseline survey, permanent transects were established within polygons in locations that were considered suitable for the species, as well as being accessible and easy to relocate. In the 2014-2017 survey, all baseline survey transects were located and re-sampled.

In the current survey, the grid reference at the start and end of each transect were recorded and photographs were taken at both the start and end to aid relocation and as a record of the habitat. The transect direction was recorded with a compass. Photographs were taken along the transect in a consistent manner, with a close-up photograph taken of each habitat zone from the end of the zone, and another taken looking back towards the start of the transect to provide a broader context.

Following the methods of Moorkens & Killeen (2011), each transect was divided into zones defining changes in habitat suitability. The linear mapping of ecological zones along the transect provided a more accurate small-scale description of habitat change than would be practical at the polygon scale. In the 2014-2017 survey, each permanent transect established by the baseline survey was monitored by re-establishing the transect and repeating the measurement of the length of the zones using 30m tapes, as well as re-assessing the habitat suitability of each zone. The data used to define the ecological zones are summarised in Table 5 and are based on wetness, habitat suitability and vegetation.

In the transect diagrams produced in Moorkens & Killeen (2011), which were the main method of recording transect information, each zone was colour-coded as optimal, sub-optimal or unsuitable, using the site-specific definitions. Each zone was also colour-coded for wetness, a key feature of *V. angustior* habitat. Examples of transect figures from the baseline survey can be found in Moorkens & Killeen (2011). For the 2014-2017 survey, the transect information was recorded in a standardised tabular form, allowing the data to be stored within the Microsoft Access database and a comparison to be made between surveys.

Table 5 Data recorded for each *Vertigo angustior* transect

Zones of wetness	Zones of habitat suitability	Vegetation notes
Definitions of wetness categories (Moorkens & Killeen, 2011): 1. Too wet - inundated to saturated; 2. Optimal wetness - damp and humid to the touch, often markedly warm in the summer; 3. Too dry - dry to the touch	Each zone is recorded within one of the five categories of Optimal, Optimal-Suboptimal, Suboptimal, Suboptimal-Unsuitable, or Unsuitable, with reference to the site-specific definitions given in Moorkens & Killeen (2011).	For each zone the main vascular plant species and bryophytes are listed (usually between three and five species). The types of species to include are those that are most common, or are characteristic of the habitat/vegetation type, or are important in terms of structure of the habitat. To avoid duplication, vegetation notes were not recorded from a zone if a transect sample point had already been recorded from within that zone.

During the baseline survey, sample points were recorded along the transect in representative areas of habitat. In the 2014-2017 survey, the location of sample points along the transect was recorded using both distance along the transect and grid references recorded with hand-held GPS devices (to allow subsequent mapping in GIS). An equivalent number of sample points to those recorded along the transect during the baseline survey were repeated during the 2014-2017 survey, though not necessarily in the same location.

For each sample point the distance along the transect was recorded from the measuring tape and the grid reference recorded using a hand-held GPS, ecological data were recorded (Table 6), and photographs were taken to record the habitat. If weather permitted, the presence of the species was confirmed in the field. If the species could not be recorded in the field a sample of litter and vegetation was collected from across a 5 m x 5 m area around the sample point. Approximately three litres of uncompacted litter was taken at each sample location, collected in muslin bags and air dried for later laboratory processing.

Table 6 Data recorded for each *Vertigo angustior* transect and spot sample point, adapted from Long & Brophy (2013)

Attribute	Measurement/category
Habitat suitability	5-point scale: Optimal, Optimal-Suboptimal, Suboptimal, Suboptimal-Unsuitable and Unsuitable
Habitat	Habitat code (Fossitt 2000)
Wetness	Too wet/Optimal wetness/Too dry
Vegetation height (cm)	Average and Maximum
Slope	Slope in degrees
Aspect	8 compass points: N, NE, E, SE, S, SW, W, NW
Weather	DS = dry and sunny, DC = dry and cloudy, LR = light rain, HR = heavy rain, RR = recent rain.
Grazers	Present/Absent/Evidence
Grazer type	Cattle/Sheep/Horses/Rabbit, etc.
Grazing level	1 = No grazing, 2 = Light grazing, 3 = Moderate grazing, 4 = Heavy grazing

To provide additional ecological context and enhanced vegetation and habitat information for each site, additional ecological data were recorded at a subset of representative spot or transect sample points (Table 7).

Table 7 Data recorded at a subset of *Vertigo angustior* transect and spot sample points, adapted from Long & Brophy (2013)

Attribute	Measurement/category
Vegetation data	Full species list of vascular plants and bryophytes including percentage cover
General data	Bare soil (%) Bare rock (%) Open water (%) Litter (%) Bryophytes (%) Field layer (%) Percentage cover recorded in 5% categories > 10%, with 0.1, 0.3, 0.5, 0.7, 1, 3, 5, and 7 utilised for cover less than 10%.

2.3.2.6 Monitoring spot samples

In addition to the transect data, spot samples were recorded across each site during the baseline survey and this was repeated in the current survey. As for the transect sample points, the grid reference of each spot sample was recorded using a hand-held GPS, ecological data were recorded (Table 6), photographs were taken and, if weather did not permit confirmation of *V. angustior* in the field, a sample of litter and vegetation was removed from a 5 m x 5 m area around the sample point. Additional ecological data (Table 7) were recorded from a subset of spot sampling points deemed to be representative of the various habitat types present at the site.

As for the transect sample points, the spot sampling points were not necessarily repeated at exactly the same locations as those in the baseline survey. As the purpose of the spot samples is to assess the occurrence of the species within a site, sampling in different areas assists our understanding of the range of the species across a site. When determining how many spot samples to take, and where to locate them, the monitoring prescriptions given in Moorkens & Killeen (2011) were consulted and the following items were considered:

1. At least one spot sample should be recorded from polygons classified as 'sub-optimal and unsuitable' or better.
2. All polygons with a positive sample for the target species in the baseline survey, even those mapped as unsuitable, should be spot sampled.
3. Spot samples may be allocated to address possible knowledge-gaps in terms of the species' distribution within the site as a whole.
4. Once spot samples have been allocated following items 1 to 3, the remaining spot samples for a site should be allocated proportionately to polygons based on the area of suitable habitat within each polygon.

2.3.3 Condition assessment monitoring

The condition assessment for *Vertigo angustior* at each site was based on the combined assessment results of three parameters: Population, Habitat and Future prospects.

2.3.3.1 Population assessment

The Population of *V. angustior* at each site was assessed by presence/absence at the transect level and at the site level (spot samples). The baseline survey set specific targets, based on expert judgement, of what each site's favourable condition should be. The 2014-2017 monitoring survey assessed the population at each site using the criteria established during the baseline survey and published in the individual site report of Moorkens & Killeen (2011). Some of these criteria were adjusted (see Appendix I), while new criteria were established for new sites.

For the Population assessment, each site either passed or failed specific criteria. The combination of the number of passes and failures resulted in a Population assessment of Favourable (green), Unfavourable-Inadequate (amber) or Unfavourable-Bad (red).

2.3.3.2 Habitat assessment

The *V. angustior* Habitat at each site was assessed at the transect level and site level. At the transect level, the baseline survey established targets for the number of zones and length in metres that should have optimal and/or sub-optimal *V. angustior* habitat. The baseline survey also established a target for the habitat quality of the transect as the length in metres that should have optimal wetness. At the site level, the baseline survey established a target for habitat extent as the number of hectares of suitable habitat at the site. The habitat suitability of the transect and site were reassessed in the 2014-2017 survey and the compared to the targets set. For new sites, similar targets were set in the current survey.

For the Habitat assessment, each site either passed or failed specific criteria. The combination of the number of passes and failures resulted in a Habitat assessment of Favourable (green), Unfavourable-Inadequate (amber), or Unfavourable-Bad (red).

2.3.3.3 Future prospects assessment

The Future prospects for *V. angustior* at each site were assessed by first listing the impacts and activities that were influencing or are likely to influence the site. The local NPWS Conservation Rangers were contacted during the 2014-2017 monitoring survey for additional information on the impacts and activities at a site. The standard list of impacts and activities (Ssymank, 2011) was applied during the 2014-2017 monitoring, as they were during the baseline survey. The location of each impact or activity (from inside or outside the site), its influence (positive, negative or neutral), intensity (low, medium or high) and the percentage of the site affected were also noted. The combination of the influences, both positive and negative, was balanced to assess the site's future prospects as Favourable (green), Unfavourable-Inadequate (amber) or Unfavourable-Bad (red).

If there were no significant negative impacts and activities and the long-term viability of the population was assured, then Future prospects were assessed as Favourable (green). If there were moderate negative impacts or management intervention was being implemented to address any negative impacts, then Future prospects were assessed as Unfavourable-Inadequate (amber). If there were high negative impacts and the viability was not assured in the long term, then Future prospects were assessed as Unfavourable-Bad (red). Long term is defined as being the length of two monitoring periods, i.e. 12 years (Ellmauer, 2010).

2.3.3.4 Overall condition assessment

The overall condition assessment for each site was a combination of the assessments of Population, Habitat and Future prospects. Where all three attributes were Favourable (green), the overall assessment was Favourable (green). If one or more attributes were assessed as Unfavourable-

Inadequate (amber) and the remainder were Favourable (green), the overall assessment was deemed to be Unfavourable-Inadequate (amber), and if one or more of the three attributes was assessed as Unfavourable-Bad (red), the overall assessment was deemed to be Unfavourable-Bad (red). The individual assessments of Population, Habitat and Future prospects and the overall condition assessment that were made during the 2014-2017 monitoring survey were compared with the assessments made in the baseline survey.

2.4 Monitoring methodology for *Vertigo geyeri*

2.4.1 Background to the species

Vertigo geyeri (Geyer's Whorl Snail) is small (<2 mm high), with a glossy shell with fine, regular growth-lines (Figure 7). It has four simple, peg-like teeth in the mouth or aperture. It is a member of the Family Vertiginidae and is one of three *Vertigo* species found in Ireland which are listed under Annex II of the EU Habitats Directive. Detailed information on identifying this species, along with its ecology, has been published (Kerney & Cameron, 1979, Cameron *et al.*, 2003, Cameron, 2003, Moorkens & Killeen, 2011), and the information presented below summarises the information found in these sources.

Figure 7 *Vertigo geyeri*. Photograph by M.P. Long © M.P. Long.

Vertigo geyeri has very specific habitat requirements. It is found at the bases of small sedges and mosses (often in the decaying leaf matter) in calcareous flushes and fens. The area of habitat which it occupies can sometimes be very small (e.g. isolated hillside flushes, and wet flushed areas of fen by calcareous lakes). This species requires stable hydrological conditions, needing the ground to be constantly saturated, yet it is not tolerant of flooding. It also requires quite open conditions, so light to moderate grazing levels are generally beneficial, though open conditions may also be maintained due to wetness. Plant species with which it is often associated include the sedges *Carex viridula* subsp. *brachyrrhyncha* and *Schoenus nigricans*, and the brown mosses of strongly calcareous fens and flushes (e.g. *Campylium stellatum*, *Drepanocladus*/*Scorpidium* spp. and *Palustriella commutata*). Tufa formation is a good indicator for the presence of this species. A degree of small-scale habitat heterogeneity greatly benefits the long-

term survival prospects of *V. geyeri* (e.g. small tussocks of *Schoenus nigricans*, small moss hummocks or uneven terrain), as it allows them to shelter or escape in conditions caused by very wet or very dry weather.

2.4.2 Survey methodology

2.4.2.1 Timing of the survey

Vertigo geyeri can live for 12-18 months and is an opportunistic breeder. While *V. geyeri* can be surveyed for at any time of the year, ideally, surveys for this species should take place between April and October, as this is the time that breeding is most likely to have occurred. Also, trampling damage to vulnerable and often small sites will likely be less outside of wetter periods. This was the timing followed by the current survey.

2.4.2.2 Sampling for Vertigo geyeri

Due to its small size, and also its usual physical location in the habitat (i.e. at the base of decaying sedges or in tufa-encrusted moss clumps), this species is exceptionally difficult to detect in the field when searching by eye. The fact that its habitat patches are often very small in size is also a confounding factor. Certainly, failure to locate the snail by searching in the field does not confirm that it is not present at a site. Taking samples for subsequent drying and sorting forms the most effective way of sampling a site for this species. During the 2014-2017 monitoring surveys, samples (consisting mainly of mosses, sedges, other plants and litter) were collected and removed from suitable habitat patches. All samples (approximately three litres, collected over an area of approximately 5m x 5m) were labelled and stored in muslin bags. The samples were then air-dried by spreading out each sample in a newspaper-lined cardboard box in a warm, ventilated room. The newspaper was changed and the samples turned frequently to aid drying. Once dry, the samples were either sorted and identified, or were transferred to labelled zip-lock bags for later analysis. To aid the process of sorting, samples were passed through a series of sieves (mesh sizes: 0.5 mm, 1 mm and 5 mm). Material that passed through the 0.5 mm sieve was discarded, while the fractions retained in the 0.5 mm and 1 mm sieves were processed. Samples were emptied into shallow white trays and searched for molluscs under good light. All putative *Vertigo* specimens were identified and counted or transferred to labelled glass vials for later work.

2.4.2.3 Mapping of polygons

Within each survey site, the polygons that had been mapped and assessed during the baseline survey were re-visited. Habitat suitability for the species was re-assessed and any changes in the polygon were mapped. Notes were made to account for any differences between the two survey periods. To assist in the practical application of polygon mapping, generally only changes in area greater than a minimum mapping unit of 100 m² were mapped. Given the small/linear nature of some areas of *Vertigo* habitat, however, this rule was applied with a degree of flexibility. Any mapped changes were denoted as either **ecological change** – where either natural factors or human activities (e.g. development, drainage, afforestation, changes in management) had brought about the change; or **interpreted change** – where the re-mapping of the polygon was due to differences in how the mapping methodology was applied between the 2014-2017 survey and the 2008-2010 baseline survey, or due to issues relating to mapping accuracy, or where the current assessment differed from the previous but no change was evident.

During the baseline survey the polygon boundaries were sometimes delineated by physical barriers, such as fences and hard-surfaced paths, or ecological boundaries such as a fen-grassland interface. In some cases, it was difficult to ascertain how the boundary was defined and here, the 2014-2017 survey confirmed or redrew improved the boundaries of polygons necessary. Any new areas of suitable habitat found within a site were also mapped.

2.4.2.4 *Habitat suitability classifications*

During the baseline survey *V. geyeri* habitat was divided into areas suitable for the species at the time of the survey, i.e. optimal and sub-optimal, and habitat unsuitable for the species. Moorkens & Killeen (2011) provided specific definitions of optimal and sub-optimal habitat for every site they surveyed, and these definitions were referred to when assessing polygons, transects and spot samples during the 2014-2017 survey. The general or over-arching definitions of habitat suitability for *V. geyeri* from Moorkens & Killeen (2011) are provided here in Table 8.

Table 8 Over-arching habitat suitability definitions for *V. geyeri* taken verbatim from Moorkens & Killeen (2011)

Habitat suitability class	**Definitions from Moorkens & Killeen (2011)**
Optimal	Where *V. geyeri* could survive in a large area (at least 50%) of the habitat. This allows for areas that have, for example, *Schoenus nigricans* tussocks. The snail will not normally be found high in a tussock, but the structure of the tussock provides the variation that sustains the snail within the first 5-6 cm of its base, depending on the hydrological conditions on the day. Thus to provide this amplitude of habitat variation to cover annual variation, the growth of unsuitable microhabitat is necessary. Another example of optimal habitat is calcareous cropped open sedge swards and moss carpets within undulating terrain. The topographical changes provide the niches for wet and dry extremes; therefore by their provision for these extremes, there will always be some habitat within them that is at least temporarily unsuitable. These habitats should not be changed to "improve" them, e.g. to make them wetter for more of the time, as the range of microtopography is important.
Sub-optimal habitat	Where there are patches of vegetation and conditions that support *V. geyeri* but the majority of the habitat cannot. This can be due to terrain being generally too high, but with small suitably wet runnel flushes occurring within, or where habitat is on the margin of base tolerance for the species, where acid influence promotes mainly calcifuge species, but where occasional groundwater seepage influence provides a suitable patch that the snail can occupy. Alternatively the snail may be restricted by succession due to lack of grazing, where the snail is shaded out of most of the area, except for patches prevented from growth by being wetter than their surroundings. Where there are patches of vegetation and conditions that support *V. angustior*, but the majority of the habitat cannot (average 5% of the habitat). An example would be in terrain that is generally too wet, but with small areas of sloping transition edges.
Unsuitable habitat	Areas of a site where the combination of vegetation and hydrological influence is entirely outside the snail's range of tolerance

Within any polygon, combinations of the three categories listed above can be found, and for that reason, to allow flexibility when assessing and to provide a guide to future surveyors, polygons were listed on a 5-point habitat suitability scale as in Table 9. This was developed in conjunction with NPWS, and while it aims to provide more detail to prospective *Vertigo* surveyors, it should be remembered that sites will vary, and expertise and experience is needed in deciding which point on the scale to apply to a polygon, point or transect zone.

Table 9 Five-point scale used for *V. geyeri* habitat in the current survey, developed from Moorkens & Killeen (2011)

Habitat suitability class	Definition
1 Optimal	*V. geyeri* could survive in >50% of the habitat.
2 Optimal-Suboptimal	*V. geyeri* could survive in 3-49% of the habitat.
3 Suboptimal	This was defined by Moorkens & Killeen (2011) where *V. geyeri* could survive in, on average, approximately 2% of the habitat.
4 Suboptimal-Unsuitable	*V. geyeri* could survive in only a very small section of the habitat (<2%). Moorkens & Killeen (2011) state that the habitat area should be "at least a number of square metres".
5 Unsuitable	There are no areas of suitable habitat i.e. the combination of vegetation and hydrological influence is outside the snail's typical range of tolerance.

For the 2014-2017 survey, the starting point for re-assessing the habitat suitability category of a polygon was to consider the classification provided by the 2008-2010 baseline survey. Expert judgement was then applied to decide if that suitability category was still appropriate for the polygon, in conjunction with the definitions of Optimal-Suboptimal habitat for that specific site, and the 5-point habitat suitability scale listed above. For this species in particular, the often small and fragmented nature of its habitat patches (e.g. small, isolated, tufa springs) also needed to be factored into the decision. As already noted, where the suitability category of a polygon was different in 2014-2017 compared to the baseline, notes were taken as to why, as well as identifying it as either an ecological change or one due to interpretation.

Photographs of examples of *V. geyeri* habitat from the current survey are presented in Figure 8 (close-up) and Figure 9 (general view).

Figure 8 Close-up of Optimal *Vertigo geyeri* habitat at Tievebaun (VgCAM02), Co. Leitrim. Photograph by J.T. Brophy © NPWS

Figure 9 General view of Optimal *Vertigo geyeri* habitat at Tievebaun (VgCAM02), Co. Leitrim. Photograph by J.T. Brophy © NPWS

2.4.2.5 Monitoring permanent transects

During the baseline survey, permanent transects were established within polygons in locations that were considered suitable for the species, as well as being accessible and easy to relocate. In 2014-2017, baseline survey transects were located and re-sampled.

In 2014-2017, the grid references at the start and end of each transect were recorded, and photographs were taken at both the start and end to aid relocation and as a record of the habitat. The transect direction was recorded with a compass. Photographs were taken along the transect in a consistent manner, whereby a close-up photograph was taken of each habitat zone from the end of the zone, and a second photograph taken looking back towards the start of the transect to provide a broader context.

Following the methods of Moorkens & Killeen (2011) each transect was divided into zones defining changes in habitat suitability. The linear mapping of ecological zones along the transect provided a more accurate small-scale description of habitat change than would be practical at the polygon scale. In the 2014-2017 survey each permanent transect established by the baseline survey was monitored by re-establishing the transect and repeating the measurement of the length of the zones, as well as re-assessing the habitat of each zone. The data used to define the ecological zones are summarised in Table 10, and are based on wetness, habitat suitability and vegetation.

In the transect diagrams produced in Moorkens & Killeen (2011), which were the main method of recording transect information was recorded, each zone was colour-coded as optimal, sub-optimal or unsuitable, using the site-specific definitions. Each zone was also colour-coded for wetness, a key feature of *V. geyeri* habitat. Examples of transect figures from the baseline survey can be found in Moorkens & Killeen (2011). For the 2014-2017 monitoring survey the transect information was recorded in a standardised tabular form, allowing the data to be stored within the Access database and a comparison to be made between surveys.

Table 10 Data recorded for each *Vertigo geyeri* transect

Zones of wetness	**Zones of habitat suitability**	**Vegetation notes**
Definitions of wetness categories (Moorkens & Killeen, 2011): 1. Too wet – inundated 2. Optimal wetness - saturated, water visibly rising following hand or foot pressure 3. Too dry - water not visibly rising following hand or foot pressure	Each zone is recorded within one of the five categories of Optimal, Optimal-Suboptimal, Suboptimal, Suboptimal-Unsuitable, or Unsuitable, with reference to the site-specific definitions given in Moorkens & Killeen (2011).	For each zone the main vascular plant species and bryophytes are listed (between three and five species). The types of species to include are those that are most common, or are characteristic of the habitat/vegetation type, or are important in terms of structure of the habitat. To avoid duplication, vegetation notes were not recorded from a zone if a transect sample point had already been recorded from within that zone

During the baseline survey, sample points were recorded along the transect in representative areas of habitat. In the 2014-2017 survey, the location of sample points along the transect was recorded using both distance along the transect and grid references recorded with hand-held GPS devices (to allow subsequent mapping in GIS). An equivalent number of sample points to those recorded along the transect during the baseline survey were repeated during the 2014-2017 monitoring survey, though not necessarily in the same locations as before.

In 2014-2017, for each sample point the distance along the transect and the grid reference were recorded using a hand-held GPS, ecological data were recorded (Table 11), and a photograph was taken to record the habitat. A sample of plants, moss and litter was collected from across a 5m x 5m area around the sample point. Approximately three litres of uncompacted litter was taken at each sample, collected in muslin bags and air dried for later laboratory processing.

Table 11 Data recorded for each *Vertigo geyeri* transect and spot sample point, adapted from Long & Brophy (2013)

Attribute	**Measurement/category**
Habitat suitability	5-point scale: Optimal, Optimal-Suboptimal, Suboptimal, Suboptimal-Unsuitable and Unsuitable
Habitat	Habitat code (Fossitt 2000)
Wetness	Too wet/Optimal wetness/Too dry
Vegetation height (cm)	Average Maximum
Slope	Slope in degrees
Aspect	8 compass points: N, NE, E, SE, S, SW, W, NW
Weather	DS = dry and sunny, DC = dry and cloudy, LR = light rain, HR = heavy rain, RR = recent rain.
Grazers	Present/Absent/Evidence
Grazer type	Cattle/Sheep/Horses/Rabbit, etc
Grazing level	1 = No grazing, 2 = Light grazing, 3 = Moderate grazing, 4 = Heavy grazing

To provide additional ecological context and enhanced vegetation and habitat information for each site, additional ecological data were recorded at a subset of representative spot and transect sample points (Table 12).

Table 12 Additional data recorded at a subset of *Vertigo geyeri* transect and spot sample points, adapted from Long & Brophy (2013).

Attribute	Measurement/category
Vegetation data	Full species list of vascular plants and bryophytes including percentage cover. Percentage cover recorded in 5% categories ≥ 10%, with 0.1, 0.3, 0.5, 0.7, 1, 3, 5, and 7 utilised for cover less than 10%.
Physical characteristics	% Bare soil, Bare rock, Open water, Litter, Bryophytes, and Field layer. Percentage cover recorded in 5% categories ≥ 10%, with 0.1, 0.3, 0.5, 0.7, 1, 3, 5, and 7 utilised for cover less than 10%.

2.4.2.6 Monitoring spot samples

In addition to the transect data, spot samples were recorded across each site during the baseline survey and this was repeated in the current survey. As for the transect sample points, the grid reference of each spot sample was recorded using a hand-held GPS, ecological data were recorded (Table 11), photographs were taken, and a sample of plants, moss and litter was removed from a 5m x 5m area around the sample point. Additional ecological data (Table 12) were recorded from a subset of spot sampling points deemed to be representative of the various habitat types present at the site.

As for the transect sample points, the spot sampling points were not necessarily repeated at exactly the same locations as those in the baseline survey. As the purpose of the spot samples is to assess the occurrence of the species within a site, sampling in different areas assists our understanding of the range of the species across a site. When determining how many spot samples to take, and where to locate them, the monitoring prescriptions given in Moorkens & Killeen (2011) were consulted, and the following items were considered:

1. At least one spot sample should be recorded from polygons classified as 'sub-optimal and unsuitable' or better.
2. All polygons with a positive sample for the target species in the baseline survey, even those mapped as unsuitable, should be spot sampled.
3. Spot samples may be allocated to address possible knowledge-gaps in terms of the species' distribution within the site as a whole.
4. Once spot samples have been allocated following items 1 to 3, the remaining spot samples for a site should be allocated proportionately to polygons based on the area of suitable habitat within each polygon.

2.4.3 Condition assessment monitoring

The condition assessment for *V. geyeri* at each site was comprised of three parameters: a Population assessment, a Habitat assessment, and an assessment of Future prospects.

2.4.3.1 Population assessment

The Population of *V. geyeri* at each site was assessed by presence/absence at the transect level and at the site level (spot samples). The 2014-2017 monitoring survey assessed population at each site using the

criteria established during the baseline survey and published in the individual site reports of Moorkens & Killeen (2011). Some of these criteria were adjusted (see Appendix I), while new criteria were established for new sites.

For the Population assessment, each site either passed or failed specific criteria. The combination of the number of passes and failures resulted in a Population assessment of Favourable (green), Unfavourable-Inadequate (amber) or Unfavourable-Bad (red).

2.4.3.2 Habitat assessment

The *V. geyeri* Habitat at each site was assessed at the transect level and site level. At the transect level, the baseline survey established targets for the number of zones and length in metres that should have optimal and/or sub-optimal *V. geyeri* habitat. The baseline survey also established a target for the habitat quality of the transect as the length in metres that should have optimal wetness. At the site level, the baseline survey established a target for habitat extent as the number of hectares of suitable habitat at the site. The habitat suitability of the transect and site were reassessed in the 2014-2017 survey and the compared to the targets set. For new sites, similar targets were set in the current survey.

For the Habitat assessment, each site either passed or failed specific criteria. The combination of the number of passes and failures resulted in an assessment for each parameter as being Favourable (green), Unfavourable-Inadequate (amber), or Unfavourable-Bad (red).

2.4.3.3 Future prospects assessment

The Future prospects for *V. geyeri* at each site were assessed by first listing the impacts and activities that were influencing or are likely to influence the site. The local NPWS Conservation Rangers were contacted during the 2014-2017 monitoring survey for additional information on the impacts and activities at a site. The standard list of impacts and activities (Ssymank, 2011) was applied during the 2014-2017 monitoring, as they were during the baseline survey. The location of each impact or activity (from inside or outside the site), its influence (positive, negative or neutral), intensity (low, medium or high) and the number of hectares of suitable habitat affected were also noted. The combination of the influences, both positive and negative, was balanced to assess the site's future prospects as Favourable (green), Unfavourable-Inadequate (amber), or Unfavourable-Bad (red).

If there were no significant negative impacts and activities and the long-term viability of the population was assured, then future prospects were assessed as Favourable (green). If there were moderate negative impacts or management intervention was being implemented to address any negative impacts, then future prospects were assessed as Unfavourable-Inadequate (amber). If there were high negative impacts and the viability is not assured in the long-term, then future prospects were assessed as Unfavourable-Bad (red). Long-term is defined as being at the length of two monitoring periods, i.e. 12 years (Ellmauer, 2010).

2.4.3.4 Overall condition assessment

The overall condition assessment for each site was a combination of the assessments of Population, Habitat and Future prospects. Where all three attributes were Favourable (green), the overall assessment was Favourable (green). If one attribute was assessed as Unfavourable-Inadequate (amber) and the remainder were Favourable (green), the overall assessment was deemed to be Unfavourable-Inadequate (amber), and if one of the three attributes was assessed as Unfavourable-Bad (red), the overall assessment was deemed to be Unfavourable-Bad (red). The individual assessments of Population, Habitat and Future prospects and the overall condition assessment that were made during the baseline survey were compared with the assessment made in the 2014-2017 monitoring survey.

2.5 Monitoring methodology for *Vertigo moulinsiana*

2.5.1 Background to the species

Vertigo moulinsiana (Desmoulin's Whorl Snail) is a small (up to 2.7 mm high), egg-shaped, red-brown snail (Figure 10), with a glossy shell and teeth present in its aperture. It is a member of the Family Vertiginidae and is one of three *Vertigo* species found in Ireland which are listed under Annex II of the EU Habitats Directive. Despite its small size, it is the largest of the Vertiginidae found in Ireland. Further information on this species can be found in Kerney & Cameron (1979), Cameron *et al.* (2003), Cameron (2003), Killeen (2003a), Killeen (2003b), Killeen & Moorkens (2003), and Moorkens & Killeen (2011), and the information given below summarises it.

Vertigo moulinsiana shows a preference for calcareous wetland places, though the vegetation structure is different from that preferred by *V. geyeri*. *Vertigo moulinsiana* needs tall-growing vegetation, and as such, is often associated with reed-beds and swamps, and some types of fens (e.g. *Cladium* fens) and marshes. Suitable vegetation types are additionally often found bordering waterbodies such as canals, ditches, lakes and rivers. Examples could include areas with *Glyceria maxima*, *Phragmites australis* and some tall or tussock-forming *Carex* species. This species, in contrast with *V. geyeri*, can migrate considerable distances vertically during the year, climbing high in the vegetation in autumn, and remaining low during winter.

Figure 10 *Vertigo moulinsiana*. Photograph by M.P. Long © M.P. Long.

2.5.2 Survey methodology

2.5.2.1 Timing of the survey

Cameron *et al.* (2003) report that peak reproduction for *V. moulinsiana* is in the summer, resulting in large numbers of juveniles being present in the autumn. This species also tends to climb high on vegetation at this time of the year, making it the most suitable time to survey. Thus September to

November are the most appropriate months for *V. moulinsiana* surveys. This timing was generally followed in the current survey.

2.5.2.2 *Sampling for* Vertigo moulinsiana

Vertigo moulinsiana can generally be identified in the field, although some specimens may be collected to confirm identification, particularly if juvenile. In areas of suitable habitat, vegetation was beaten over a white tray (approximately 50 cm x 50 cm). At each sample point, three adjacent areas were beaten and these were treated as single samples, with specimens pooled in the field. Molluscs collected on the tray were either identified in the field and recorded, or transferred into glass jars for return to the laboratory.

2.5.2.3 *Mapping of polygons*

Within each survey site, the polygons that had been mapped and assessed during the baseline survey were re-visited. Habitat suitability for the species was re-assessed and any changes in the polygon were mapped. Notes were made to account for any differences between the two survey periods. To assist in the practical application of polygon mapping, generally only changes in area greater than a minimum mapping unit of 100 m² were mapped. Given the small/linear nature of some areas of *Vertigo* habitat, however, this rule was applied with a degree of flexibility. Any mapped changes were denoted as either **ecological change** – where either natural factors or human activities (e.g. development, drainage, afforestation, changes in management) had brought about the change; or **interpreted change** – where the re-mapping of the polygon was due to differences in how the mapping methodology was applied between the 2014-2017 survey and the 2008-2010 baseline survey, or due to issues relating to mapping accuracy, or where the current assessment differed from the previous but no change was evident.

During the baseline survey the polygon boundaries were sometimes delineated by physical barriers, such as fences and hard-surfaced paths, or ecological boundaries such as a fen-grassland interface. In some cases, it was difficult to ascertain how the boundary was defined and here, the 2014-2017 survey confirmed or redrew improved the boundaries of polygons necessary. Any new areas of suitable habitat found within a site were also mapped.

2.5.2.4 *Habitat suitability classification*

In the baseline survey, *V. moulinsiana* habitat was divided into areas suitable for the species at the time of the survey, i.e. optimal and sub-optimal, and habitat unsuitable for the species. Moorkens & Killeen (2011) provided specific definitions of optimal and sub-optimal habitat for every site they surveyed based on vegetation class (Table 13) and wetness (Table 14). These definitions were referred to when assessing polygons, transects and spot samples during the 2014-2017 survey. The general or over-arching definitions of habitat suitability for *V. moulinsiana* from Moorkens & Killeen (2011) are provided in Table 15.

Table 13 An example of vegetation classes for a *Vertigo moulinsiana* site. Plant species are classified into four groups at each site, with Class I being the most suitable and Class IV being the least suitable. Note that this is an example only - the baseline survey (Moorkens & Killeen 2011) has defined different classifications for each site, and these are found in the individual site reports.

Class I	Class II	Class III	Class IV
Tall *Carex* species	*Cladium mariscus*	*Juncus subnodulosus*	All other species
Schoenus nigricans	*Equisetum fluviatile*	*Menyanthes trifoliata*	
Phragmites australis		*Mentha aquatica*	
		Angelica sylvestris	

Table 14 Five wetness classes defined by Moorkens & Killeen (2011) for *Vertigo moulinsiana* habitats.

Wetness class	Wetness class description
1	Dry – no visible moisture on ground surface
2	Damp – ground visibly damp, but water does not rise under pressure
3	Wet – water rises under light pressure
4	Very wet – pools of standing water, generally <5 cm deep
5	Site under water – entire sampling site in standing or flowing water >5 cm deep

Table 15 Over-arching habitat suitability definitions for *V. moulinsiana* taken verbatim from Moorkens & Killeen (2011)

Habitat suitability class	Definitions from Moorkens & Killeen (2011)
Optimal	Where *V. moulinsiana* could survive in a large area (average 50%) of the habitat. It includes a good distribution of tall *Carex* species, sometimes interspersed with *Schoenus nigricans* and *Phragmites australis*. It is wet enough for water to rise and surround the surveyor's boot under light pressure.
Sub-optimal habitat	Where there are patches of vegetation and conditions that support *V. moulinsiana* (average 10% of habitat), but the majority of the habitat cannot. An example would be in terrain that is generally too wet, but with small patches of tussocks arising out of open water, or an area of low growing *Schoenus* interspersed by a few taller tussocks. In these situations the snail uses the lower growing *Schoenus* to spread across relatively wide areas, so although they are not used every year, and are unsuitable for most of the time, they are essential to the function of the population. Sub-optimum wetness is either open water (too wet) or damp conditions where water does not rise under light pressure (too dry).
Unsuitable habitat	Area of the site where the combination of vegetation and hydrological influence is outside the snail's range of tolerance. This may be natural unsuitability (e.g. where bedrock is close to the surface), or alternatively the snail may be excluded by excessive cutting or burning of vegetation.

For the 2014-2017 survey, the starting point for re-assessing the habitat suitability category of a polygon was to consider the classification provided by the 2008-2010 baseline survey. Expert judgement was then applied to decide if that suitability category was still appropriate for the polygon, in conjunction with the definitions of optimal and sub-optimal habitat for that specific site, and the 5-point habitat suitability scale listed in Table 16. As already noted, where the suitability category of a polygon was assessed as being different in 2014-2017 compared to the baseline, notes were taken as to why, as well as identifying it as either an ecological change or one due to interpretation.

Table 16 Five-point scale used for *V. moulinsiana* habitat in the current survey developed from Moorkens & Killeen (2011).

Habitat class	Definition
Optimal	*V. moulinsiana* could survive in ≥50% of the habitat
Optimal-suboptimal	*V. moulinsiana* could survive in 16-49% of the habitat
Suboptimal	For this category Moorkens & Killeen (2011) state that *V. moulinsiana* could survive in, on average, 10% of the habitat. This definition was expanded to cover the range 5- 15%.
Suboptimal-Unsuitable	*V. moulinsiana* could survive only in a very small section of the habitat (<5%). Moorkens & Killeen (2011) state that the habitat area should be "at least a number of metres square".
Unsuitable	There are no areas of habitat where the combination of vegetation and hydrological influence is within the snail's known range of tolerance.

For the 2014-2017 survey, the starting point for re-assessing the habitat suitability category of a polygon was to consider the classification provided by the 2008-2010 baseline survey. Expert judgement was then applied to decide if that suitability category was still appropriate for the polygon, in conjunction with the definitions of optimal and sub-optimal habitat for that specific site, and the 5-point habitat suitability scale listed above. As already noted, where the suitability category of a polygon was assessed as being different in 2014-2017 compared to the baseline, notes were taken as to why, as well as identifying it as either an ecological change or one of interpretation.

An example of *V. moulinsiana* habitat from the current survey is shown in Figure 11.

Figure 11 View of Optimal *Vertigo moulinsiana* habitat at Royal Canal, Longford Branch (VmCAM21), Co. Longford. Photograph by J.T. Brophy © NPWS.

2.5.2.5 Monitoring permanent transects

During the baseline survey, permanent transects were established within polygons in locations that were considered suitable for the species, as well as being accessible and easy to relocate. In 2014-2017, baseline survey transects were located and re-sampled.

In 2014-2017, the grid references at the start and end of each transect were recorded, and photographs were taken at both the start and end to aid relocation and as a record of the habitat. In addition, the transect direction was recorded with a compass. Photographs were also taken along the transect.

The transect methodology devised by Moorkens & Killeen (2011) for *V. moulinsiana* differed from the other two species in that multiple samples were taken at roughly regular intervals along a transect, rather than it being divided into zones from which small numbers of vegetation samples were removed. This was done because the species can be relatively easily seen and counted in the field, and also because the removal of tall-growing vegetation would be difficult (as compared to sample removal for *V. geyeri*).

At each sample point along a *V. moulinsiana* transect the following information was recorded:

- date of survey
- transect identifier
- number of metres from the start of the transect and grid reference
- 1-3 of the most common vascular plant species present, with most dominant noted first
- vegetation class (e.g. Table 13)
- vegetation height
- ground moisture class (Table 14)
- numbers of *V. moulinsiana*, noting adults and juveniles separately

Transect diagrams were not produced by Moorkens & Killeen (2011) for *V. moulinsiana*. Instead, tables providing the data listed above were used. Examples can be found in Moorkens & Killeen (2011). For the 2014-2017 monitoring survey the transect information was again recorded in this format to allow a comparison between surveys.

During the baseline survey sample points were recorded at multiple points along the transect. The location of sample points was recorded using both distance along the transect and grid references recorded with hand-held GPS devices. An equivalent number of sample points to those recorded during the baseline survey were repeated during the 2014-2017 monitoring survey, though not necessarily in the same location.

To provide additional ecological context and enhanced vegetation and habitat information for each site, at a subset of representative sample points along the transect a more detailed set of ecological parameters was recorded (Table 17). These data were recorded from an area of approximately 5 m x 5 m around a sample point.

Table 17 Data recorded for a subset of *Vertigo moulinsiana* transect and spot sample points, adapted from Long & Brophy (2013).

Attribute	Measurement/category
Vegetation data	Full species list of vascular plants and bryophytes including percentage cover. Percentage cover recorded in 5% categories ≥ 10%, with 0.1, 0.3, 0.5, 0.7, 1, 3, 5, and 7 utilised for cover less than 10%.
Vegetation class	Vegetation class (I to IV) using the site-specific classification from Moorkens & Killeen (2011)
Vegetation height (cm)	Average and Maximum
Habitat	Habitat code (Fossitt 2000)
Wetness	Dry/Damp/Wet/Very wet/Site under water (1-5)
Aspect	N, NE, E, SE, S, SW, W, NW
Slope	Degrees
Physical characteristics	% of Bare soil, Bare rock, Open water, Litter, Bryophytes, and Field layer. Percentage cover recorded in 5% categories ≥ 10%, with 0.1, 0.3, 0.5, 0.7, 1, 3, 5, and 7 utilised for cover less than 10%.
Weather	DS = dry and sunny, DC = dry and cloudy, LR = light rain, HR = heavy rain, RR = recent rain.
Grazing levels	1 = No grazing, 2 = Light grazing, 3 = Moderate grazing, 4 = Heavy grazing

2.5.2.6 Monitoring spot samples

In addition to the transect data, spot samples were recorded across each site during the baseline survey and this was repeated in the current survey. As for the transect sample points, the grid reference of each spot sample was recorded using a hand-held GPS, ecological data were recorded as listed above, photographs were taken and the vegetation was beaten over a white tray to sample for *V. moulinsiana*. A more detailed set of ecological data (Table 17) was recorded from a subset of spot sampling points deemed to be representative of the various habitat types present at the site.

The spot sampling points were not necessarily repeated at exactly the same locations as those in the baseline survey. As the purpose of the spot samples is to assess the occurrence of the species within a site, sampling in different areas assists our understanding of the range of the species across a site. When determining how many spot samples to take, and where to locate them, the monitoring prescriptions given in Moorkens & Killeen (2011) were consulted and the following items were considered:

1. At least one spot sample should be recorded from polygons classified as sub-optimal and unsuitable or better.
2. All polygons with a positive sample for the target species in the baseline survey, even those mapped as unsuitable, should be spot sampled.
3. Spot samples may be allocated to address possible knowledge-gaps in terms of the species' distribution within the site as a whole
4. Once spot samples have been allocated following items 1 to 3 the remaining spot samples for a site should be allocated proportionately to polygons based on the area of suitable habitat within each polygon.

2.5.3 Condition assessment monitoring

The condition assessment for *V. moulinsiana* at each site was comprised of three elements, a population assessment, a habitat assessment, and an assessment of future prospects.

2.5.3.1 Population assessment

The Population of *V. moulinsiana* at each site was assessed by presence/absence at the transect level and at the site level (spot samples). The 2014-2017 monitoring survey assessed population at each site using the criteria established during the baseline survey and published in the individual sites report of Moorkens & Killeen (2011). Some of these criteria were adjusted (see Appendix I), while new criteria were established for new sites.

For the Population assessment, each site either passed or failed specific criteria. The combination of the number of passes and failures resulted in a Population assessment of Favourable (green), Unfavourable-Inadequate (amber) or Unfavourable-Bad (red).

2.5.3.2 Habitat assessment

The Habitat of *V. moulinsiana* at each site was assessed at the transect level and site level, as appropriate. At the transect level, the baseline survey established targets for the number of sample points that should have Class I and II vegetation. The baseline survey also established a target for the habitat quality of the transect as the number of sample points within soil moisture classes 3-4, or 3-5, depending on the nature of the site. At the site level, the baseline survey established a target for habitat extent as the number of hectares of suitable habitat at the site. The habitat suitability of the transect and site were reassessed in the 2014-2017 survey and the compared to the targets set. For new sites, similar targets were set in the current survey.

For the Habitat assessment, each site either passed or failed specific criteria. The combination of the number of passes and failures results in an assessment for each parameter as being Favourable (green), Unfavourable-Inadequate (amber), or Unfavourable-Bad (red).

2.5.3.3 Future prospects assessment

The Future prospects for *V. moulinsiana* at each site were assessed by first listing the impacts and activities that were influencing or likely to influence the site. The local NPWS Conservation Rangers were contacted during the 2014-2017 monitoring survey for additional information on the impacts and activities. The standard list of impacts and activities (Ssymank, 2011) was applied during the 2014-2017 monitoring, as they were during the baseline survey. The location of each impact or activity (from inside or outside the site), its influence (positive, negative or neutral), intensity (low, medium or high) and the number of hectares of suitable habitat affected were also noted. The combination of the influences, both positive and negative, was balanced to assess the site's future prospects as Favourable (green), Unfavourable-Inadequate (amber), or Unfavourable-Bad (red).

If there were no significant negative impacts and activities and the long-term viability of the population is assured, then Future prospects were assessed as Favourable (green). If there were moderate negative impacts or management intervention was being implemented to address any negative impacts, then future prospects were assessed as Unfavourable-Inadequate (amber). If there were highly negative impacts and the viability was not assured in the long-term, then future prospects were assessed as Unfavourable-Bad (red). Long-term is defined as being the length of two monitoring periods, i.e. 12 years (Ellmauer, 2010).

2.5.3.4 Overall condition assessment

The Overall condition assessment for each site was a combination of the assessments of Population, Habitat and Future prospects. Where all three parameters were Favourable (green), the overall assessment was Favourable (green). If one attribute was assessed as Unfavourable-Inadequate (amber)

and the remainder were Favourable (green), the overall assessment was deemed to be Unfavourable-Inadequate (amber), and if one of the three attributes was assessed as Unfavourable-Bad (red), the overall assessment was deemed to be Unfavourable-Bad (red). The individual assessments of Population, Habitat and Future prospects and the Overall condition assessment that were made during the baseline survey were compared with the assessment made in the 2014-2017 monitoring survey.

2.6 Data audit

A number of amendments were made to the project's Access database. To eliminate any mis-matches between stored data and site reports, new database reports were designed within Access so that comprehensive site reports can now be produced automatically. This entailed some restructuring of the database to add key fields to allow differentiation between data from different monitoring periods, and to hold extra information required for the site reports, such as a site summary, discussion paragraph and management recommendations. Additional buttons were added to the main switchboard of the database to allow users to run these reports either singly, for an individual site, or collectively for a *Vertigo* species.

A detailed audit was carried out on the data from the baseline survey at the beginning of this project. This took the form of checking for consistency between data from different sources of the survey: GIS shapefiles, Access database and previous site reports. Errors detected included omission of transect data from the GIS transect shapefile, incorrectly geo-referenced points, sample points located outside digitised habitat polygons, and inconsistencies between information in the site reports and in the Access database or GIS shapefiles. Correcting all issues was outside the remit of the project, but GIS issues were corrected where possible, particularly where they impacted on the current project. In the corrected GIS shapefiles, all original data were retained for transparency, but the corrected data were placed in a new field (the original fieldname with the suffix "_aud").

The full data audit report was lodged with NPWS in 2015. Other errors were reported to NPWS in the course of the project, particularly where they had resulted in incorrect assessment results in the previous monitoring period.

3 Results

3.1 Data deliverables

The following data deliverables were set out in the project tender and were submitted to NPWS:

1. Final report, summarising the results of the survey, and highlighting and discussing changes since the last monitoring period (this report)
2. Individual site reports derived from the Microsoft Access database (Brophy & Long, 2019a,b,c)
3. Enhanced database in Microsoft Access
4. GIS package including polygon, transect and sample point ESRI shapefiles for 2014-2017 and checked polygon, transects and sample point ESRI shapefiles for 2008-2010
5. Digital photographs with a log in NPWS Image Databank format
6. Species records in NPWS/NBDC Recorder 6 database compliant format

3.2 Overview of results

Overall, the monitoring survey recorded the target species as present at 17 out of 21 *V. angustior* sites, 16 out of 19 *V. geyeri* sites and 17 out of 20 *V. moulinsiana* sites. The sites that were positive for the target species in the previous monitoring period but negative in the current monitoring period were:

- VaCAM09 Fanore (Co. Clare)
- VgCAM09 Annaghmore Lough (Co. Roscommon)
- VgCAM20 Lisduff Fen (Co. Offaly)
- VmCAM01 Borris (Co. Carlow)

Two other sites were negative in the previous monitoring period and were negative again in the current monitoring period:

- VaCAM04 Glencolmcille (Co. Donegal)
- VmCAM15 Lisbigney Bog (Co. Laois)

The target species *Vertigo moulinsiana* was also not recorded at VmCAM22 Fiagh Bog (Co. Tipperary), which was not surveyed in the previous monitoring period. Waterstown Lough was only surveyed for *V. moulinsiana* in the 2007-2010 survey, but *V. angustior* and *V. geyeri* were found incidentally and so the site was subjected to a full survey and assessment for all three species in the current monitoring survey. All three species were again recorded at this site (VaCAM22, VgCAM23 and VmCAM09).

To understand the issues relevant to a particular site, it is necessary to look at that site in more detail, and therefore to refer to the site reports. Aside from those mentioned above, some sites that continue to support the relevant target species have shown apparent, and in some cases dramatic, declines. In many cases, however, the cause of the decline is unclear. This is discussed further in Section 4.

3.3 Vertigo angustior results

3.3.1 *Vertigo angustior* results overview

Twenty-one *V. angustior* sites were surveyed as part of the 2014-2017 survey, covering nine counties across Ireland (Table 1). Of the sites visited in the current survey, only Waterstown Lough (VaCAM22) was not located within, or partially overlapping with, an SAC. The sites surveyed covered all 13 SACs for which *V. angustior* is listed as a qualifying interest.

Vertigo angustior was recorded at 17 out of the 21 *V. angustior* sites. Both Fanore (VaCAM09) and Curragh Chase (VaCAM17) were positive for the species in the previous monitoring period, but negative in the current monitoring period; Glencolmcille (VaCAM04) and Louisa Bridge (VaCAM19) were negative in both. *V. angustior* was incidentally recorded at Waterstown Lough in the course of the previous monitoring survey, but a full assessment was only carried out for the reporting period 2013-2018.

Basic presence/absence data do not, of course, give a complete picture of the situation with regard to *V. angustior*. For example, while some sites continue to be positive for the snail, the number of positive samples, as a proxy for the population, may have shown a decline since the previous monitoring period, suggesting a possible issue at the site. Equally, while *V. angustior* may continue to be recorded at a site, the suitability of the habitat may have declined and the future presence of the snail at that site may be uncertain. The individual site reports should be referred to for further detail on each site (Brophy & Long, 2017a) as well as Section 3.3.4 and Appendix III, which present the site-specific conservation assessment results, along with an interpretation of the status of the sites.

3.3.2 *Vertigo angustior* habitat area

In the current survey, a total of 1045.7 ha of habitat was surveyed within the 21 *V. angustior* sites, of which 878.7 ha (84%) was deemed to have the potential to support the target species (Suboptimal-Unsuitable or better) (Table 18). The remaining 166.9 ha (16%) was Unsuitable. (See Section 2.3.2.4 for an explanation of the habitat suitability classes.)

Table 18 Area of habitat surveyed for *Vertigo angustior* in hectares broken down by habitat suitability class. Definitions of habitat suitability classes presented in Section 2.3.2.4.

Habitat suitability class	ha	%
Optimal	69.25	6.6
Optimal-Suboptimal	149.23	14.3
Suboptimal	312.69	29.9
Suboptimal-Unsuitable	347.55	33.2
Unsuitable	166.94	16.0
TOTAL	1045.66	

When compared with the 2008-2010 survey (with sites not surveyed in both periods excluded), the total habitat area has shown a slight increase from 1038.7 ha to 1043.0 ha, an increase of 4.4 ha or 0.4% (Table 19). This increase is due to changes in mapping aimed at including habitat that was previously excluded, or to extend a polygon to a more visible boundary, such as a wall or fenceline. The habitat area with a suitability class of Suboptimal-Unsuitable or better has increased from 746.1 ha to 876.1 ha (130.0 ha or 17%) between the monitoring periods. This change is due to both to interpretation and ecological change.

Table 19 Comparison of area of habitat suitability classes in hectares (ha) between the 2008-2010 and 2014-2017 surveys for *Vertigo angustior*. Changes due to both ecological and interpreted change are included. Excludes sites not surveyed in both survey periods (i.e. VaCAM18, VaCAM22). Figures presented for the 2008-2010 survey are corrected figures based on the audit of the previous GIS data.

Habitat suitability class	2008-2010	2014-2017	Difference (ha)	Difference (%)
Optimal	53.00	69.25	+16.25	+30.7
Optimal-Suboptimal	191.70	146.60	-45.10	-23.5
Suboptimal	155.70	312.69	+156.99	+100.8
Suboptimal-Unsuitable	345.74	347.55	+1.81	+0.5
Unsuitable	292.51	166.94	-125.57	-42.9
TOTAL	1038.65	1043.03	+4.38	+0.4

While the change in total area between the two reporting periods is slight, there has been considerable change with regard to the areas of the five habitat suitability classes, with a significant increase in Suboptimal (+101%) and a significant decrease in Unsuitable (-43%). The detail relating to these changes can best be found and understood by looking at the individual site reports as overall trends are difficult to interpret, and some issues are masked[2]. Two identifiable over-arching trends should be noted, however. The first trend is the movement of large blocks of land from Unsuitable to Suboptimal. This occurred at some sites where the ground was walked (and typically sampled) and found to hold some suitable habitat. The second trend is for some habitat to slip from Optimal-Suboptimal to Suboptimal, and this often reflects changes in management (e.g. effect of grazing).

3.3.3 Vertigo angustior *impacts and activities*

Impacts and activities acting on a site were recorded in the course of the 2014-2017 monitoring survey following the Ssymank (2011) codes. A total of 41 categories or sub-categories were recorded across all 21 sites and, for each site, were assessed as having a positive, negative or neutral effect on the *V. angustior* habitat. This compares with a total of 28 categories or sub-categories recorded by Moorkens & Killeen (2011). The full list of impacts and activities recorded in the course of the 2014-2017 monitoring survey is presented in Table 20, in order of decreasing frequency of occurrence of those with a negative influence. Full details can be found in the individual site reports.

[2] An example of a masked issue is highlighted here. The apparent 31% increase in the area of Optimal habitat for *V. angustior* (Table 19) masks a drop in 41.58 ha of previously Optimal habitat to Optimal-Suboptimal, or Suboptimal. These losses were due to a number of factors at different sites, including ecological change (e.g. vegetation becoming more rank) and interpreted change (e.g. the merging of polygons).

Table 20 List of impacts and activities recorded at *Vertigo angustior* sites in 2014-2017, in order of decreasing frequency of occurrence of those with a negative influence.

Activity code	Activity	Negative	Positive	Neutral	Total
K01.01	Erosion	10	-	-	10
A04.02.01	Non-intensive cattle grazing	7	6	-	13
D01.01	Paths, tracks, cycling tracks	6	-	2	8
A04.03	Abandonment of pastoral systems, lack of grazing	5	-	-	5
G01.02	Walking, horse-riding and non-motorised vehicles	5	-	-	5
H05.01	Garbage and solid waste	5	-	-	5
I02	Problematic native species	4	-	-	4
K02.01	Species composition change (succession)	4	-	-	4
G02.08	Other outdoor sports and leisure activities	3	-	1	4
G05.01	Trampling, overuse	3	-	-	3
I01	Invasive non-native species	3	-	1	4
K04.05	Damage by herbivores (including game species)	3	1	1	5
A04.01.01	Intensive cattle grazing	2	-	-	2
A04.02.03	Non-intensive horse grazing	2	1	-	3
A05.02	Stock feeding	2	-	-	2
G02.01	Golf course	2	-	1	3
A01	Cultivation	1	-	-	1
A03.01	Intensive mowing or intensification	1	-	-	1
A03.02	Non-intensive mowing	1	-	-	1
A04.02.02	Non-intensive sheep grazing	1	1	1	3
A04.02.05	Non-intensive mixed animal grazing	1	-	-	1
A07	Use of biocides, hormones and chemicals	1	-	-	1
A08	Fertilisation	1	-	-	1
A10.01	Removal of hedges and copses or scrub	1	-	-	1
A11	Agriculture activities not referred to above	1	-	-	1
B01	Forest planting on open ground	1	-	-	1
B01.02	Artificial planting on open ground (non-native trees)	1	-	-	1
C01.01	Sand and gravel extraction	1	-	-	1
D01.02	Roads, motorways	1	-	-	1
D04.01	Airport	1	-	-	1
D04.02	Aerodrome, heliport	1	-	-	1
E04.01	Agricultural structures, buildings in the landscape	1	-	-	1
F06.01	Game/bird breeding station	1	-	-	1
G02.07	Missing or wrongly directed conservation measures	1	-	-	1
G05	Other human intrusions and disturbances	1	-	-	1
J02.02	Removal of sediments (mud...)	1	-	-	1
J02.07	Water abstractions from groundwater	1	-	-	1
K01.03	Drying out	1	-	-	1
K01.04	Submersion	1	-	-	1
L07	Storm, cyclone	1	-	-	1
L08	Inundation (natural processes)	1	-	-	1

Those impacts and activities that are having a negative influence on the habitat of *V. angustior* are of most importance in terms of understanding population or habitat changes, and for making management recommendations. For this reason, the impacts and activities that were recorded as having a negative

influence in the 2014-2017 monitoring survey are presented in Table 21 in more detail. The impacts and activities are listed in order of Intensity of influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites that were not surveyed in both survey periods were excluded (VaCAM18 Doonbeg and VaCAM22 Waterstown Lough).

Table 21 Impacts and activities recorded as having a negative influence at *Vertigo angustior* sites during the 2014-2017 monitoring survey, ranked in order of Influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites not surveyed in both survey periods are excluded.

Activity code	Activity	Influence	Area affected (ha)	No of sites
K04.05	Damage by herbivores (including game species)	High	34.13	1
A04.03	Abandonment of pastoral systems, lack of grazing	High	28.19	2
A04.02.03	Non-intensive horse grazing	High	26.69	1
K01.01	Erosion	High	25.25	6
A04.01.01	Intensive cattle grazing	High	19.36	2
L08	Inundation (natural processes)	High	18.98	1
K02.01	Species composition change (succession)	High	18.58	2
G02.08	Other outdoor sports and leisure activities	High	11.95	1
A07	Use of biocides, hormones and chemicals	High	10.8	1
I02	Problematic native species	High	10.06	3
I01	Invasive non-native species	High	6.48	1
A04.02.01	Non-intensive cattle grazing	High	5.5	1
D04.02	Aerodrome, heliport	High	2.66	1
G01.02	Walking, horse-riding and non-motorised vehicles	High	2.28	3
C01.01	Sand and gravel extraction	High	2.16	1
A05.02	Stock feeding	High	1.93	2
A01	Cultivation	High	1.56	1
B01.02	Artificial planting on open ground (non-native trees)	High	1.18	1
A03.01	Intensive mowing or intensification	High	0.78	1
D04.01	Airport	High	0.39	1
D01.01	Paths, tracks, cycling tracks	High	0.31	2
G05.01	Trampling, overuse	High	0.19	1
L07	Storm, cyclone	High	0.19	1
H05.01	Garbage and solid waste	High	0.16	1
B01	Forest planting on open ground	High	0.13	1
J02.02	Removal of sediments (mud...)	High	0.05	1
E04.01	Agricultural structures, buildings in the landscape	High	0.003	1
A04.02.01	Non-intensive cattle grazing	Medium	231.19	
G02.01	Golf course	Medium	96.73	1
A04.03	Abandonment of pastoral systems, lack of grazing	Medium	31.35	
K02.01	Species composition change (succession)	Medium	16.22	
A11	Agriculture activities not referred to above	Medium	13.4	
A04.02.02	Non-intensive sheep grazing	Medium	6.5	

Activity code	Activity	Influence	Area affected (ha)	No of sites
K01.04	Submersion	Medium	6.5	
G05.01	Trampling, overuse	Medium	5.34	
A03.02	Non-intensive mowing	Medium	3.32	
D01.01	Paths, tracks, cycling tracks	Medium	2.55	
I02	Problematic native species	Medium	2.16	
K04.05	Damage by herbivores (including game species)	Medium	2.16	
A04.02.05	Non-intensive mixed animal grazing	Medium	1.94	
A08	Fertilisation	Medium	0.34	
H05.01	Garbage and solid waste	Medium	0.06	
A04.02.01	Non-intensive cattle grazing	Low	44.86	2
H05.01	Garbage and solid waste	Low	11.67	3
G01.02	Walking, horse-riding and non-motorised vehicles	Low	5.27	3
K01.01	Erosion	Low	5.13	4
G02.08	Other outdoor sports and leisure activities	Low	3.56	2
A04.03	Abandonment of pastoral systems, lack of grazing	Low	2.68	1
K04.05	Damage by herbivores (including game species)	Low	2.31	1
G02.07	Missing or wrongly directed conservation measures	Low	1.96	1
A04.02.03	Non-intensive horse grazing	Low	1.38	1
I01	Invasive non-native species	Low	1.08	2
D01.02	Roads, motorways	Low	1.07	1
D01.01	Paths, tracks, cycling tracks	Low	1.06	2
A10.01	Removal of hedges and copses or scrub	Low	0.48	1
G05	Other human intrusions and disturbances	Low	0.06	1
G05.01	Trampling, overuse	Low	0.003	1

To enable comparison between the impacts and activities of this survey round with the previous, those recorded as having a negative influence in the 2008-2010 monitoring survey are presented in Table 22.

Table 22 Impacts and activities recorded as having a negative influence at *Vertigo angustior* sites during the 2008-2010 monitoring survey (Moorkens & Killeen 2011). Ranked in order of Influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites not surveyed in both survey periods are excluded.

Activity code	Activity	Influence	Area affected (ha)	No of sites
A04.01.02	Intensive sheep grazing	High	34.7	1
A04.01.01	Intensive cattle grazing	High	27	2
B01	Forest planting on open ground	High	10	1
D01.01	Paths, tracks, cycling tracks	High	2	1
A04.02.01	Non-intensive cattle grazing	High	1.7	1
A04.02.01	Non-intensive cattle grazing	Medium	268.19	5
A04.03	Abandonment of pastoral systems, lack of grazing	Medium	55.62	4
A04.02.02	Non-intensive sheep grazing	Medium	34.39	2
G02.08	Other outdoor sports and leisure activities	Medium	33	3
G01.03	Motorised vehicles	Medium	25	1
D04.01	Airport	Medium	21	1
A04.01.01	Intensive cattle grazing	Medium	8	1
A05.02	Stock feeding	Medium	2	1
B06	Grazing in forests/woodland	Medium	2	1
D01.03	Car parks and parking areas	Medium	1.5	1
E06	Other urbanisation, industrial and similar activities	Medium	1	1
J02.04.01	Flooding	Medium	0.6	1
J02.05.02	Modifying structures of inland water courses	Medium	0.6	1
M01.01	Rise of temperature & extremes	Low	79.6	2
M01.02	Droughts and less precipitations	Low	79.6	2
A08	Fertilisation	Low	24.33	1
A04.02.01	Non-intensive cattle grazing	Low	17.1	1
M01.03	Flooding and rising precipitations	Low	14.6	2
A05.02	Stock feeding	Low	1	1
E01.03	Dispersed habitation	Low	1	1

Factoring in the area involved, as well as the intensity of the influence, the following are the top four negative impacts and activities recorded in 2014-2017:

- Non-intensive cattle grazing
- Golf course
- Abandonment of pastoral systems, lack of grazing
- Damage by herbivores (including game species)

This compares to a top four from Moorkens & Killeen (2011) of:

- Non-intensive cattle grazing
- Non-intensive sheep grazing
- Abandonment of pastoral systems, lack of grazing
- Rise of temperature & extremes/ Droughts and less precipitations

Considerably more negative impacts and activities were recorded in the 2014-2017 survey than in the 2008-2010 survey and there is also variation in the categories and sub-categories recorded, including those of highest importance. This is likely to be due to the subjective nature of recording such data and the difficulty in positively identifying some of the listed. In some cases it is likely that there has been a difference in interpreting the Impacts and activities. For example, there are no instances of new golf courses, or of clear changes on sites due to them being managed as golf courses, so it is likely that management as a golf course failed to make the list produced by Moorkens & Killeen (2011) on occasion. Similarly, in consultation with NPWS, climate change concerns were not noted at individual sites during the 2013-2018 survey; however, incidents that may be related to climate change, such as flooding or storm damage, were recorded.

The area affected by sheep grazing is considerably higher in the 2007-2012 monitoring period (69.1 ha) as compared to the 2013-2018 monitoring period (6.5 ha). Closer analysis of the numbers shows that this is due to a change in grazer from sheep to cattle at Kinlackagh Bay (VaCAM06), the recording of sheep grazing as having a positive rather than negative effect at Malin Dunes (VaCAM12), and the recording of grazing at Glencolmcille (VaCAM04) as mixed in the current survey, where it was sheep in the previous survey.

3.3.4 *Vertigo angustior* site-specific conservation assessments

An Overall conservation assessment was derived for each site based on the Population assessment, Habitat assessment and Future prospects[3]. The results of the assessments are presented in Table 23 which includes a comparison between the 2007-2012 and 2013-2018 monitoring periods and a note as to whether changes in Overall conservation assessment results between monitoring periods are considered to reflect a real decline at a site or may be due to the assessment criteria set for the site being too stringent. As noted in the methods section, the assessments are based on the criteria and targets of Moorkens & Killeen (2011), with only minor alterations (listed in Appendix I). Where larger criteria and target revisions might be necessary, or where the calculated assessment result did not tally with the situation on the ground, expert judgement was applied to recommend an alternative assessment result. This process was agreed with NPWS, who will make the final decision in these cases.

Further information on each site is included in site summary paragraphs presented in Appendix III and site reports which should be referred to for the fullest information.

[3] In the results and subsequent sections, Favourable (green), Unfavourable-Inadequate (amber) and Unfavourable-Bad (red) are synonymous with 'Green', 'Amber' and 'Red', respectively.

Table 23 Comparison of conservation assessments for *Vertigo angustior* between the 2007-2012 and 2013-2018 monitoring periods. Ordered primarily by Overall assessment result in 2013-2018. Favourable (green), Unfavourable-Inadequate (amber) and Unfavourable-Bad (red) are referred to as 'Green', 'Amber' and 'Red', respectively.

		2007-2012				2013-2018			
Site code	**Site name**	**Population**	**Habitat**	**Future prospects**	**Overall**	**Population**	**Habitat**	**Future prospects**	**Overall**
VaCAM10	Killanley Glebe	Green	Green	Green	Green	Green	Green	Green	Green
VaCAM15	Bartraw	Green	Green	Green	Green	Green	Green	Green	Green
VaCAM20	Ballysadare Bay	Green	Green	Green	Green	Green	Green	Green	Green
VaCAM22	Waterstown Lough	NA	NA	NA	NA	Green	Green	Green	Green
VaCAM14	Streedagh Point Dunes	Green	Green	Green	Green	Green	Amber	Green	Amber*
VaCAM12	Malin Dunes	Green	Green	Green	Green	Green	Red	Green	Red*
VaCAM03	Dooaghtry	Green	Green	Green	Green	Green	Green	Amber	Amber**
VaCAM02	Derrynane	Green	Green	Green	Green	Amber	Amber	Amber	Amber**
VaCAM16	Inishmore Island	Green	Green	Green	Green	Amber	Amber	Amber	Amber**
VaCAM01	Beal Point	Amber	Amber	Amber	Amber	Amber	Amber	Amber	Amber
VaCAM08	Dog's Bay	Green	Green	Green	Green	Green	Red	Amber	Red**
VaCAM11	Lahinch	Green	Green	Green	Green	Red	Green	Amber	Red**
VaCAM05	Kilshannig	Green	Green	Green	Green	Red	Red	Amber	Red**
VaCAM09	Fanore	Green	Amber	Amber	Amber	Red	Amber	Amber	Red**
VaCAM21	Strandhill Airport	Green	Amber	Amber	Amber	Red	Red	Amber	Red**
VaCAM13	Pollardstown Fen	Green	Green	Amber	Amber	Red	Red	Red	Red**
VaCAM17	Curragh Chase	Green	Amber	Amber	Amber	Red	Red	Red	Red**
VaCAM06	Kinlackagh Bay	Amber	Red	Amber	Red	Amber	Red	Amber	Red
VaCAM07	Maharees	Red	Red	Amber	Red	Red	Red	Amber	Red
VaCAM04	Glencolmcille	Red	Amber	Amber	Red	Red	Amber	Red	Red**
VaCAM19	Louisa Bridge	Red	Amber	Red	Red	Red	Red	Red	Red**

* Site/population appears to be in good condition. Assessment criteria may need attention – Recommend 'Green'. See notes below and individual site reports for further information.
** Decline in status considered to reflect real issue at site.

3.3.5 *Management of* Vertigo angustior *sites*

The apparent decline in the population of *V. angustior* across numerous sites, with a range of activities impacting on the habitat of the species, shows that active management is required to ensure the continued presence of the target species and suitable habitat at a number of sites. The impacts and activities recorded as part of the Future prospects assessment form the basis of any future management action recommendations designed to address the declines and to return the sites to favourable conservation status. Given the disparate ecological requirements between the 'dune phase' and the 'wetland phase' of *V. angustior*, and the diversity of pressures acting at the individual site level, there is no generally applicable approach that can be taken. For this reason, it is necessary to refer to the individual site reports to review the pressures present at a given site and the recommendations in relation to future management. In the site reports, an overly prescriptive approach was not taken, but rather areas that require actions were identified (e.g. reduce grazing levels). In dune habitats, all management recommendations will be aimed at achieving the favoured micro-habitat of the species in that ecosystem – i.e. a light, open, damp thatch of *Festuca rubra* litter in a sward of *Festuca rubra* and *Ammophila arenaria*, which typically occurs in the presence of moderate grazing or mowing management. In marshes, a layer of damp bryophytes at the base of taller vascular plants (such as *Iris pseudacorus*) is needed.

A summary of recommended management actions for each *V. angustior* site is presented in Table 24. As can be seen, management of grazing levels is the most common measure that is required to maintain or improve *V. angustior* habitat.

Table 24 Summary list of management action recommendations by *Vertigo angustior* site.

Site code	Site name	Management actions
VaCAM01	Beal Point	Increase cattle grazing
VaCAM02	Derrynane	Reduce cattle grazing
VaCAM03	Dooaghtry	Remove sheep grazing Reintroduce cattle grazing Control spread of *Carex acutiformis*
VaCAM04	Glencolmcille	Remove sheep grazing Reintroduce cattle grazing Remove other activities (e.g. potato growing)
VaCAM05	Kilshannig	Reduce cattle grazing
VaCAM06	Kinlackagh Bay	Maintain appropriate cattle grazing level
VaCAM07	Maharees	Reduce cattle grazing (Polygon D & part Polygon E). Reintroduce cattle grazing (part Polygon E) Maintain management of rough in golf course Stop biocide use (polygons G & H) Reduce grazing level (polygons G-K)
VaCAM08	Dog's Bay	Reduce cattle grazing Planting of *Ammophila arenaria*
VaCAM09	Fanore	Reduce cattle grazing Reduce rabbit grazing
VaCAM10	Killanley Glebe	No change recommended
VaCAM11	Lahinch	Introduce limited mowing to some areas of rough Reduce mowing levels of some areas of rough Minimise use of herbicides and fertilisers

Site code	Site name	Management actions
VaCAM12	Malin Dunes	Reduce grazing level (Polygon D) Stop supplementary feeding
VaCAM13	Pollardstown Fen	Reduce grazing level (polygons B & D) Reintroduce grazing (Polygon A)
VaCAM14	Streedagh Point Dunes	Maintain cattle grazing level Reduce horse grazing level (Conor's Island) Implement measures to protect habitat from human trampling and vehicles.
VaCAM15	Bartraw	Prevent horse-riding in dunes Implement measures to stabilise damaged dunes
VaCAM16	Inishmore Island	Reduce cattle grazing (Polygon B)
VaCAM17	Curragh Chase	Reduce grazing level Control cattle access with fencing
VaCAM19	Louisa Bridge	No actions recommended
VaCAM20	Ballysadare Bay	Introduce light cattle grazing
VaCAM21	Strandhill Airport	Introduce light cattle grazing
VaCAM22*	Waterstown Lough	No actions recommended

3.3.6 Monitoring for *Vertigo angustior*

Proposed monitoring prescriptions for *V. angustior* are site-specific and are set out in the individual site reports (Brophy & Long, 2019a). The details of the monitoring presented in the site reports are based on Moorkens & Killeen (2011) or were developed as part of the current project. For some sites, slight changes were made to existing criteria, or new criteria introduced, and so the monitoring prescription was amended appropriately. For sites where issues were noted or population/habitat declines were seen, monitoring was usually recommended to take place more frequently than the typical six-yearly interval. In fact, Moorkens & Killeen (2011) recommended a three-yearly monitoring cycle as a general rule. In general, monitoring prescriptions take the form of the example given in Table 25, but the reader is directed to individual sites for specific-site monitoring guidelines. It is worth noting that if there were to be any changes to the survey methodology for future monitoring rounds (Section 5), this would necessitate a review of, and possibly changes to, how the future monitoring will be carried out.

Table 25 Typical example of a monitoring prescription for *Vertigo angustior*. This example includes a small change to reflect changes made in the assessment criteria at this site.

VaCAM07 – Maharees – Monitoring recommendations
The site should be monitored broadly following the recommendations of Moorkens & Killeen (2011) on a 3-yearly basis, but due to the fact that it is a large site with complex management, extra spot samples are required and this requirement has been added below. Prescription as follows: • Describe habitat and take at least 1 sample each from at least 6 of the main zones with the most suitable habitat on the transect and analyse for molluscan composition • Describe habitat and take at least 3 samples from areas with the most suitable habitat in Polygon F (golf course) and analyse for molluscan composition • Describe habitat and take at least 6 samples from areas with the most suitable habitat in polygons D, G and H and K • Describe habitat and take at least 3 samples from areas with the most suitable habitat (dune and transition marsh) in polygons I and J at Fermoyle and analyse for molluscan composition • Re-determine boundary of the habitat polygons and assign habitat to either Optimal, Optimal-Sub-optimal, Suboptimal, Suboptimal-Unsuitable, or Unsuitable • Assess the management regime and impacts upon the habitat for *Vertigo angustior* • Use results to determine overall condition assessment

3.4 Vertigo geyeri results

3.4.1 *Vertigo geyeri* results overview

Nineteen *V. geyeri* sites were surveyed as part of the 2014-2017 survey, covering 10 counties across Ireland (Table 1). Of the sites visited in the current survey, Silver River (VgCAM15), Waterstown Lough (VgCAM23) and Duleek Commons (VgCAM24) were not located within, or partially overlapping with, an SAC. The sites surveyed covered 12 of the 14 SACs for which *V. geyeri* is listed as a qualifying interest, with Lough Hoe Bog (000633) and Clew Bay Complex (001482) not included for survey.

Vertigo geyeri was recorded at 16 out of the 19 *V. geyeri* sites. Both Annaghmore Lough (VgCAM09) and Lisduff Fen (VgCAM20) were positive for the species in the previous monitoring period but negative in the current monitoring period; Clonaslee Eskers (VgCAM04) was negative in both. *Vertigo geyeri* was incidentally recorded at Waterstown Lough in the course of the previous monitoring survey, but a full assessment was only carried out for the current reporting period, 2013-2018.

As with the other species, the full data need to be examined, not just presence/absence, to gain an understanding of how the species is faring at a site. Some sites which still host the snail may have seen large decreases in population size, or may display habitat degradation, suggesting that the species' future there may be threatened. The individual site reports should be referred to for further detail on each site (Brophy & Long, 2019b) as well as Section 3.4.4 and Appendix III, which present the site-specific conservation assessment results, along with an interpretation of the status of the sites.

3.4.2 *Vertigo geyeri* habitat area

In the current survey, a total of 206.6 ha of habitat was surveyed within the 19 *V. geyeri* sites, of which 158.2 ha (77%) was deemed to have the potential to support the target species (Suboptimal-Unsuitable or better) (Table 26). The remaining 46.3 ha (23%) was Unsuitable. (See Section 2.4.2.4 for an explanation of the habitat suitability classes.)

Table 26 Area of habitat surveyed for *Vertigo geyeri* in hectares broken down by habitat suitability class. Definitions of habitat suitability classes presented in Section 2.4.2.4.

Habitat suitability class	Area (hectares)	%
Optimal	9.24	4.5
Optimal-Suboptimal	62.71	30.4
Suboptimal	48.17	23.3
Suboptimal-Unsuitable	38.04	18.4
Unsuitable	46.30	22.4
Unknown*	2.17	1.1
TOTAL	206.63	

When compared with the 2008-2010 survey (with sites not surveyed in both periods excluded), the total habitat area has shown a slight increase of 1.9 ha, from 188.6 ha to 190.5 ha, an increase of 1% (Table 27). This change is due to a combination of increases and decreases in area at a number of sites as a result of refinements in mapping and the addition of new habitat polygons (e.g. at VgCAM15 Silver River). The area of habitat with a suitability class of Suboptimal-Unsuitable or better has declined from 153.4 ha to 144.2 ha (a decrease of 9.2 ha or 6%) between the monitoring periods.

Table 27 Comparison of area of habitat suitability classes in hectares (ha) between the 2008-2010 and 2014-2017 surveys for *Vertigo geyeri**. Changes due to both ecological and interpreted change are included.

Habitat suitability class	2008-2010**	2014-2017	Difference (ha)	Difference (%)
Optimal	5.34	9.24	+3.90	+73.0
Optimal-Suboptimal	87.70	60.06	-27.64	-31.5
Suboptimal	14.47	47.97	+33.50	+231.5
Suboptimal-Unsuitable	45.90	26.97	-18.93	-41.2
Unsuitable	35.19	46.3	+11.11	+31.6
TOTAL	188.60	190.54	1.94	+1.0

*Excludes sites not surveyed in both surveys (i.e. VgCAM07, VgCAM11, VgCAM12, VgCAM17, VgCAM19, VgCAM23, VgCAM24). An area of 2.17 ha in VgCAM22 was not visited in 2014-2017 and so was excluded from both totals (Suboptimal in 2008-2010)

**Figures presented here for the 2008-2010 survey are corrected figures based on the audit of the previous GIS data

There have been considerable changes to the areas of the five habitat suitability classes between the two reporting periods. The largest increase has been in the area classed as Suboptimal, which has increased by 33.5 ha (232%). Overall trends are hard to decipher from composite figures such as these, and the issues and changes are better examined at a site level. However, it would seem that a number of *V. geyeri*

habitat polygons have slipped from Optimal-Suboptimal to Suboptimal since the last survey. An example of this is Fermoyle (VgCAM16), where a 21.1 ha polygon previously classed as Optimal-Suboptimal was reassessed as a 15.6 ha Suboptimal polygon due to the redrawing of the boundary to remove a large area of unsuitable habitat and a differing assessment of the condition of the habitat within the polygon. This represented an interpreted and ecological change.

There has, however, also been a substantial increase in the area of habitat classed as Optimal in the current survey (up 73%, or almost 4 ha). This increase is due predominantly to the reassessment of a 4.7 ha polygon at Polaguil Bay (VgCAM14) from Suboptimal-Unsuitable to Optimal. There is no indication of ecological change and so this change is considered to be one of interpretation. On the other hand, 0.4 ha of Optimal habitat dropped to Suboptimal at Polaguil Bay, due to ecological change (the vegetation becoming rank).

At the other end of the scale, there has been an increase in the area of habitat classed as Unsuitable. In the main, this is due to a 10.2 ha polygon of Suboptimal-Unsuitable habitat at Dooaghtry (VgCAM05) dropping to Unsuitable due to ecological change (undergrazing has led to the vegetation becoming rank), with a minor contribution of a 0.3 ha Suboptimal-Unsuitable polygon at Ballyness Bay (VgCAM10) being reassessed as Unsuitable due to interpretation, as the habitat here is too acid to support *V. geyeri* and it is unlikely to have ever supported the snail.

3.4.3 *Vertigo geyeri* impacts and activities

Impacts and activities acting on a site were recorded in the course of the 2014-2017 monitoring survey following the Ssymank (2011) codes. A total of 28 categories or sub-categories were recorded across all 19 sites and, for each site, were assessed as having a positive, negative or neutral effect on the *V. geyeri* habitat. This compares with a total of 19 categories or sub-categories recorded by Moorkens & Killeen (2011). The full list of impacts and activities recorded in the course of the 2014-2017 monitoring survey is presented in Table 28, in order of decreasing frequency of occurrence of those with a negative influence.

Table 28 List of impacts and activities recorded at *Vertigo geyeri* sites in 2014-2017, in order of decreasing frequency of occurrence of those with a negative influence

Activity code	Activity	Negative	Positive	Neutral	Total
A04.03	Abandonment of pastoral systems, lack of grazing	6	-	-	6
H05.01	Garbage and solid waste	5	-	-	5
K02.01	Species composition change (succession)	5	-	-	5
A04.02.01	Non-intensive cattle grazing	4	4	-	8
A04.02.05	Non-intensive mixed animal grazing	2	2	-	4
A10.01	Removal of hedges and copses or scrub	2	-	-	2
I02	Problematic native species	2	-	-	2
K01.03	Drying out	2	-	-	2
A02.01	Agricultural intensification	1	-	-	1
A03.03	Abandonment / lack of mowing	1	-	-	1
A04.01.02	Intensive sheep grazing	1	-	-	1
A04.02	Non-intensive grazing	1	-	-	1
A08	Fertilisation	1	-	-	1
B07	Forestry activities not referred to above	1	-	-	1
C01.03	Peat extraction	1	-	-	1

Activity code	Activity	Negative	Positive	Neutral	Total
E01.03	Dispersed habitation	1	-	-	1
F06.01	Game/bird breeding station	1	-	-	1
H01.05	Diffuse pollution to surface waters due to agricultural and forestry activities	1	-	-	1
I01	Invasive non-native species	1	-	-	1
J01.01	Burning down	1	-	1	2
J02.01	Landfill, land reclamation and drying out, general	1	-	-	1
J02.06.01	Surface water abstractions for agriculture	1	-	-	1
J02.07	Water abstractions from groundwater	1	-	-	1
J02.07.01	Groundwater abstractions for agriculture	1	-	-	1
J02.15	Other human induced changes in hydraulic conditions	1	-	-	1
K04.05	Damage by herbivores (including game species)	1	-	-	1
A04.02.02	Non-intensive sheep grazing	-	5	-	5
C03.03	Wind energy production	-	-	1	1

Those impacts and activities that are having a negative influence on the habitat of *V. geyeri* are of most importance in terms of understanding population or habitat changes, and for making management recommendations. For this reason the impacts and activities that were recorded as having a negative influence in the 2014-2017 monitoring survey are presented in Table 29 in more detail. The impacts and activities are listed in order of Intensity of influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites that were not surveyed in both survey periods were excluded (VgCAM07 Lough Talt, VgCAM11 Carrowmoreknock, VgCAM12 Rosmoney, VgCAM17 Cooley Lough, VgCAM19 Island Lake, VgCAM23 Waterstown Lough and VgCAM24 Duleek Commons).

To enable comparison between the impacts and activities of this survey round with the previous, those recorded as having a negative influence in the 2008-2010 monitoring survey are presented in Table 30.

Table 29 Impacts and activities recorded as having a negative influence at *Vertigo geyeri* sites during the 2014-2017 monitoring survey; ranked in order of Influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites not surveyed in both survey periods are excluded.

Activity code	Activity	Influence	Area affected (ha)	No of sites
A04.03	Abandonment of pastoral systems, lack of grazing	High	23.41	4
A04.02.03	Non-intensive horse grazing	High	4.11	1
K02.01	Species composition change (succession)	High	3.53	2
J02.06.01	Surface water abstractions for agriculture	High	1.42	1
A04.02	Non-intensive grazing	High	0.51	1
E01.03	Dispersed habitation	High	0.41	1
H05.01	Garbage and solid waste	High	0.34	4
J02.01	Landfill, land reclamation and drying out, general	High	0.31	1
A02.01	Agricultural intensification	High	0.21	1

Activity code	Activity	Influence	Area affected (ha)	No of sites
A04.02.01	Non-intensive cattle grazing	Medium	2.11	1
A03.03	Abandonment / lack of mowing	Medium	1.52	1
A08	Fertilisation	Medium	1.42	1
J02.07.01	Groundwater abstractions for agriculture	Medium	0.57	1
H01.05	Diffuse pollution to surface waters due to agricultural and forestry activities	Medium	0.46	1
I02	Problematic native species	Medium	0.41	1
K02.01	Species composition change (succession)	Medium	0.31	1
A10.01	Removal of hedges and copses or scrub	Medium	0.29	1
K01.03	Drying out	Medium	0.17	1
A04.01.02	Intensive sheep grazing	Low	29.95	1
C01.03	Peat extraction	Low	21.29	1
A04.03	Abandonment of pastoral systems, lack of grazing	Low	9.3	2
K04.05	Damage by herbivores (including game species)	Low	3.51	1
J02.15	Other human induced changes in hydraulic conditions	Low	2.13	1
A04.02.03	Non-intensive horse grazing	Low	1.41	1
I02	Problematic native species	Low	0.43	1
A04.02.01	Non-intensive cattle grazing	Low	0.19	1
B07	Forestry activities not referred to above	Low	0.03	1
I01	Invasive non-native species	Low	0.03	1
K02.01	Species composition change (succession)	Low	0.03	1
A10.01	Removal of hedges and copses or scrub	Low	0.02	1

Factoring in the area involved, as well as the intensity of the influence, the following are some of the most important negative impacts and activities recorded for *V. geyeri* sites in the 2014-2017 survey:

- Abandonment of pastoral systems, lack of grazing
- Non-intensive horse grazing
- Species composition change (succession)
- Non-intensive sheep grazing
- Non-intensive cattle grazing

This compares to the following most important impacts and activities from Moorkens & Killeen (2011) for the 2008-2010 survey:

- Forest planting on open ground
- Wind energy production
- Paths, tracks, cycling tracks
- Reclamation of land from sea, estuary or marsh
- Motorised vehicles
- Abandonment of pastoral systems, lack of grazing
- Non-intensive cattle grazing

Table 30 Impacts and activities recorded as having a negative influence at *Vertigo geyeri* sites during the 2008-2010 monitoring survey (Moorkens & Killeen 2011). Ranked in order of Influence

(High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites not surveyed in both survey periods are excluded.

Activity code	Activity	Influence	Area affected (ha)	No of sites
D01.01	Paths, tracks, cycling tracks	High	>3	1
J02.01.02	Reclamation of land from sea, estuary or marsh	High	>3	2
G01.03	Motorised vehicles	Medium	26	2
A04.03	Abandonment of pastoral systems, lack of grazing	Medium	12.59	4
A04.02.01	Non-intensive cattle grazing	Medium	2.42	3
K02.01	Species composition change (succession)	Medium	1.62	2
M01	Changes in abiotic conditions	Medium	1.37	1
J02.04.01	Flooding	Medium	1	1
M01.02	Droughts and less precipitations	Medium	1	1
M01.03	Flooding and rising precipitations	Medium	1	1
A04.02.01	Non-intensive cattle grazing	Low	>25.47	2
B02	Forest and Plantation management & use	Low	>25	1
C01.03	Peat extraction	Low	>25	1
J02.01.02	Reclamation of land from sea, estuary or marsh	Low	>25	1
A04.02.02	Non-intensive sheep grazing	Low	10.3	1
A04.03	Abandonment of pastoral systems, lack of grazing	Low	<2.5	1
M01.01	Temperature changes (e.g. rise of temperature & extremes)	Low	>1.6	1
M01.02	Droughts and less precipitations	Low	>1.6	1
M01.03	Flooding and rising precipitations	Low	>1.6	1
C03.03	Wind energy production	Low	ND	1

The most notable thing about these lists of impacts and activities is their lack of overlap. As was the case for *Vertigo angustior*, considerably more negative impacts and activities were recorded in the 2014-2017 survey than in the 2008-2010 survey and there is also variation in the categories and sub-categories recorded, including those of highest importance. This is likely to be down to the subjective nature of recording such data and the difficulty in positively identifying some of the listed impacts and activities. In some cases it is likely that there has been a difference in interpreting the impacts and activities.

Another notable difference from the short-lists above is the large increase in the amount of land which is considered to be affected by abandonment and/or lack of grazing in the current survey compared to the previous. This was found on the ground to be an issue at very many sites, with vegetation often growing tall and rank, and sometimes precluding suitable habitat for the target species. Given that it ranks as the most important negative impact in the current survey (and even more so if combined with the linked impact of 'Succession', a process which often happens in the absence of grazing), it can be seen to be a factor which is changing with time, and one which needs to be addressed.

Wind energy production was noted as a negative by Moorkens & Killeen (2011). This relates to the Ox Mountains (VgCAM21) where turbines had very recently been installed adjacent to the *V. geyeri* habitat at the time of the previous survey. During the current survey, it was assessed that the siting of the turbines near the flush line has not, in fact, had a direct impact on the habitat, although some ancillary activities have been flagged. Forestry and paths/tracks were noted by Moorkens & Killeen (2011) as impacts at Easkey Valley (VgCAM13). These were noted as occurring mostly outside of the site (though

nearby) in the current survey. The use of motorised vehicles, which makes the short-list of Moorkens & Killeen (2011) impacts and activities, refers to Dooaghtry (VgCAM05), and this impacting activity was not noted in the current survey. It is likely to have ceased, or decreased to such a level that the impact is negligible.

3.4.4 *Vertigo geyeri* site-specific conservation assessments

An Overall conservation assessment was derived for each *V. geyeri* site based on the Population assessment, Habitat assessment and Future prospects. The results of the assessments are presented in Table 31, which includes a comparison between the 2007-2012 and 2013-2018 monitoring periods and a note as to whether changes in Overall conservation assessment results between monitoring periods are considered to reflect a real decline at a site or may be due to the assessment criteria set for the site being too stringent or perhaps set too high. As noted in the methods section, the assessments are based on the criteria and targets of Moorkens & Killeen (2011), with only minor alterations (listed in Appendix I). Where larger criteria and target revisions might be necessary, or where the calculated assessment result did not tally with the situation on the ground, expert judgement was applied to recommend an alternative assessment result. This process was agreed with NPWS, who will make the final decision in these cases.

Further information on each site is included in site summary paragraphs presented in Appendix III and site reports should be referred to for the fullest information.

Table 31 Comparison of conservation assessments for *Vertigo geyeri* between the 2007-2012 and 2013-2018 monitoring periods. Ordered primarily by Overall Assessment result in 2013-2018. Favourable (green), Unfavourable-Inadequate (amber) and Unfavourable-Bad (red) are referred to as 'Green', 'Amber' and 'Red', respectively.

		2007-2012				2013-2018			
Site code	**Site name**	**Population**	**Habitat**	**Future prospects**	**Overall**	**Population**	**Habitat**	**Future prospects**	**Overall**
VgCAM01	Meenaphuil	Green	Green	Green	Green	Green	Green	Green	Green
VgCAM02	Tievebaun	Green	Green	Green	Green	Green	Green	Green	Green
VgCAM23	Waterstown Lough	NA	NA	NA	NA	Green	Green	Green	Green
VgCAM21	Ox Mountains	Green	Green	Green	Green	Amber	Green	Green	Amber*
VgCAM14	Polaguil Bay	Green	Green	Green	Green	Amber	Amber	Green	Amber*
VgCAM05	Dooaghtry	Green	Green	Green	Green	Amber	Amber	Green	Amber**
VgCAM15	Silver River	Green	Green	Green	Green	Green	Amber	Green	Amber***
VgCAM16	Fermoyle	Green	Green	Green	Green	Green	Amber	Green	Amber***
VgCAM18	Fin Lough (Offaly)	Green	Green	Green	Green	Green	Green	Amber	Amber***
VgCAM10	Ballyness Bay	Green	Green	Green	Green	Red	Green	Green	Red****
VgCAM08	Sheskinmore Lough	Green	Green	Green	Green	Green	Red	Amber	Red****
VgCAM13	Easkey Valley	Green	Green	Green	Green	Red	Green	Green	Red***
VgCAM06	Drimmon Lough	Green	Green	Green	Green	Red	Amber	Green	Red***
VgCAM09	Annaghmore Lough	Green	Green	Green	Green	Red	Amber	Red	Red***
VgCAM20	Lisduff Fen	Green	Green	Green	Green	Red	Green	Amber	Red***
VgCAM03	Brackloon	Amber	Amber	Amber	Amber	Red	Amber	Amber	Red***
VgCAM22	Pollardstown Fen	Green	Amber	Amber	Amber	Red	Amber	Red	Red***
VgCAM04	Clonaslee Eskers	Red	Green	Red	Red	Red	Red	Red	Red***
VgCAM24	Duleek Commons	NA	NA	NA	NA	Green	Red	Amber	Red

* Site/population appears to be in good condition. Assessment criteria may need attention – Recommend 'Green'. See site notes below and individual site reports for further information.
** Population appears to be better than result suggests. Assessment criteria may need attention – Recommend 'Green' for population. See site note below and individual site report for further information. *** Decline in status considered to reflect real issue at site. **** Site/population appears to be in better condition than result suggests. Assessment criteria may need attention – Recommend 'Amber'. See site notes below and individual site reports for further information.

3.4.5 Management of *Vertigo geyeri* sites

Vertigo geyeri has declined at a number of sites, and there are a range of activities impacting on its habitat. It is clear that management is required at some sites. The impacts and activities recorded guide the formulation of management recommendations, and these are designed to address the issues seen and should help to return the sites to favourable conservation status. Because each site and each population has its own set of characteristics and issues, it is necessary to refer to the individual site reports to review the pressures at play for a given site and the recommendations in relation to future management. In general, in the site reports an overly prescriptive approach was not taken, but rather areas that require actions were identified (e.g. modification of grazing levels). In all cases, an open habitat is required for *V. geyeri*, whether this is maintained by the wetness of the habitat (e.g. in a wet flush) or by light grazing (typically sheep), or both. The aim should be a short sward with sedges such as *Carex viridula* ssp. *brachyrrhyncha* and mosses such as *Drepanocladus revolvens* and *Campylium stellatum*, with the water table within 5 cm of the ground surface for most or all of the year.

An overview of management actions needed at each *V. geyeri* site is presented in Table 32, and full details are provided in the individual site reports. As can be seen, management of grazing levels is the most common measure that is required to maintain or improve *V. geyeri* habitat.

Table 32 Summary list of management action recommendations by *Vertigo geyeri* site. Please read the individual site reports for fuller details.

Site code	Site name	Management actions
VgCAM01	Meenaphuil	Maintain sheep grazing level
VgCAM02	Tievebaun	Maintain sheep grazing level
VgCAM03	Brackloon	No actions recommended
VgCAM04	Clonaslee Eskers	Reintroduce limited grazing Trial cutting *Schoenus nigricans* tussocks
VgCAM05	Dooaghtry	Maintain appropriate level of sheep grazing Reintroduce grazing (Polygon F)
VgCAM06	Drimmon Lough	Maintain appropriate cattle grazing level
VgCAM08	Sheskinmore Lough	Reduce grazing level
VgCAM09	Annaghmore Lough	Reduce grazing level (Polygon A - western end, Polygon B – eastern end) Completely remove grazing temporarily (Transect 3 area) Reintroduce grazing (Polygon A – eastern end, Polygon B – western end)
VgCAM10	Ballyness Bay	Replace cattle grazing with sheep grazing
VgCAM13	Easkey Valley	Fencing to protect flushes (Polygon A) Slight increase in sheep grazing (Polygon N)
VgCAM14	Polaguil Bay	Maintain sheep grazing level (polygons B & C) Cutting of rank vegetation and maintain with sheep grazing (Polygon E and parts polygons A & D)
VgCAM15	Silver River	Reduce cattle grazing (Polygon B) Maintain grazing level (Polygon C)
VgCAM16	Fermoyle	Review grazing level Remove invasive species Limit drain clearance

Site code	Site name	Management actions
VgCAM18	Fin Lough (Offaly)	Maintain appropriate level of grazing (Polygon A) Consider cutting back *Schoenus nigricans* tussocks (Polygon C)
VgCAM20	Lisduff Fen	Maintain grazing level (southern section) Reintroduce limited grazing (northern section) Stop roadside water abstraction Stop scrub clearance and dumping around the fen
VgCAM21	Ox Mountains	Maintain sheep grazing level
VgCAM22	Pollardstown Fen	Refer to Moorkens & Killeen (2011) for detailed measures
VgCAM23	Waterstown Lough	Slightly reduce cattle grazing level
VgCAM24	Duleek Commons	Reduce cattle grazing level

3.4.6 Monitoring for *Vertigo geyeri*

The proposed monitoring prescriptions for *V. geyeri* are site-specific and are set out in the individual site reports (Brophy & Long, 2019b). These are based on Moorkens & Killeen (2011), Long & Brophy (2013), or were developed as part of the current project. In some cases, changes were made to the existing criteria or new additions made. Where potential problems were noted at a site, monitoring was usually recommended to take place more frequently than the typical six-yearly interval. (Moorkens & Killeen (2011) generally recommended a three-yearly monitoring cycle.) Monitoring prescriptions for *V. geyeri* usually followed the example given in Table 33. It is worth noting that if there were to be any changes to the survey methodology for future monitoring rounds (Section 5), this would necessitate a review of, and possibly changes to, how the future monitoring will be carried out.

Table 33 Typical example of a monitoring prescription for *Vertigo geyeri*.

VgCAM01 - Meenaphuil – Monitoring recommendations
Because the Overall assessment of the site is Favourable, with no damaging activities noted, it is recommended that monitoring is carried out at six-yearly intervals. This should be reassessed in light of any deterioration of condition or any changes to site management. Monitoring should follow that of Moorkens & Killeen (2011): • Repeat Transect 1, delineate the plant community/habitat zones, and assign the habitat and wetness in each zone as Optimal, Sub-optimal or Unsuitable • Take at least 1 sample from the most suitable habitat in each of the two main zones on the transect and analyse for molluscan composition • Re-determine boundary of the habitat polygon and assign habitat to either Optimal, Optimal-Suboptimal, Suboptimal, Suboptimal-Unsuitable, or Unsuitable • Assess the management regime and impacts upon the habitat for *Vertigo geyeri* • Use results to determine overall condition assessment

3.5 Vertigo moulinsiana results

3.5.1 *Vertigo moulinsiana* results overview

Twenty *V. moulinsiana* sites were surveyed as part of the 2014-2017 survey, covering 12 counties across Ireland (Table 1) Of the sites visited in the current survey, Ballybeg Lough (VmCAM06), Waterstown Lough (VmCAM09), Kildallan Bridge (VmCAM14), Royal Canal, Longford Branch (VmCAM21), Fiagh Bog (VmCAM22) and Castletown (VmCAM23) were not located within, or partially overlapping with, an SAC. The sites surveyed covered all seven of the SACs for which *V. moulinsiana* is listed as a qualifying interest.

Vertigo moulinsiana was recorded at 17 out of the 20 *V. moulinsiana* sites. Only Borris (VmCAM01) was positive for the species in the previous monitoring period but negative in the current monitoring period; Lisbigney Bog (VmCAM15) was negative in both. Fiagh Bog (VmCAM22) was not surveyed in the previous monitoring survey and the species was not found in the 2004-2017 survey, nor was any suitable habitat recorded.

As mentioned in the case of *V. angustior* and *V. geyeri*, presence/absence data at a site level provides little indication of the true picture. For example, some sites may continue to be positive for the snail but the number of positive samples (used as a proxy for the population size) may have declined, suggesting an issue at the site. Similarly, declines in habitat quality may be occurring, with the species still present in low numbers and resulting in a positive at the site level. The individual site reports should be referred to for further detail on each site (Brophy & Long, 2019c) as well as Section 3.5.4 and Appendix III, which present the site-specific conservation assessment results, along with an interpretation of the status of the sites.

3.5.2 *Vertigo moulinsiana* habitat area

In the current survey, a total of 169.6 ha of habitat was surveyed within the 20 *V. moulinsiana* sites, of which 163.8 ha (97%) was deemed to have the potential to support the target species (Suboptimal-Unsuitable or better)[4]. The remaining 5.8 ha (3%) was Unsuitable. (See Section 2.5.2.4 for an explanation of the habitat suitability classes).

Table 34 Area of habitat surveyed for *Vertigo moulinsiana* in hectares broken down by habitat suitability class. Unknown refers to areas not accessible during current survey. The figures exclude Fiagh Bog (VaCAM22) for which no habitat polygons were defined due to the lack of habitat suitable for the snail. Definitions of habitat suitability classes are presented in Section 2.4.2.4.

Habitat suitability class	Area (hectares)	%
Optimal	30.08	15.3
Optimal-Suboptimal	71.17	36.1
Suboptimal	67.93	34.5
Suboptimal-Unsuitable	19.93	10.1
Unsuitable	5.78	2.9
Unknown	2.19	1.1
TOTAL	197.08	

[4] These figures exclude Fiagh Bog (VaCAM22) for which no habitat polygons were defined due to the lack of habitat suitable for the snail.

When compared with the 2008-2010 survey (with sites not surveyed in both periods excluded), the total habitat area has shown an increase from 98.8 ha to 169.6 ha, an increase of 70.7 ha or 72% (Table 35). The area of habitat with a suitability class of Suboptimal-Unsuitable or better has increased from 93.1 ha to 163.8 ha (70.7 ha or 76%) between the monitoring periods.

Table 35 Comparison of area of habitat suitability classes in hectares (ha) between the 2008-2010 and 2014-2017 surveys for *Vertigo moulinsiana**. Changes due to both ecological and interpreted change are included.

Habitat suitability class	2008-2010**	2014-2017	Difference (ha)	Difference (%)
Optimal	18.76	27.03	+8.27	+44.1
Optimal-Suboptimal	25.81	68.02	42.21	+163.5
Suboptimal	38.77	48.79	+10.02	+25.8
Suboptimal-Unsuitable	9.72	19.93	+10.21	+105.0
Unsuitable	5.78	5.78	0	0
TOTAL	98.84	169.55	+70.71	+71.5

*Excludes sites not surveyed in both surveys (i.e. VmCAM07, VmCAM13, VmCAM20, VmCAM21, VmCAM22, VmCAM23). An area of 1.47 ha in VmCAM18 was not visited in 2014-2017 and so was excluded from both totals (Suboptimal in 2008-2010)

**Figures presented here for the 2008-2010 survey are corrected figures based on the audit of the previous GIS data

The most notable change for *V. moulinsiana* is the 72% increase in habitat that was assessed. This comes largely from four sites: Waterstown Lough (VmCAM09), Charleville Lake (VmCAM11), The Murrough (VmCAM17) and Portumna (VmCAM19). At Waterstown Lough, an area of 12.87 ha extending around three sides of the lough was flagged by Moorkens & Killeen (2011) as "potential but unsurveyed habitat". This area was sampled in the current monitoring survey and assessed as Optimal-Suboptimal. At Charleville Lake, further investigation of habitat resulted in areas being found that supported the snail or were deemed to have potential for the species and were mapped into the site. An area of 5.89 ha was assessed as Suboptimal and a further 9.23 ha was tentatively assessed as Suboptimal-Unsuitable, as this area was inaccessible. At The Murrough, three new polygons were added to the site: 4.53 ha of Suboptimal habitat and 18.57 ha of Optimal-Suboptimal habitat. Work by Long & Brophy (2013) identified further areas of *V. moulinsiana* habitat around Lough Derg and this has added 8.11 ha of habitat to Portumna ranging from Optimal to Suboptimal-Unsuitable in the current survey.

3.5.3 *Vertigo moulinsiana* impacts and activities

Impacts and activities acting on a site were recorded in the course of the 2014-2017 monitoring survey following the Ssymank (2011) codes. A total of 32 categories or sub-categories were recorded across all 20 sites and, for each site, were assessed as having a positive, negative or neutral effect on the *V. moulinsiana* habitat. This compares with a total of 19 categories or sub-categories recorded by Moorkens & Killeen (2011). The full list of impacts and activities recorded in the course of the 2014-2017 monitoring survey is presented in Table 36, in order of decreasing frequency of occurrence of those with a negative influence.

Table 36 List of impacts and activities recorded at *Vertigo moulinsiana* sites in 2014-2017, in order of decreasing frequency of occurrence of those with a negative influence.

Activity code	Activity	Negative	Positive	Neutral	Total
K02.01	Species composition change (succession)	12	-	-	12
H05.01	Garbage and solid waste	8	-	-	8
A04.02.01	Non-intensive cattle grazing	5	2	1	8
K01.03	Drying out	4	-	-	4
A04.03	Abandonment of pastoral systems, lack of grazing	3	-	-	3
A10.01	Removal of hedges and copses or scrub	3	-	-	3
A03	Mowing/cutting of grassland	2	-	-	2
A04.02.03	Non-intensive horse grazing	2	-	-	2
H02.06	Diffuse groundwater pollution due to agricultural and forestry activities	2	-	-	2
J02.01	Landfill, land reclamation and drying out, general	2	-	-	2
L08	Inundation (natural processes)	2	-	2	4
A03.02	Non-intensive mowing	1	-	-	1
A04.02.02	Non-intensive sheep grazing	1	-	-	1
A08	Fertilisation	1	-	-	1
D01.01	Paths, tracks, cycling tracks	1	-	-	1
D03.01.02	Piers/tourist harbours or recreational piers	1	-	-	1
E03.03	Disposal of inert materials	1	-	-	1
F06.01	Game/ bird breeding station	1	-	-	1
G05.07	Missing or wrongly directed conservation measures	1	-	-	1
H01.05	Diffuse pollution to surface waters due to agricultural and forestry activities	1	-	-	1
H05	Soil pollution and solid waste (excluding discharges)	1	-	-	1
H07	Other forms of pollution	1	-	-	1
I01	Invasive non-native species	1	-	-	1
J02.06.01	Surface water abstractions for agriculture	1	-	-	1
J02.07	Water abstractions from groundwater	1	-	-	1
J02.07.01	Groundwater abstractions for agriculture	1	-	-	1
J02.11.02	Other siltation rate changes	1	-	-	1
J02.15	Other human induced changes in hydraulic conditions	1	-	-	1
K04.05	Damage by herbivores (including game species)	1	3	-	4
K06	Other forms or mixed forms of interspecific floral competition	1	-	-	1
A04.02.05	Non-intensive mixed animal grazing	-	1	-	1
F06	Hunting, fishing or collecting activities not referred to above	-	1	-	1

Those impacts and activities that are having a negative influence on the habitat of *V. moulinsiana* are of most importance in terms of understanding population or habitat changes, and for making management recommendations. For this reason the impacts and activities that were recorded as having a negative influence in the 2014-2017 monitoring survey are presented in Table 37 in more detail. The impacts and

activities are listed in order of Intensity of influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites that were not surveyed in both survey periods were excluded (VmCAM07 Mullaghmore, VmCAM13 Dromkeen Bridge, VmCAM20 Royal Canal, Cloondara to Kilashee, VmCAM21 Royal Canal, Longford Branch, VmCAM22 Fiagh Bog and VmCAM23 Castletown).

Table 37 Impacts and activities recorded as having a negative influence at *Vertigo moulinsiana* sites during the 2014-2017 monitoring survey. Ranked in order of Influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites not surveyed in both survey periods are excluded.

Activity code	Activity	Influence	Area affected (ha)	No of sites
K02.01	Species composition change (succession)	High	18.83	2
A03.02	Non-intensive mowing	High	2.2	1
K01.03	Drying out	High	1.86	1
J02.15	Other human induced changes in hydraulic conditions	High	1.49	1
J02.06.01	Surface water abstractions for agriculture	High	0.75	1
G05.07	Missing or wrongly directed conservation measures	High	0.66	1
A04.02.01	Non-intensive cattle grazing	High	0.38	1
A10.01	Removal of hedges and copses or scrub	High	0.08	1
E03.03	Disposal of inert materials	High	0.08	1
H05.01	Garbage and solid waste	High	0.08	5
J02.11.02	Other siltation rate changes	Medium	22.68	1
A04.03	Abandonment of pastoral systems, lack of grazing	Medium	16.92	2
K01.03	Drying out	Medium	6.28	2
K02.01	Species composition change (succession)	Medium	1.59	6
L08	Inundation (natural processes)	Medium	1.16	1
A08	Fertilisation	Medium	0.75	1
A04.02.01	Non-intensive cattle grazing	Medium	0.63	2
D01.01	Paths, tracks, cycling tracks	Medium	0.63	1
J02.07.01	Groundwater abstractions for agriculture	Medium	0.3	1
H02.06	Diffuse groundwater pollution due to agricultural and forestry activities	Medium	0.29	1
A10.01	Removal of hedges and copses or scrub	Medium	0.15	2
K01.03	Drying out	Low	17.18	1
K04.05	Damage by herbivores (including game species)	Low	10.59	1
A04.02.01	Non-intensive cattle grazing	Low	5.16	2
A04.02.03	Non-intensive horse grazing	Low	2.33	2
H05.01	Garbage and solid waste	Low	2.27	3
J02.07	Water abstractions from groundwater	Low	0.86	1
L08	Inundation (natural processes)	Low	0.42	1
H02.06	Diffuse groundwater pollution due to agricultural and forestry activities	Low	0.37	1
H07	Other forms of pollution	Low	0.26	1

Activity code	Activity	Influence	Area affected (ha)	No of sites
A04.02.02	Non-intensive sheep grazing	Low	0.22	1
D03.01.02	Piers/tourist harbours or recreational piers	Low	0.18	1
F06.01	Game/bird breeding station	Low	0.18	1
H01.05	Diffuse pollution to surface waters due to agricultural and forestry activities	Low	0.13	1
K06	Other forms or mixed forms of interspecific floral competition	Low	0.04	1
I01	Invasive non-native species	Low	0.03	1
A03	Mowing/cutting of grassland	Low	0.02	2
H05	Soil pollution and solid waste (excluding discharges)	Low	0.02	1
K02.01	Species composition change (succession)	Low	0.02	2

To enable comparison between the impacts and activities of this survey round with the previous, those recorded as having a negative influence in the 2008-2010 monitoring survey are presented in Table 38.

Table 38 Impacts and activities recorded as having a negative influence at *Vertigo moulinsiana* sites during the 2008-2010 monitoring survey (Moorkens & Killeen 2011). Ranked in order of Influence (High to Low), Area affected (High to Low) and Activity code (alphabetical). Sites not surveyed in both survey periods are excluded. ND = No data

Activity code	Activity	Influence	Area affected (ha)	No of sites
J02.01.02	Reclamation of land from sea, estuary or marsh	High	5.78	1
J02.02.01	Dredging/removal of limnic sediments	Medium	21.31	1
J02.03	Canalisation & water deviation	Medium	21.31	1
K02.01	Species composition change (succession)	Medium	3.49	2
A04.03	Abandonment of pastoral systems, lack of grazing	Medium	3.07	1
A04.02.01	Non-intensive cattle grazing	Medium	0.41	1
J02.10	Management of aquatic and bank vegetation for drainage purposes	Medium	ND	1
J02.11.01	Dumping, depositing of dredged deposits	Medium	ND	1
A04.03	Abandonment of pastoral systems, lack of grazing	Low	21.31	3
H01	Pollution to surface waters (limnic, terrestrial, marine & brackish)	Low	6.2	1
K02.01	Species composition change (succession)	Low	5.49	1
J02.01.03	Infilling of ditches, dykes, ponds, pools, marshes or pits	Low	4.49	2
A04.02.01	Non-intensive cattle grazing	Low	<1	1
M01.01	Temperature changes (e.g. rise of temperature & extremes)	Low	ND	5
M01.02	Droughts and less precipitations	Low	ND	5
M01.03	Flooding and rising precipitations	Low	ND	5

Factoring in the area involved, as well as the intensity of the influence, the following are some of the most important negative impacts and activities recorded at *V. moulinsiana* sites in 2013-2018:

- Species composition change (succession)
- Drying out
- Abandonment of pastoral systems, lack of grazing
- Non-intensive mowing

This compares to the following from Moorkens & Killeen (2011) for the 2007-2012 survey:

- Reclamation of land from sea, estuary or marsh
- Dredging/removal of limnic sediments
- Canalisation & water deviation- Reclamation of land from sea, estuary or marsh
- Abandonment of pastoral systems, lack of grazing
- Species composition change (succession)

Much like for *V. geyeri*, one of the most notable aspects of these lists of impacts and activities is their lack of overlap, for which some explanations are provided below. As was the case for *V. angustior* and *V. geyeri*, considerably more negative impacts and activities were recorded in the 2014-2017 monitoring period than in the 2007-2012 monitoring period and there is also variation in the categories and sub-categories recorded, including those of highest importance. This is likely to be down to the subjective nature of recording such data and the difficulty in positively identifying some of the listed impacts and activities. In some cases it is likely that there has been a difference in interpreting the impacts and activities.

In terms of overlaps, both abandonment and succession (often a consequence of lack of grazing/management) feature in both short-lists. These are common themes across all three species, and cause widespread issues at many sites. These will be some of the biggest challenges to be overcome in terms of managing *Vertigo* habitats into the future. However, for *V. moulinsiana*, some new pressures emerge as big issues, such as drying out (VmCAM04 Mountmellick, VmCAM09 Waterstown Lough, VmCAM10 Ballynafagh Bog and VmCAM18 Pollardstown Fen) and mowing management (VmCAM14 Kildallan Bridge). The first highlights land and hydrological management issues which are likely to be operating at scales much larger than that of the study sites. The impacts and activities listed by Moorkens & Killeen (2011) of reclamation, dredging and canalisation are all related to the same phenomenon of hydrological changes. Ensuring that the much-needed steady hydrological regime continues to be a feature of *V. moulinsiana* sites will be a big challenge, and will require liaison between NPWS, landowners and other agencies.

Reclamation of land was recorded by Moorkens & Killeen (2011) at Lisbigney Bog (VmCAM15) on land that was mapped as Unsuitable for the snail. Following agreement with NPWS, impacts which occurred only on areas mapped as Unsuitable were not recorded or analysed. Dredging and canalisation were recorded by Moorkens & Killeen (2011) at Pollardstown Fen (VmCAM18). These activities were not seen during the current survey, but a number of other impacts were recorded at this site, some of which may relate to those previously recorded (e.g. drying out).

3.5.4 *Vertigo moulinsiana* site-specific conservation assessments

An Overall conservation assessment was derived for each *V. moulinsiana* site based on the Population assessment, Habitat assessment and Future prospects. The results of the assessments are presented in Table 39, which includes a comparison between the 2007-2012 and 2013-2018 monitoring periods and a note as to whether changes in Overall conservation assessment results between monitoring periods is considered to reflect a real decline at a site or may be due to the assessment criteria set for the site being too stringent. As noted in the methods section, the assessments are based on the criteria and targets of

Moorkens & Killeen (2011), with only minor alterations (listed in Appendix I). Where more significant criteria and target revisions might be necessary, or where the calculated assessment result did not tally with the situation on the ground, expert judgement was applied to recommend an alternative assessment result. This process was agreed with NPWS, who will make the final decision in these cases.

Further information on each site is included in site summary paragraphs presented in Appendix III and site reports which should be referred to for the fullest information.

Table 39 Comparison of conservation assessments for *Vertigo moulinsiana* between the 2007-2012 and 2013-2018 monitoring periods. Ordered primarily by Overall Assessment.

		2007-2012				2013-2018			
Site code	**Site name**	**Population**	**Habitat**	**Future prospects**	**Overall**	**Population**	**Habitat**	**Future prospects**	**Overall**
VmCAM11	Charleville Lake	Green	Green	Green	Green	Green	Green	Green	Green
VmCAM14	Kildallan Bridge	Green	Green	Green	Green	Green	Green	Green	Green
VmCAM19	Portumna	Green	Green	Green	Green	Green	Green	Green	Green
VmCAM21	Royal Canal, Longford Branch	NA	NA	NA	NA	Green	Green	Green	Green
VmCAM08	Cappankelly	Green	Green	Green	Green	Amber	Green	Green	Amber*
VmCAM06	Ballybeg Lough	Green	Green	Green	Green	Amber	Green	Green	Amber*
VmCAM03	Lough Owel	Green	Green	Green	Green	Amber	Amber	Green	Amber**
VmCAM17	The Murrough	Green	Green	Green	Green	Amber	Amber	Amber	Amber**
VmCAM16	Lisduff Fen	Green	Green	Green	Green	Amber	Green	Amber	Amber**
VmCAM12	Curragh Chase	Red	Green	Green	Red	Amber	Amber	Green	Amber
VmCAM02	Fin Lough (Offaly)	Green	Green	Green	Green	Red	Green	Green	Red***
VmCAM05	Louisa Bridge	Green	Green	Green	Green	Red	Green	Green	Red***
VmCAM04	Mountmellick	Green	Green	Green	Green	Red	Amber	Amber	Red***
VmCAM09	Waterstown Lough	Green	Green	Green	Green	Red	Green	Green	Red***
VmCAM23	Castletown	NA	NA	NA	NA	Green	Red	Amber	Red***
VmCAM18	Pollardstown Fen	Green	Green	Green	Green	Red	Red	Amber	Red**
VmCAM10	Ballynafagh Bog	Green	Green	Green	Green	Red	Red	Amber	Red**
VmCAM01	Borris	Amber	Green	Amber	Amber	Red	Green	Amber	Red**
VmCAM15	Lisbigney Bog	Red	Red	Red	Red	Red	Red	Red	Red
VmCAM22	Fiagh Bog	NA	NA	NA	NA	Red	Red	Red	Red

* Site/population appears to be in good condition. Assessment criteria may need attention – Recommend 'Green'. See site notes below and individual site reports for further information.
** Decline in status considered to reflect real issue at site
*** Site/population appears to be in better condition than result suggests. Assessment criteria may need attention – Recommend 'Amber'. See site notes below and individual site reports for further information.

3.5.5 Management of *Vertigo moulinsiana* sites

There has been a decline in the population of *V. moulinsiana* at a number of sites, along with decreases in habitat quality, and a range of activities have been recorded impacting on the sites. Nonetheless, a clear and overwhelming management need has not emerged for this species, as it did for *V. angustior* and *V. geyeri*. On a site-by-site basis, however, management recommendations have been made based on the threats and pressures recorded, ranging from garbage removal to scrub removal to hydrological management. As for the other two species, an overly prescriptive approach was not taken, but rather the areas that require action were highlighted. A summary of management actions recommended for each *V. moulinsiana* site is presented in Table 40.

Table 40 Summary list of management actions recommendations by *Vertigo moulinsiana* site.

Site code	Site name	Management actions
VmCAM01	Borris	• No actions recommended
VmCAM02	Fin Lough (Offaly)	• No actions recommended
VmCAM03	Lough Owel	• No actions recommended
VmCAM04	Mountmellick	• Reduce grazing level • Remove dumped rubbish
VmCAM05	Louisa Bridge	• No actions recommended
VmCAM06	Ballybeg Lough	• Reintroduce limited cattle grazing (Polygon A)
VmCAM08	Cappankelly	• No change recommended
VmCAM09	Waterstown Lough	• No change recommended
VmCAM10	Ballynafagh Bog	• Continue scrub removal programme • Carry out hydrological study to inform management • Refer to Moorkens & Killeen (2011)
VmCAM11	Charleville Lake	• Maintain lake levels • Carry out hydrological study to inform management • Refer to Moorkens & Killeen (2011)
VmCAM12	Curragh Chase	• No change recommended
VmCAM14	Kildallan Bridge	• Restrict cutting of canal-fringe emergent vegetation
VmCAM15	Lisbigney Bog	• No actions recommended
VmCAM16	Lisduff Fen	• Maintain grazing level • Stop roadside water abstraction • Stop scrub clearance and dumping around the fen • Refer to Moorkens & Killeen (2011)
VmCAM17	The Murrough	• Reduce grazing level (Polygon A) • Introduce light grazing (Polygon C) • Maintain grazing level (Polygon B) • Reducing mowing (polygons D & E)
VmCAM18	Pollardstown Fen	• Maintain or increase water level within fen • Reintroduce light gracing • Refer to Moorkens & Killeen (2011)
VmCAM19	Portumna	• No change recommended
VmCAM21	Royal Canal, Longford Branch	• Implement limited scrub/tree removal
VmCAM22	Fiagh Bog	• No actions recommended
VmCAM23	Castletown	• Counteract drain clearance to maintain suitable groundwater level

3.5.6 Monitoring for *Vertigo moulinsiana*

The proposed monitoring prescriptions for *V. moulinsiana* are site-specific and are set out in the individual site reports (Brophy & Long 2019c). These are based on Moorkens & Killeen (2011), Long & Brophy (2013), or were developed as part of the current project. In some cases, changes were made to the existing criteria or new additions made, and where potential problems were noted at a site, more frequent monitoring than the typical six-yearly interval was usually recommended. (Moorkens & Killeen (2011) generally recommended a three-yearly monitoring cycle.) Monitoring prescriptions for *V. moulinsiana* usually following the example given in Table 41. It is worth noting that if there were to be any changes to the survey methodology for future monitoring rounds (Section 5), this would necessitate a review of, and possibly changes to, how the future monitoring will be carried out.

Table 41 Typical example of a monitoring prescription for *Vertigo moulinsiana*.

VmCAM12 – Curragh Chase – Monitoring recommendations
Given the decline in the *Vertigo moulinsiana* population and distribution in the fen area to the south, monitoring of Curragh Chase should be carried out on a three yearly basis. The monitoring protocol should follow that of Moorkens & Killeen (2011), with some alterations to clarify sampling locations: • Take samples at 5 locations in polygons A and B, in field record: vegetation height, vegetation composition, ground moisture class, numbers of *Vertigo moulinsiana* (adult & juvenile) and other molluscs, minimum 10 samples • Take samples at 5 locations in Polygons C and D, record as above, minimum 10 samples • Take samples at a minimum of 2 locations in the fen site, record as above, minimum 10 samples • Re-determine boundary of the habitat polygons and assign habitat to either Optimal, Optimal-Suboptimal, Suboptimal, Suboptimal-Unsuitable, or Unsuitable • Assess the management regime and impacts upon the habitat for *Vertigo moulinsiana* • Use results to determine overall condition assessment

4 Discussion

In general, individual sites and issues pertaining to them are not discussed in this section; this type of detailed information is to be found in the individual site reports (Brophy & Long, 2019a,b,c), and to a lesser extent, in the Results (Section 3) of this report. Instead, overall results, patterns, comparisons and issues are presented and discussed, as well as recommendations for the future.

4.1 Overview of assessment results

4.1.1 Population

Populations of all three species, when assessed using the monitoring criteria of Moorkens & Killeen (2011), appear to have declined across multiple sites since the last reporting period. For *V. angustior*, eight sites obtain a Green conservation assessment status for population, compared to 15 in the previous survey. For *V. geyeri*, eight also achieve Green, compared to 15 previously, and for *V. moulinsiana*, the figures are only five Green compared to 14 previously. At each site it was attempted to determine what might be driving any changes seen, and the habitat assessments and analysis of the impacts and activities often provide some answers. (Note should be of the information provided in the individual site reports, and changes since the last monitoring period are also discussed in Results section of this report (Section 3)). In some cases, however, there is no apparent cause for an observed decline. Over-arching factors which may also have had an impact such as weather, recorder bias and potential issues with the assessment criteria are discussed in Section 4.4.

4.1.2 Habitat

Based on the monitoring criteria as set out in Moorkens & Killeen (2011), habitat conditions have also declined for all three target species. *Vertigo angustior* enjoys Green habitat status at just six sites now, compared to 12 in the previous monitoring period. *Vertigo geyeri* achieves Green status at eight out of 19 sites now, compared to 14 in the previous survey. Finally, *V. moulinsiana* habitat was scored Green at 11 sites in this round of monitoring, compared to 16 (i.e. all but one) in the previous round.

As for Population, an attempt has been made at each site to identify the factors driving the changes seen. Impacts and activities at the site have been listed, and in some cases these provide answers as to the issues. In some cases, however, there is a lack of an apparent cause for an observed decline in habitat quality. Over-arching factors which may also have an impact such as weather and potential issues with the assessment criteria are discussed further in Section 4.4.

4.1.3 Future prospects

Impacts and activities affecting sites were recorded, along with the intensity of the impact on the sites (high, medium, low) and whether the impact was positive, negative or neutral. Based on this information, the Future prospects of the sites were determined. To give an overview, the Future prospects were Green at six sites for *V. angustior* in the current survey, compared to 11 in the previous one. For *V. geyeri*, the corresponding figures are 11 Green from the current survey, and 14 from the previous; and for *V. moulinsiana*, 10 Green in the current survey, and 14 in the previous. Clearly there has been some decline in all cases, but it is generally not as pronounced as with the Population or Habitat results. This reflects the fact that, in many cases, with management changes, or reviews of the assessment criteria, the situation and outlook may improve for the target species at some sites. There were some discrepancies in how the impacts and activities were recorded between survey periods, and that is discussed in Section 4.4.5.

4.1.4 Overall conservation assessments

The Overall conservation assessment results for a site given an overall view of the condition of the site based on the results of the three assessment parameters: Population, Habitat and Future prospects. Overall conservation assessment results are down across all three parameters for all three species compared to the baseline survey. *Vertigo angustior* achieved Green status overall at just four sites, compared to 11 previously; *V. geyeri* achieved Green at only three, compared to 14 in the baseline; and *V. moulinsiana* achieved Green at four sites, compared to 14 in the baseline. These are clearly substantial decreases.

The findings in terms of Overall conservation assessment are mitigated somewhat by a number of factors. Firstly, expert judgement was used to recommend to NPWS that some sites should achieve a higher status than that calculated using the Moorkens & Killeen (2011) assessment criteria. This means that two *V. angustior* sites (VaCAM14 Streedagh Point Dunes and VaCAM12 Malin Dunes,) might move up to having a Green Overall conservation assessment status. In the case of *V. geyeri*, two sites have been recommended for an increase to Green status (VgCAM21 Ox Mountains and VgCAM14 Polaguil Bay,), and two to Amber (VgCAM10 Ballyness Bay, and VgCAM08 Sheskinmore). For *V. moulinsiana*, two sites are recommended for increase to Green status (VmCAM08 Cappankelly and VmCAM06 Ballybeg Lough) and five are recommended for Amber (VmCAM02 Fin Lough (Offaly), VmCAM05 Louisa Bridge; VmCAM04 Mountmellick, VmCAM09 Waterstown Lough and VmCAM23 Castletown) (see Tables 23, 31 and 39 in Results (Section 3.3-3.5), and Table 42 in the Discussion (section 4.2.1)).

Clearly these recommended changes in Overall conservation assessment results, if implemented by NPWS, would improve the results to some degree, but there would still remain a large number of sites with decreased and unfavourable status.

The results above need to be read and understood in the context of the issues highlighted in the following sections of the Discussion. A series of factors such as weather, stringent assessment criteria and recorder bias may all have had an impact on the results of this survey. For example, the fact that it is now clear that assessment targets were set in a period of unusually wet weather (see Section 4.4.1), meaning that populations may have been unusually high at the time, suggests that if a review of the criteria and target levels were undertaken, a number of sites might achieve a higher Overall Assessment result. These factors are discussed in more detail in the following sections.

4.2 Comparison with previous monitoring period

All three target species have shown a decline in terms of Population, Habitat and Future prospects based on the assessment criteria set by Moorkens & Killeen (2011). In some cases, the apparent decline of a site is considered to be due to overly stringent assessment criteria or the criteria being too heavily weighted towards a small part of the site, e.g. the transect. There is a difficulty with setting such criteria, in particular as the derivation of these criteria was based on limited data (e.g. data on population changes over time was usually not available). In most cases the criteria were set based on the results of one, or at most two, monitoring surveys, and so it is not possible to know whether, for example, they are set based on a population level that is higher or lower than might typically be expected. Some sites, which appear in good condition in terms of Habitat and Future prospects, failed to meet the population criteria set for them, and whether this is due to a real decline in the population, or merely a natural fluctuation in the population, or one driven by weather conditions perhaps, cannot easily be determined.

Notwithstanding the above, there are many sites at which real issues were noted and where the decline in population, habitat suitability/area or the future prospects are due to documented and identifiable issues. A wide range of pressures are acting on the natural and semi-natural habitats on which the three *Vertigo* species depend. These include widespread activities such as under- or overgrazing by a range of species including sheep, cattle, horses and rabbits; erosion; drying out and/or succession; and the spread of problematic native species. These pressures are acting on *Vertigo* sites against the backdrop of

the threat of large-scale ecological change that may come with climate change. Without the implementation of management plans, and crucially, active management taking place on the ground, for many of the sites current declines are likely to continue.

4.2.1 Species by species

An overview of the Overall conservation assessment results for each of the three target species from the monitoring periods 2007-2012 and 2013-2018 is provided in Table 42. There is a clear difference between the two monitoring periods, with a large drop in the number of sites achieving an Overall conservation status assessment of Green, common across all three target species. This is matched by a similarly large increase in sites receiving a Red rating for *V. angustior* and *V. geyeri*. A breakdown of the figures is presented in Table 43, allowing further investigation into whether these changes are being driven more by one factor than another (e.g. by population decreases, more so than habitat changes).

Table 42 Overview of Overall conservation assessment results for each of the three *Vertigo* species, for both the current and the previous monitoring periods*.

	Va 2007-12	**Va 2013-18**	**Vg 2007-12**	**Vg 2013-18**	**Vm 2007-12**	**Vm 2013-18**
Green	11	4	14	3	14	4
Recommend Green		2		2		2
Amber	5	4	2	4	1	4
Recommend Amber				2		5
Red	4	11	1	8	2	3
Sites to be dropped due to loss of species and habitat						2
Not included 2007-2012	1		2		3	

In the case of *V. angustior*, it can be seen that both the Population assessments and the Habitat assessments have shown a drop in the number of sites achieving Favourable (green) status (for Population, nine now Red compared to three previously; for Habitat, nine now Red compared to two previously). It is for this species in particular that the most noticeable drop in Habitat assessment results is seen. This suggests that significant and immediate management interventions are needed across a suite of *V. angustior* sites. Even if the recommendations (based on expert judgement, and on the findings on the ground) of increasing one Amber site and one Red site to Green status are taken on board, the incontrovertible fact remains that the Overall conservation status of *V. angustior* sites has moved from a majority of sites with a Green Overall assessment result (11 out of 20) to a majority with a Red result (11 out of 21).

Vertigo geyeri also showed a significant increase in the number of sites with a Red Population assessment result. Decreases in quality/condition of habitat were noted, but it is in the Amber category that this was most notable (for Population, eight now Red compared to one previously; for Habitat, eight now Amber compared to two previously). This suggests that habitat changes were noted, but they were not as serious as for *V. angustior*. If the recommendations (based on expert judgement, and on the findings on the ground) of increasing two Red sites to Amber, and two Amber sites to Green are taken on board, it still results in a poor picture for *V. geyeri* overall, with eight sites getting a Red Overall Assessment compared to just one in the previous round. The results overall point to a series of moderately serious issues at *V. geyeri* sites which need to be tackled before their effects become more severe – so timely

intervention and habitat management is of the essence to prevent further habitat or population decreases.

Vertigo moulinsiana sees significant downward trend in Population assessment results, whereas the changes in the Habitat assessment results are less dramatic (for Population, nine now Red compared to two previously; for Habitat, five now Red compared to one previously). This suggests that, for some sites at least, perhaps criteria may have been set too high for assessing the health of populations, and/or that the population was at a low point during the years of the current survey (perhaps related to weather, or to irregular population cycles). In other words, at some sites at least, the habitat seems in good condition, and other factors may explain the low numbers of snails recorded. Researchers in the UK have also reported declines across many sites for this species in recent years (Abrehart Ecology, 2014a; 2014b, Willing, 2015). The priority for *V. moulinsiana* at this point is to review the criteria and targets used in the assessments in light of the above, and to implement changes at those sites where they have been recommended. Further data collection on population cycles for this species in Ireland is needed.

If the recommendations (based on expert judgement, and on the findings on the ground) of increasing five Red sites to Amber, and two Amber sites to Green are taken on board, it improves the overall picture for *V. moulinsiana* to some degree. There is still a sizeable drop in sites from Green (previously 14 out of 17, down to six out of 20), but the drop is more significantly to Amber rather than to Red when compared to the other two species. This may be indicative of weather-related population cycles, or other unknown issues, and further population surveys are needed to help to elucidate this.

The above notes and analyses come with the caveat that they are very broad in nature. The diversity of habitats, pressures, and issues pertinent to each site mean that such broad generalisations are useful as pointers only. Each site must be assessed and dealt with on its own merits, and decision-makers are encouraged to read individual reports for full details on each site.

Table 43 Results of all elements of the conservation assessments for all species, from both the current and previous monitoring periods.

	No. of sites assessed		Population		Habitat		Future prospects		Overall Assessment	
	2007-2012*	2013-2018	2007-2012	2013-2018	2007-2012	2013-2018	2007-2012	2013-2018	2007-2012	2013-2018
Vertigo angustior	20	21								
Favourable (green)			15	8	12	6	11	6	11	4
Unfavourable-Inadequate (amber)			2	4	6	6	8	11	5	5**
Unfavourable -Bad (red)			3	9	2	9	1	4	4	12**
Vertigo geyeri	17	19								
Favourable (green)			15	8	15	8	14	11	14	3
Unfavourable-Inadequate (amber)			1	3	2	8	2	5	2	6***
Unfavourable-Bad (red)			1	8	0	3	1	3	1	10^
Vertigo moulinsiana	17	20								
Favourable (green)			14	5	16	11	15	11	14	4
Unfavourable-Inadequate (amber)			1	6	0	4	1	7	1	6***
Unfavourable-Bad (red)			2	9	1	5	1	2	2	10^^

* only those in common with 2013-2018 survey included here.

** one site recommended for increase to green status

*** two sites recommended for increase to green status

^ two sites recommended for increase to amber status

^^ five sites recommended for increase to amber status

4.3 Sites with negative results

Moorkens & Killeen (2011) reported a number of sites where the target *Vertigo* species has not been found for some years, and the habitat has deteriorated to such an extent that the species may have been lost completely. Three of these sites, Louisa Bridge (VaCAM19), Clonaslee Eskers (VgCAM04) and Lisbigney Bog (VmCAM15), were revisited in the current survey and in each case, the target species was yet again not found.

The *V. angustior* site at Louisa Bridge was always small, consisting of a narrow transition zone at the base of flushed slope, where it meets the river floodplain. The target species was last recorded in 1997 (Moorkens 1997), despite several surveys since, including in 2006 (Moorkens 2007a), 2010 (Moorkens & Killeen, 2011) and 2016 (current study). Vegetation change (mainly shading from developing willows and other trees) and potentially, changes to the hydrological regime, have caused the apparent loss of *V. angustior* from this site. Limited surveying is recommended for a further period of time in case the species continues to survive at the site, albeit at a low density. However, it is possible that the species may already have been lost from this site, in spite of some management efforts.

At Clonaslee Eskers, *V. geyeri* has not been recorded since 1998 despite surveys in 2005 (Moorkens 2006), 2008 (Moorkens & Killeen, 2011) and 2014 (current study). The site is suffering from drying out and the consequent development of unsuitable vegetation, despite management intervention. It remains to be seen if conservation efforts are timely, or sufficient, to halt the decline in habitat at this site. The species may still occur at low numbers here, and therefore both management and survey efforts should continue.

At Lisbigney Bog, *V. moulinsiana* was recorded in 1998 (Moorkens 1998) and has not been recorded since, despite several visits in 2006 (Moorkens, 2007b), 2010 (Moorkens & Killeen, 2011) and 2016 (current study). The 2016 survey confirmed that there is no longer any suitable habitat for *V. moulinsiana* at the site. It has been impacted by drainage, which has resulted in drying out and a change in vegetation, including a move towards more acid-loving species such as *Molinia caerulea* and *Myrica gale*. *Vertigo moulinsiana* is considered to have been lost from this site and no future monitoring is recommended.

A record from 1970 exists for *V. moulinsiana* at Fiagh Bog, Co. Tipperary (VmCAM22) and dead shells were recorded by Moorkens (1995). The site did not form part of the monitoring surveys of Moorkens & Killeen (2011). The site was surveyed in the current survey period, but the species was not recorded, and the site has undergone extensive drainage and reclamation for agricultural land. *Vertigo moulinsiana* is considered to be extinct at this site and no further surveys are recommended.

4.4 Factors impacting on results

In each of the following sections, the degree of impact a factor is likely to have had on the results of this project (high, moderate, low) is noted and recommendations for future work for future work are made that may help to avoid or mitigate such impacts.

4.4.1 Weather

The impact of the prevailing weather, and the weather of recent seasons, on sampling results for *Vertigo* cannot be over-estimated. *Vertigo,* like many molluscs, are opportunistic breeders – when conditions are right, they will often have large reproductive events, resulting in spikes in population. Conversely, if conditions are sub-optimal (e.g. dry, exceptionally warm, exceptionally cold), breeding will be depressed. If conditions are less than ideal for a number of years in a row, this will clearly lead to low population numbers, and will increase the challenge of detecting them in the field.

In order to investigate if the prevailing weather conditions (at a seasonal level) played a role in the apparent wide-scale decreases and losses of *Vertigo* populations in Ireland between the 2007-2012 and the 2013-2018 monitoring periods, weather data from Met Éireann, Ireland's National Meteorological Service, were accessed (www.met.ie and for example, 2008 overview at: https://www.met.ie/climate/monthly_summarys/annual08.pdf). This preliminary investigation suggests that the surveys in 2008-2010 may have taken place in an unusually wet period, and that the field surveys for the current project took place in a time of more average weather conditions. Given that the targets used to assess the conservation status of the species at each site were set in what was probably an unusually wet period, it is likely to be the case that some were set at a level which is unachievably high in most years, a fact that would not have been evident at the time of the 2008-2010 survey.

A more thorough investigation of weather patterns would be desirable, but it is recommended that criteria and targets be reviewed with the above suggested patterns in mind. However, extreme care should be taken not to unnecessarily or overly relax targets, and so risk missing out on actual decreases or impacts on populations.

Degree of impact: This factor is likely to have had a moderate to high impact on results.

Recommendations: No recommendations available to directly remedy this issue. Only the continued collection of data and analysis of prevailing weather patterns can help to counteract the effect on results and so future monitoring phases may help to clarify this issue.

4.4.2 Lack of multiple data points, subjectivity of targets

"*A year with very low recorded numbers should not necessarily be interpreted as a population decline, especially if meteorological conditions have been unfavourable in the months preceding the survey*" (Moorkens & Killeen 2011 – pg 74).

One of the most challenging aspects of interpreting the results of the current survey has been attempting to understand whether the decreases in populations that were recorded are part of a natural variation, are as a result of prevailing weather, or are because of a pressure or impact on the species/site. In some cases, all three may be occurring. The only remedy for the issue is the continued collection of population data, such that population variations can be better understood. In the meantime, however, expert judgements as to what is driving the observed changes have been made on a site-by-site basis.

Directly related to this is the unavoidable subjectivity of the assessment criteria as set out in Moorkens & Killeen (2011). Criteria were, by necessity, based largely on expert judgement. Furthermore, rather than setting broad targets applicable across species and/or sites, they were designed for each site separately. This has led to a situation where, for some sites at least, the criteria may be too stringent, or too specific. In these cases, the habitat may appear on the ground to be in good condition, but yet the site scored poorly. In the current survey, this was noted where it was presumed to have. Issues such as these are inevitable at the outset of long-term monitoring projects where accurate or time-series data are not yet available.

Degree of impact: These factors are likely to have had a moderate impact on results.

Recommendations: Continue to collect data so that population variations may be better understood. Aim to standardise targets more in future monitoring rounds, across sites and across species.

4.4.3 Complexities and inconsistencies in existing data

Another significant challenge in this project was the complex nature of the existing data, as well as the inconsistencies that were sometimes found within it. Before the project commenced, NPWS had carried out an initial data check, and listed and rectified some issues. As part of the current project, a full data audit focusing on the database and the GIS files was required. This was carried out at the outset and a list of issues highlighted. Those issues which could be rectified at the time were dealt with, and some

were rectified after clarification in the field. As well as issues between the old database and the GIS files, there were also inconsistencies between the original site reports and both the database and the GIS. Some of these issues have been rectified, and others listed and sent to NPWS. A full review and correction of all issues was not within the remit of the current project. While large efforts were made to correct errors, the consistency of the data from the baseline survey continued to pose problems and to create uncertainties (e.g. inconsistent labelling of polygons, conflicting status assignments, incorrect areas provided). It is worth noting that while the errors and inconsistencies caused some problems, the overall data was of such a complex nature that some issues were to be expected.

Degree of impact: This factor is likely to have had a low impact on results.

Recommendations: Carry out rigorous data checks at all stages of project, cross-checking between all data sources.

4.4.4 Variation between surveyors

A common concern in long-term or repeat surveys in ecology is variation in the data collected by different surveyors who may have different experiences, different skills, and may interpret methodologies differently. In this project, inter-surveyor variation was minimised because the lead surveyor on the current project received training from the surveyors on the previous project, and had surveyed over one-third of the sites previously as part of the first monitoring round. A small survey team also added to consistency within the current project.

In terms of having confidence in results, both in terms of methodologies and the potential for inter-surveyor variation, and particularly in light of negative site returns, it is useful to note that, for example, although the large site at Fanore (VaCAM09) produced all negative samples (18 samples), in the same week Bartraw (VaCAM15) produced 10 out of 13 positive samples. This illustrates that methodologies in the field were appropriate, and that issues at negative sites were real.

Degree of impact: This factor is likely to have had a low impact on results.

Recommendations: Endeavour to have overlap of at least one experienced malacologist between monitoring projects, or training days to allow for knowledge transfer.

4.4.5 Discrepancies in recording impact and activities

In the Results sections some discrepancies in the recording of impacts and activities have already been highlighted and discussed. In summary, considerably more impacts and activities were recorded in the 2014-2017 monitoring period than in 2007-2012, and there was variation in the categories and sub-categories recorded. This is due to the subjective nature of recording impacts and activities and the difficulty in positively identifying and/or interpreting some of the listed categories. Also, in consultation with NPWS, climate change concerns were not noted at individual sites during the 2013-2018 survey (however, incidents related to climate change, such as flooding or storm damage were), whereas Moorkens & Killeen (2011) did record them at some sites.

The Ssymank (2011) list of impacts has been revised as time has passed since its introduction. For the 2013-2018 reporting round, the list of impacts and activities is being updated and, in some cases, simplified (current version 2.0 released 31/07/2017). However, it is not yet finalised and a method of relating the current system to the updated system is not yet available. It is hoped that the updated system will result in fewer discrepancies in future monitoring rounds.

Degree of impact: This factor is likely to have had a low impact on results.

Recommendations: In future monitoring projects, the list of impacts recorded in the most recent survey round should be taken into the field to be added to or amended, rather than starting from scratch. This will help to achieve more consistency in terms of the exact impacts and activities recorded.

4.4.6 Mapping issues

In the baseline survey, there was, at times, a lack of consistency in terms of the size of polygons drawn around sample points and/or areas of suitable habitat, and also the areas of unsuitable habitat included in a site, or of potentially suitable habitat not included in a site. In the current survey, areas were re-mapped at times to address this, but changes to too many polygons at too many sites would have run the risk of obscuring actual habitat/site changes. Thus, for the most part, the polygons were accepted as given, and only relatively minor mapping adjustments were made.

Related to the above point, it is worth noting that the digital mapping for the previous monitoring project was carried out after the survey was completed, and not by the malacologists who surveyed the sites on the ground. While this is not an uncommon way to work, it will undoubtedly have contributed to some of the issues and errors which arose. Given the prevalence of GIS technology now, and the frequency of its use in ecological survey work, including the current survey, it is unlikely that this situation will arise in future surveys.

In the 2008-2010 monitoring survey, zones on transects were mapped to the nearest 10 cm in many instances, inferring a false level of accuracy (handheld GPS devices do not give sub-metre accuracy). During the current project, transect zones were generally mapped to the nearest 1m (see Section 4.4.7).

Degree of impact: These factors are likely to have had a low impact on results.

Recommendations: Digitisation of field maps should be carried out by, or in close association with, the project team, and efforts should be made to continue to standardise polygons. Transect zones need only be mapped to the nearest 1m.

4.4.7 Transect marking

In many cases, transects did not have a fixed start point or a marker created during the 2008-2010 survey. While 10-figure grid references were recorded (in theory, providing 1m^2 accuracy), handheld GPS units typically provide an accuracy range of only 5-10m. During the current survey, time was frequently wasted trying to relocate transect start (and end) points, and to find the best fit for the original transect.

Degree of impact: This factor is likely to have had a low impact on results.

Recommendations: Consider the use of fixed markers for some transects, such as buried metal markers, re-findable using metal detectors, or over-ground wooden posts. Each site will have its own considerations (e.g. presence of grazers, presence of walkers), and may need tailored solutions. The cost and ease with which markers could be utilised should be weighed against the time spent trying to re-establish exact transect locations, and the consequences this inaccuracy has on resulting transect measurements.

4.4.8 Definitions of habitat suitability classes

The lack of concrete and easily applicable definitions of habitat suitability classes, and particularly percentages of suitable habitat, within a polygon for a given level on the 5-point scale was an issue at the outset of this project. The definitions of Moorkens & Killeen (2011) were therefore refined, in conjunction with NPWS, and are provided in the methodology section of this report (Section 2.3-2.5). The differences are small but should assist fieldworkers in classifying polygons in the field. It should be remembered, however, that sites will vary, and expertise and experience is needed in deciding which point on the scale to apply to a polygon, point or transect zone.

Degree of impact: This factor is likely to have had a low impact on results.

Recommendations: Follow current habitat suitability definitions in future monitoring rounds to ensure as much consistency as possible.

4.4.9 Vegetation classes for *Vertigo moulinsiana*

One of the issues highlighted in this project was the need for more consistency in the vegetation class definitions for *V. moulinsiana*. For the other two species, written definitions of habitat were provided by Moorkens & Killeen (2011) at a site level. For *V. moulinsiana*, however, vegetation classes were devised for each site, and involved lists of plant species divided into Class I ("most favoured plants"), Class II and III (presumed less favoured), and Class IV ("unsuitable plants"). This resulted in a situation where, for example, *Sparganium erectum* is listed as Class I vegetation for the species at one site, but as Class III at another (just one level above Class IV, the "unsuitable plants").

Working on the assumption that *V. moulinsiana* will, in general, be associated with similar plants across sites, an analysis was carried out in order to make recommendations for standardising the vegetation classes used. This included all sites and their "Specific Habitat Definitions" given in Moorkens & Killeen (2011). Table 44 presents the results, showing which species were used most often in defining Class I (and then followed by Classes II and III), and also the number of times a species occurred in the listings overall.

Table 44 Summary of vegetation species and groups used by Moorkens & Killeen (2011) in Classes I, II and III within the "Specific Habitat Definitions" for *Vertigo moulinsiana*. Only those species occurring three times or more are included and these are listed in order of most commonly referred to as Class I.

Species	Class I	Class II	Class III	Total number of times used
Tall *Carex* species	12	-	-	12
Glyceria maxima	8	2	-	10
*Phragmites australis**	5	10	-	15
Sparganium erectum	4	3	2	9
Equisetum fluviatile	3	11	-	14
*Typha latifolia***	3	4	2	9
Schoenus nigricans	2	2	4	8
Carex paniculata	2	1	3	6
Cladium mariscus	1	7	1	9
Carex rostrata	1	5	-	6
Iris pseudacorus	1	4	3	8
*Phalaris arundinacea**	1	2	1	4
Eriophorum angustifolium	-	3	-	3
Mentha aquatica	-	1	11	12
Epilobium hirsutum	-	1	8	9
Menyanthes trifoliata	-	-	8	8
Urtica dioica	-	-	3	3
Filipendula ulmaria	-	-	3	3
Juncus spp.	-	-	3	3

* At least at some sites, these two species were confused in Moorkens & Killeen (2011). *Phragmites australis* was the most commonly encountered.
** This was listed as *T. angustifolia* in Moorkens & Killeen (2011) in error.

There are two clear leaders at the top of the table: 'Tall *Carex* species' and '*Glyceria maxima*'. These tally well in terms of the amount of times they are used overall, the amount of times they fall in Class I in Moorkens & Killeen (2011), and finally, in terms of experience on the ground in the course of the current survey.

The most commonly occurring species in the list is *Phragmites australis*. It should be noted that in more than one instance Moorkens & Killeen (2011) listed *Phalaris arundinacea* at a site, when it was found in the current survey to have been *Phragmites australis*. As a consequence, the frequency with which *Phragmites* is associated with *V. moulinsiana* is possibly underestimated in this table. It is a species with which *V. moulinsiana* is very often associated.

Other species which are listed as common components of the vegetation at *V. moulinsiana* sites are *Equisetum fluviatile* and *Mentha aquatica*. The former is most commonly listed as Class II, and the latter is almost exclusively listed as Class III. These relate well to experience of *V. moulinsiana* habitat in the field during the 2014-2017 survey – i.e. they may be present but are not typically the main species on which *V. moulinsiana* is found.

Other species which appear to be strongly associated with *V. moulinsiana* include: *Sparganium erectum*, *Typha latifolia* (note error in Moorkens & Killeen (2011), where this species is usually called *Typha angustifolia*), *Carex paniculata, Cladium mariscus* and *Iris pseudacorus.* All of these have proved to be good vegetation types for supporting *V. moulinsiana*. Other species that were found to be associated with *V. moulinsiana*, though less commonly, are *Schoenus nigricans* and *Carex rostrata*.

Based on this analysis of the site-specific vegetation classes developed by Moorkens & Killeen (2011), and combined with our experience in the field, it is proposed that the following is a workable vegetation class system for *V. moulinsiana* that should be applicable across most sites (Table 45) While some sites are likely to be anomalous, where the vegetation may differ from the understood norm, these should be the exception rather than the rule, and in those cases, the judgement of the surveyor can be employed.

Table 45 Proposed vegetation classes for use at all *Vertigo moulinsiana* sites, based on analysis of all sites in Moorkens & Killeen (2011) and on experience from the field.

Class I	Class II	Class III
Tall *Carex* species	*Phragmites australis*	*Schoenus nigricans*
Glyceria maxima	*Equisetum fluviatile*	*Carex rostrata*
Sparganium erectum	*Typha latifolia*	*Mentha aquatica*
	Carex paniculata	*Epilobium hirsutum*
	Cladium mariscus	*Menyanthes trifoliata*
	Iris pseudacorus	

Degree of impact: This factor is likely to have had a low impact on results.

Recommendations: Implement the new over-arching vegetation class system to increase consistency across sites. Modify if/as necessary following trial run in next monitoring period.

4.5 Management of sites

4.5.1 Overview

The apparent decline in the population of the three *Vertigo* target species across numerous sites, along with recorded overall declines in the area of suitable habitat for *V. angustior* and *V. geyeri* in particular, shows that active management is required to ensure the continued presence of the target species and suitable habitat at many of these sites. As a general rule, such decreases in population or habitat should trigger management actions from NPWS and/or landowners. The pressures recorded as part of the Future prospects assessment form the basis of any management actions designed to address the declines and to return the sites to favourable conservation status. Given the disparate ecological requirements of each of the three species, and the diversity of pressures acting at the individual site level, there is no universally applicable approach that can be taken. For this reason, it is necessary to refer to the individual site reports to review the pressures affecting a given site and the recommendations in relation to future management. A prescriptive approach was not taken, but rather areas that require actions identified (e.g. reduce grazing levels) and summaries of recommended management actions for each site for each species are presented in Tables 24, 32 and 40.

Management of grazing levels is the common measure that is required to maintain or improve *Vertigo* habitat. In most cases, it is necessary to engage with landowners and land managers in order to enact such measures aimed at improving the condition of the site, and this should be a collaborative process

where possible, rather than top-down, as often the imposition of restrictions on how privately owned lands can be managed leads to resentment and poor results (Dunford, 2016).

As well as the need to engage positively with landowners and land managers in order to involve them in the actions that need to be taken for the good of the relevant *Vertigo* species and its habitat, there is the opportunity to utilise the knowledge that comes with being intimately familiar with a piece of land and the reactions of the lands to various changes in management. For example, rather than attempting to apply a grazing regime based on published literature, it may be more appropriate to allow the farmer to have input into the stocking levels and timing in order to produce the desired result, i.e. a habitat that is approaching optimal for the target species. This results-based approach has been used to good effect in the Burren Life Programme.

While a collaborative approach is preferable for many sites, some pressures may require a firmer approach, for example where illegal activities such as dumping are occurring. However, these are likely to be in the minority, and the initial approach to any landowner should aim to bring them on-side voluntarily rather than create conflict, which is unlikely to benefit the species in question in the long term.

In order to achieve clear, positive and measurable results, it will be necessary to prepare a management plan for each site, with input from all stakeholders, as well as input from and monitoring by suitably qualified ecologists and malacologists, familiar with the species' requirements and the habitat.

Sites that support more than one of the target species (e.g. Pollardstown Fen, Fin Lough (Offaly), Waterstown Lough) require particular care in relation to the development of a management plan to ensure that conflicting requirements of the different species are appropriately considered. Similarly, all sites where there are other conservation interests will need to balance those with the needs of *Vertigo*.

4.5.2 Summary of management recommendations by species

For *V. angustior*, a mix of grazing adjustments is required, with many sites needing an increase in grazing, and many needing a decrease. The latter is by far the easier adjustment to make in practical terms, and there are a number of sites at which this needs to be implemented immediately in order to reverse the decline of *V. angustior*. Cattle are the most frequent grazer (and the most suitable in most cases), but horses, sheep and rabbits also feature prominently at some sites. Sheep and rabbits tend to graze vegetation too low to be suitable for *V. angustior*, and horse grazing has often been found to have the same effect due to overly high stocking levels. At some sites non-intensive mowing creates good habitat for *V. angustior,* e.g. at golf courses, and this management, with key species requirements considered, can be beneficial for the species. Another key management issue at *V. angustior* sites is trampling and other human disturbances (e.g. vehicles, caravans). At its wetland sites, moderate grazing levels (by a range of species), which allow a build-up of litter and moss at the base of taller plants, are best.

In the case of *V. geyeri,* the biggest management need is also getting the grazing right. Moderate levels of sheep grazing are ideal; cattle are usually too heavy for many of these fragile habitats. It should be noted, however, that some *V. geyeri* sites may be maintained without grazing as the hydrological regime (e.g. flushing with calcareous water) is such that vegetation does not become dense. In any case, the ideal is a low, open sward of sedges and indicator 'brown mosses'. Other actions such as manual cutting of vegetation (e.g. *Schoenus nigricans* tussocks) or drain blocking to maintain wetness may occasionally be needed.

For *V. moulinsiana*, the situation is unusual in that for almost half of the sites no management actions are recommended. At many sites, there is little or no management currently occurring, unlike the situation for the other two target species. Where management actions were not recommended it is because some sites do not need intervention; some due to their nature (e.g. floating vegetation) are exceedingly difficult to manage, and others are managed largely by the wide-scale hydrological regime within which

they exist, and so would be very difficult to influence. Succession is a factor at a number of sites for this species (e.g. infilling lakes). Difficult management decisions may be needed in terms of whether to try to arrest or reverse succession, e.g. by flooding/re-wetting sites, or by the continued removal of scrub. These actions are costly, labour-intensive, and may not benefit some other species of flora and fauna. Unlike the other two *Vertigo* species, manual management of vegetation (e.g. mowing, scrub removal) features prominently at *V. moulinsiana* sites, and so examination of these activities is needed at a number of sites. Overall, hydrological management is the main management concern for *V. moulinsiana* – the species needs sites that do not dry out and have relatively stable hydrology (although the species has been shown to tolerate occasional flooding). All of these points lead to the conclusion that at some sites at least, management options are limited and/or complex.

5 Future monitoring

"It is important to be careful not to make a false negative condition assessment where the fluctuations are only temporary, and equally important not to make a false positive condition assessment where the snail is persisting but facing continuous decline. Assessment of population trends in conjunction with survey weather conditions is essential" (Moorkens & Killeen, 2011 – pg 74).

The current monitoring methodologies for the three Annex II *Vertigo* species, developed for the 2007-2012 monitoring period and slightly altered for the 2013-2018 monitoring period, have a number of issues that make the application of the survey and the assessment of the results difficult. Some of these have been addressed in the Discussion (Section 4). However, it should be stressed that there are inherent difficulties in monitoring and assessing species, particularly species difficult to see in the field, and where there are gaps in our knowledge of their ecology and population dynamics. The setting of targets based on baseline reference values is, by its very nature, prone to subjectivity and to the risk that the chosen reference value is in some way atypical. This is an issue in any monitoring project. Dealing with this involves finding a balance between specific targets and overly vague ones, and both experience and expert judgement are needed, as well as a constant review and updating of the process to allow incorporation of further findings.

Overall, it is the opinion of the project team that the current sampling methodology is suitable for monitoring *Vertigo* species, particularly once one is aware of the limitations, and expert judgement is applied where necessary. The main difficulty is the limited data points on which many of the criteria are set and the difficulties inherent in sampling tiny organisms that are likely to have fluctuating populations, even without anthropogenic influences (e.g. due to weather or population cycles). Another feature of this methodology is that it is laborious, time-consuming, involves the collection of a large volume of data, and consequently there may be scope for streamlining. However, any proposal to alter the current methodology would need to provide clear improvements and also to continue to meet the data requirements of the Article 17 reporting process under the Habitats Directive. It would also need to be prepared in advance of any future monitoring surveys and piloted for a number of sites for each of the three Annex II *Vertigo* species to ensure it is fit for purpose. Some suggestions are made in Section 5.1.1 which might be considered, both in terms of improvements to the current methodology, and in terms of more significant new directions which could be taken.

5.1 Recommendations for future monitoring

For first consideration is whether a large change to a much simpler model for monitoring *Vertigo* species would be beneficial. One author has worked on surveys (on *V. angustior* and *V. geyeri*) in a neighbouring country where the amount of data collected was much less – for example, the habitat information collected consisted of descriptions and statements on suitability based on the surveyor's expert judgement. Sampling was consequently much quicker, as was dealing with the data afterwards (data entered to an excel spreadsheet, and site report cards typed up following notes taken in the field). The strength of this system is that it captures the essence of the information needed in a simple way, and can be done relatively quickly by experienced workers. The weakness is the lack of depth of data gathered, and the possible consequent difficulties in drawing detailed comparisons in future monitoring rounds. Similarly, in Hungary, the sampling model in use is much simpler (in this case for *V. angustior* and *V. moulinsiana*), with one site for each occupied 10km square sampled by carrying out just five samples, twice in a year (Fehér, 2009). The number of samples is fixed, regardless of the size of the site, or of the population. Again, this saves time and confusion with over-complicated methodologies, but may run the risk of problems at a site not being identified in a timely manner.

Another example worth considering is the methodology for monitoring the tiny liverwort, *Petalophyllum ralfsii*, here in Ireland (Campbell, Hodgetts & Lockhart, 2013). In summary, the presence of the species at a site is enough for a pass, and while detailed data (e.g. vegetation quadrats) are collected, the criteria

for pass/fail are much simpler and more broadly applicable across sites. The following is taken from the previous Article 17 backing document:

> *"Due to the natural variability of the occurrence and density of* P. ralfsii*, targets involving thalli number cannot be set. Therefore the confirmation of the presence of the species at the locality is the sole target to achieve a Favourable population assessment (Green). If the species cannot be found after three repeated locality visits then it is to receive an Unfavourable - Inadequate status (Amber)."*

Notwithstanding all of the above, it is believed that the detailed data collected by using the current monitoring methodology is largely worthwhile. Below are a series of suggestions for possible changes, which are relatively minor, but some of which could greatly change the workload involved and/or improve the monitoring process.

Upcoming change in reporting:

Before laying out the suggestions, it is necessary to note a significant upcoming change in Article 17 reporting. For the 2013-2018 monitoring period, the reporting unit for mollusc population size is the number of populated 1km squares (DG Environment, 2017). This will simplify the nationwide assessment of the populations of the three Annex II *Vertigo* species and may provide a route for simplifying the survey methodology. Rather than the current system of spot sampling, a simpler regime to establish the presence/absence of the target species within 1km squares may be sufficient to meet future reporting requirements. A new consideration would be necessary – to ensure that all 1km squares covering a site are sampled. However, the danger of only sampling once (or a small number of times) in a 1km square is that this sampling effort is likely to be too low to detect population declines at many sites. It is recommended in future monitoring rounds that consideration be given to taking spot samples in such a way as to ensure that at least one falls within every 1km square at a site. At present, however, we do not recommend any further simplification of the spot sampling regime due to this reporting change.

Recommendations for consideration:

1. *Broader, simpler, less specific assessment criteria*: Targets for populations and habitats were at times overly specific and overly stringent. It is suggested that, overall, it would be helpful to review these and to aim for broader, less specific targets. This would help to decrease complexity in the project and also decrease the amount of potentially false negative results. Great care would be needed to ensure they still provided enough information to assess the species' status. Options include switching to presence/absence at spot sample locations for all species, and/or to standardise the number of spot samples taken at a site (e.g. a set number for all sites, or a set number related to the size of the site). For example, a move to simply recording presence/absence at a site, such as is in use for *Petalophyllum ralfsii* is not currently recommended.
2. *More samples, fewer data*: For species that can be found relatively easily in the field (*V. angustior*, *V. moulinsiana*), it may be useful to employ a more minimalist data approach, where presence/absence is recorded at a higher number of sample locations within a site, rather than more detailed sampling at fewer locations.
3. *Drop or reduce vegetation quadrats*: In order to allow a significant streamlining of data collection, it is proposed that the recording of detailed vegetation quadrats be dropped. The exception is where new sites are brought into the monitoring, or new areas with different vegetation are added to existing sites. The vegetation recording required expertise and was time-consuming, and the data were not used extensively enough to warrant their continued collection. They form excellent baseline data, however, and future collection should still be considered in some cases, particularly in sites that are deemed to be changing.

4. *Time-series population data needed*: In order to generate much-needed data on population fluctuations of these three species, more rapid surveying at shorter intervals is needed. While this may not be practical across all sites, it is recommended that a subset of sites for each species be chosen for rapid and repeated surveying, aimed solely at tracking broad population changes. These sites should have easy and agreed access, and not be vulnerable to trampling. An example of such a sampling regime would be choosing three sites for each species that would be surveyed three times a year, for a period of five years.
5. *Decreases/changes trigger increased data collection*: If a simpler model is implemented or trialled, using either fewer or quicker samples, it is recommended that detailed data collection should be triggered if a population decrease is seen; that is, detailed data or surveying is not carried out routinely, but only when declines are noted or suspected in populations, habitats or future prospects.
6. *Impact recording*: In future monitoring rounds, the list of impacts recorded in the most recent survey should be taken into the field to be added to or amended, rather than starting from scratch. This will help reduce discrepancies between threats, pressures and activities recorded between surveys.
7. *Monitoring interval*: For sites that are deteriorating in particular, regular monitoring is essential, and the 6-yearly cycle is too long. Repeat surveys for all sites that do not have a Green status should be at three-yearly intervals, if not sooner. If management actions are instigated, monitoring should be yearly for a few years to ensure no unintended consequences occur.
8. *Habitat mapping*: A more extensive *Vertigo* habitat re-mapping exercise would be extremely useful. The focus should be on standardising the amount of habitat included around suitable habitat (especially for *V. geyeri*), and also in choosing appropriate boundaries to follow.
9. *Transect markers*: Permanent markers for start and end points of transects should be considered (see Section 4.4.7).
10. *Vegetation/habitat descriptions*: The difficulties encountered by having different vegetation classes in use at different sites for *V. moulinsiana* has been discussed, and an over-arching system was suggested for trial before the next monitoring round. A similar approach might be useful for the other two species, though the discrepancies between sites are less pronounced. This is not to say that all sites *must* conform to these over-arching descriptions, but it will allow standard descriptions to be applied to most sites, and those that differ can be noted as such.
11. *Recording weather*: The effect that prevailing weather may have on data collected on *Vertigo* species was discussed in Section 4.4.1. It is therefore a necessity that data on seasonal weather, at the least, be included in any further surveys and factored into assessments.

6 Conclusion

"The future for populations of Vertigo geyeri, V. angustior *and* V. moulinsiana *must be assessed in the context that none of these species are likely to be able to easily colonise new areas of habitat, and therefore their current locations are of high conservation value. New sites for all three species continue to be discovered but these are not examples of spread, but rather the finding of previously undocumented wetlands. All three species for this reason are considered to be dependent on the conservation of a diminishing resource of sites"* (Moorkens & Killeen, 2011 – pg 73).

The future of the three Annex II *Vertigo* species across Ireland depends on developing and implementing the necessary management plans, continued monitoring and further research into aspects of the biology and ecology of the target species. It has been clearly laid out in this report that management intervention is needed at many sites. In many cases, a relaxation of grazing is all that is needed, and this is a relatively easy and quick change to implement. These sites should be tackled immediately.

NPWS are best placed to take the lead on management, which would include liaising and developing management plans in conjunction with landowners, land users and relevant organisations such as Coillte and Waterways Ireland. Land users need information to show what is special about their land, and these species, and most importantly, about what needs to happen in terms of management. Damaging or illegal activities should be stopped and remedial action taken where necessary. Many NPWS local staff are in a strong position to get involved in active conservation of sites, with *Vertigo* populations in mind, and site reports should be disseminated immediately to all regional staff.

The broad-scale decreases in both population and habitats documented in this report suggest there is no room for complacency and management action is needed at a number of sites. However, the fact that new sites are still being found, some existing sites have been extended by the current survey, and that there are sites that have very healthy populations of their respective target species of *Vertigo* (e.g. Streedagh Point Dunes, and Bartraw for *V. angustior*, Meenaphuil and Tievebaun for *V. geyeri*, and Charleville Lake and Portumna for *V. moulinsiana*) shows that there is still reason to be optimistic about the future of these three species in Ireland.

7 Bibliography & Relevant Literature

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Appendix I – Changes to 2007-2012 *Vertigo* assessment criteria

Presented here is a list of criteria changes made during *Vertigo* monitoring project 2014-2017. All were sent to Dr Brian Nelson in NPWS during the course of the project. Note also that all are relatively minor – as discussed and agreed at interim meetings, major changes were not made, but instead noted to NPWS.

Vertigo angustior

VaCAM01 - Beal Point
Re-worded one of the population assessment targets to include samples from Polygon C (Target 1, for site rather than transect).

VaCAM02 – Derrynane
Added a criterion for samples off the transect to allow better assessment of whole site, not just the transect.

VaCAM03 – Dooaghtry
Dropped criterion mentioning requirement for six or more individuals in two samples on the transect as it is too specific and unnecessarily stringent. Replaced with a criterion based on the occurrence of the species across a number of spot samples taken across the site.

VaCAM05 – Kilshannig
It was decided in the field to drop Transect 2; it was very long, had only one sample, and was essentially a nearly defunct extension of Transect 1. This was replaced with multiple extra spot samples. The assessment criterion based on Transect 2 was dropped, and replaced with one based on the spot samples to give a better indication of the status of the species at the site.

As a consequence of the above change, in one case it was necessary to change the number of passes required to reach Amber status from three to two.

VaCAM10 – Killanley Glebe
Third habitat criterion: Area of polygon reduced slightly when redrawn to better reflect the habitat on the ground, so needed to reduce target area mentioned in assessment criterion.

Transect 1: Snail never found there (2006, 2009, 2015), now planted with trees, => decided to drop. The original polygon was split into A and B, with Polygon B (where Transect 1 was located) classed as Unsuitable.

VaCAM14 – Streedagh Point Dunes
One criterion for each of population and habitat needed to be split (had been combined in error in Moorkens & Killeen (2011)).

Previously, no criterion for population off the transect for the site, so one added (i.e. take at least 3 samples in polygons A and B).

Habitat criterion mentioned only Polygon A, so Polygon B added in, and area changed accordingly.

VaCAM15 – Bartraw
Adjusted a habitat criterion slightly to reflect the 5-point suitability scale now in use.

VaCAM16 – Inishmore Island
Population criteria:

Re-worded one to "*3 locations in Polygon B*" (rather than on "*Transect 2*"), due to fact that Transect 2 did not really exist (was a series of spot samples taken in an approximate line, with none of the data typically associated with a transect recorded).

Added a criterion to take account of polygons C and D.

Habitat criteria:

Re-worded one which previously related only to sample points. As this is a large polygon, criterion now relates to area (i.e. Polygon B >12 ha Optimal-Suboptimal or better).

Added the following: at least 1.5 ha from A, C or D to be Suboptimal or better (C and D were previously not included, nor was the non-transect part of Polygon A).

VaCAM19 - Louisa Bridge
Changed wording of two habitat criteria from "*5 samples*" to "*all samples*" (as Moorkens & Killeen (2011) recommended just three samples, and species probably extinct at site so five samples is too many).

VaCAM20 – Ballysadare Bay
Changed habitat criterion "*50m on Transect to be Optimal*" to "*Optimal-Suboptimal or better*". This reflects fact that a 5-point scale was used rather than 3-point.

Vertigo geyeri

VgCAM3 – Brackloon
Habitat on transect likely to continue to be dry (succession), => recommend to drop the transect and instead to do more spot samples, including possibly a visit to nearby site mentioned in Moorkens & Killeen (2011).

VgCAM4 - Clonaslee Eskers
Re-worded two of the habitat assessment targets from *"...in the 6 most favourable flushes...*" to "*... in 6 of the most favourable flushes...*", as this is what we believe was intended.

VgCAM6 – Drimmon Lough
Re-drew polygon to better reflect both a management unit and also suitable habitat. Consequently, needed to alter target area in one of the habitat assessment criteria from 1.4 ha to 1.1 ha.

VgCAM10 – Ballyness Bay
Polygon B dropped – snail has not been found here, and the habitat is not suitable.

Re-worded one habitat criterion (to take account of the 5-point scale used).

VgCAM15 – Silver River
Changed population criterion #2 to include new Polygon C.

Changed #1 and #3 habitat criteria to say "*Optimal-Suboptimal or better*" – reflects 5-point scale.

Dropped from 4 out of 4, to 3 out of 4 habitat zones to be Optimal-Suboptimal or better to reflect conditions on the ground.

VgCAM16 – Fermoyle
Habitat area decreased in second habitat criterion to reflect new polygon boundary (better reflects occurrence of habitat on the ground).

Also changed the number of passes needed as follows:

Old	New
2 = green	2 = green
0-1 = red	1 = amber
	0 = red

VgCAM18 - Fin Lough (Offaly)
Added mention of polygons to reduce confusion (Moorkens & Killeen (2011) used sample numbers, but these change from year to year) in population criteria #2 and #3.

Removed mention of polygons in #3 habitat criterion – it unnecessarily excluded polygons C and D.

VgCAM20 – Lisduff Fen
Changed #1 habitat criterion to say Optimal-Suboptimal or better, i.e. not just Optimal – reflects 5-point scale.

VgCAM22 - Pollardstown Fen
A discrepancy existed between Moorkens & Killeen (2011) report and the related database in that two transects were assessed as one criterion in their written report, but as separate criteria in the database. The latter situation was retained, as is believed to be the best (otherwise negates the point in doing two transects).

Re-worded the population assessment criterion which relates to the site (i.e. not the transect) from being limited to two particular sample locations, to *"...at least two other locations at the site..."*. It is believed that this allows better scope for assessment.

Needed 30m of Transect 1 to be Optimal-Suboptimal to pass; result was 29.5m. We propose to count this as a pass.

Vertigo moulinsiana

VmCAM01 – Borris
90% of transect samples with Class I/II vegetation are needed to pass at this site, but we had 85%. We propose that this is ok to pass.

VmCAM03 - Lough Owel
An error in the site area in the baseline reporting meant that 22 ha was listed when it should have been *circa* 6 ha. This necessitated a change to the assessment criteria: from "20-22 ha" to "5-6 ha".

VmCAM 04 – Mountmellick
An error in Moorkens & Killeen (2011) in relation to site area meant that 1.4 ha was listed, when should have been 0.14 ha. This impacted on one of the assessment criteria, where the area is mentioned. As the length of habitat was also given, and as the habitat is of uniform width/shape throughout, this works equally well. => Dropped mention of 1.4 ha from the assessment criterion, and rely on length of habitat instead.

VmCAM05 - Louisa Bridge
One of the assessment criteria is currently worded such that we need 5/10 of the sample locations to have vegetation Class I or II. The site currently fails on this (it has 4/10). Yet 9/10 sample locations were classed as Suboptimal or better, and 5/10 as Optimal-Suboptimal or better. This suggests that the vegetation classifications as defined may not be ideal for this site. Re-worded the assessment criterion to read: "*5 out of 10 samples taken in areas classified as Optimal-Suboptimal or better*" as this allows more flexibility.

VmCAM06 – Ballybeg Lough
Re-worded habitat criterion to include Polygon B and increased area.

VmCAM11 – Charleville Lake
Added criteria to take account of ALL the site, not just the transect:

A – Population – added one criterion: "Vertigo moulinsiana *present in four other locations, to include Polygon C*"

B – Habitat – added one criterion: "*25% of Polygon C with patches of tall sedge and wetness 3-5*"

C – Habitat – Change word "*site*" to "*Polygon A*" in third Moorkens & Killeen (2011) criterion

VmCAM12 – Curragh Chase
Needed to re-word most criteria as numerous errors encountered including inconsistencies and untraceable spot samples.

A – Population - #1 – *"…a least one location in Polygons C and D…"*

B – Population - #2 – *"…two out of four locations in Polygons A and B…"*

C – Population - #3 – *"…at least two locations…. In the fen/swamp in Polygons E and F…"*

D – Habitat – include polygon letters in the criteria.

VmCAM 18 – Pollardstown Fen
Moorkens & Killeen (2011) recommend taking 10 samples in "*site 1*", but do not provide information as to where "*site 1*" is. We assume it to be Polygon B. We assessed the sampling needs at the site, and instead took 15 samples (with 5 subsamples at each location, giving a total of 75) across multiple polygons. Three of these (i.e. 15 subsamples) were in Polygon B.

a - Due to the above, needed to change wording of one of the population assessment criteria. New wording: "*Adult or sub-adult snails are present in 9 out of 15 sample locations from across the site, and this must include at least 3 positives from Polygon B*"

b - Similarly, re-worded the 3rd criterion for the habitat assessment: "*Over 80% of the sample locations across the site are dominated … .. classes 3-5, and this must include sample locations from Polygon B*."

VmCAM19 – Portumna
A number of changes made to this complex site. Population and Habitat criteria added for the new polygons.

- - - Added 8 new polygons

- - - Transect set up in 2013 by Long & Brophy (2013) repeated this survey

- - - Population

Target #1 – Transect

Target #2 – Portumna Forest Park polygons

Target #3 – other areas

- - - Habitat

Target #1 – Transect

Target #2 – Portumna Forest Park - sample points

Target #3 – Portumna Forest Park - habitat area

Target #4 – Other areas – habitat area

Appendix II – Details of project GIS shapefiles

The deliverables for this project included a number of GIS shapefiles (ESRI-compatible), which have been submitted to NPWS following the required data checks. The following is a list of the shapefiles and short description of each, followed by the definitions of the data fields used.

- <VNMP13_Va_Habitat_2014-2017> – *V. angustior* habitat polygons assigned to one of five habitat suitability classes
- <VNMP13_Va_Spot_Samples_2014-2017> – Details of individual spot samples taken for *V. angustior* including positive/negative, habitat suitability and wetness
- <VNMP13_Va_Transects_2014-2017> – Details of transect data including habitat suitability and wetness
- <VNMP13_Vg_Habitat_2014-2017> - *V. geyeri* habitat polygons assigned to one of five habitat suitability classes
- VNMP13_Vg_Spot_Samples_2014-2017> - Details of individual spot samples taken for *V. geyeri* including positive/negative, habitat suitability and wetness
- <VNMP13_Vg_Transects_2014-2017>- Details of transect data including habitat suitability and wetness
- <VNMP13_Vm_Habitat_2014-2017>– *V. moulinsiana* habitat polygons assigned to one of five habitat suitability classes
- <VNMP13_Vm_Spot_Samples_2014-2017> - Details of individual spot samples taken for *V. moulinsiana* including positive/negative and habitat suitability
- <VNMP13_Vm_Subsamples_2014-2017> - Details of subsamples within individual spot samples taken for *V. moulinsiana* including positive/negative habitat suitability and wetness

The field names, structure and descriptions for the habitat shapefiles are common across all three *Vertigo* species and are presented in Table A1, while the fields for *V. angustior* and *V. geyeri* spot and transect sample shapefiles are presented in Table A2. *Vertigo angustior* and *V. geyeri* shared a structure for recording transects and this is presented in Table A3. Table A4 contains the fields used in recording data for *V. moulinsiana* spot samples, while Table A5 presents the fields for the subsamples shapefile.

Table A1: Field definitions for the *Vertigo* habitat shapefiles

Field name	Type	Length	Precision	Scale	Description
FID	Object ID	-	-	-	Reserved ArcGIS object ID field
Shape *	Text	-	-	-	Reserved ArcGIS object type field
SITE_CODE	Text	20	-	-	Site code of *Vertigo* site (VxCAMXX)
SITE_NAME	Text	150	-	-	Name of *Vertigo* site
SAC_CODE	Text	6	-	-	Site code of SAC
SAC_NAME	Text	100	-	-	Name of SAC
HAB_POLY	Text	10	-	-	Habitat polygon ID
POLY_SUIT1	Text	50	-	-	Habitat suitability of polygon in 2008-2010
POLY_SUIT2	Text	50	-	-	Habitat suitability of polygon in 2014-2017
AREA	Double (numeric)	10	10	0	Area of polygon in sq. metres
CHANGE	Text	30	-	-	Nature of change, if any (e.g. interpreted, ecological)
CHANGE_DES	Text	254	-	-	Description of change

Table A2: Field definitions for the *Vertigo angustior* and *Vertigo geyeri* spot sample shapefiles

Field name	Type	Length	Precision	Scale	Description
FID	Object ID	-	-	-	Reserved ArcGIS object ID field
Shape *	Text	-	-	-	Reserved ArcGIS object type field
DATE_	Date	8	-	-	Date of sampling
SITE_CODE	Text	10	-	-	Site code of *Vertigo* site (VxCAMXX)
SITE_NAME	Text	150	-	-	Name of *Vertigo* site
SAC_CODE	Text	6	-	-	Site code of SAC
SAC_NAME	Text	100	-	-	Name of SAC
SURVEYOR	Text	20	-	-	Initials of field surveyors
SAMPLE_ID	Text	15	-	-	ID number of sample
S_REMOVED	Text	5	-	-	Sample removed for lab ID (Yes or No)
SAMPLE_RES	Text	25	-	-	Sample result (positive or negative)
HAB_SUIT	Text	25	-	-	Habitat suitability at sample point
WETNESS	Text	25	-	-	Wetness on scale of Too wet/Optimal/Too dry
FOSS_HAB	Text	10	-	-	Fossitt (2000) habitat code
RELEVE_Y_N	Text	3	-	-	Relevé completed for spot sample Yes/No
VEG_AV	Short (numeric)	4	4	-	Average vegetation height
VEG_MAX	Short (numeric)	4	4	-	Maximum vegetation height
SLOPE	Short (numeric)	3	3	-	Slope in degrees
ASPECT	Text	5	-	-	Aspect by compass points N, NE, E, SE, S, SW, W, NW
WEATHER	Text	5	-	-	DS = dry and sunny, DC = dry and cloudy, LR = light rain, HR = heavy rain, RR = recent rain.
GRAZERS_P	Text	15	-	-	Grazers Present/Absent/Evidence
GRAZER_TYP	Text	15	-	-	Grazer type, e.g. cattle
GRAZER_N	Text	8	-	-	Number of grazers (if known)
GRAZING	Short (numeric)	1	1	-	Grazing level 1 = No grazing, 2 = Light grazing, 3 = Moderate grazing, 4 = Heavy grazing
X_GRID	Long (numeric)	7	7	0	X-coordinate of sample point in Irish Grid
Y_GRID	Long (numeric)	7	7	0	Y-coordinate of sample point in Irish Grid

Table A3: Field definitions for the *Vertigo angustior* and *Vertigo geyeri* transect shapefiles

Field name	Type	Length	Precision	Scale	Description
FID	Object ID	-	-	-	Reserved ArcGIS object ID field
Shape *	Text	-	-	-	Reserved ArcGIS object type field
DATE_	Date	8	-	-	Date of transect
TRANS_ID	Text	15	-	-	Transect ID number
START_END	Text	5	-	-	Indicates if start or end of transect
ZONE	Short (numeric)	3	3	0	Number of zone along transect
WETNESS	Text	20	-	-	Wetness suitability of zone
HAB_SUIT	Text	25	-	-	Habitat suitability of zone
LENGTH_M	Float (numeric)	5	4	1	Distance of start of zone along transect in metres
X_GRID	Long (numeric)	7	7	0	X-coordinate of start of zone in Irish Grid
Y_GRID	Long (numeric)	7	7	0	Y-coordinate of start of zone in Irish Grid
VEGETATION	Text	100	-	-	Main plant species recorded in zone
TOPOGRAPHY	Text	60	-	-	Topography of zone

Table A4: Field definitions for the *Vertigo moulinsiana* spot sample shapefile

Field name	Type	Length	Precision	Scale	Description
FID	Object ID	-	-	-	Reserved ArcGIS object ID field
Shape *	Text	-	-	-	Reserved ArcGIS object type field
DATE_	Date	8	-	-	Date of sampling
SITE_CODE	Text	10	-	-	Site code of *V. moulinsiana* site (VmCAMXX)
SITE_NAME	Text	150	-	-	Name of *V. moulinsiana* site
SAC_CODE	Text	6	-	-	Site code of SAC
SAC_NAME	Text	100	-	-	Name of SAC
SURVEYOR	Text	20	-	-	Initials of field surveyors
SAMPLE_ID	Text	15	-	-	ID number of sample
S_REMOVED	Text	5	-	-	Sample removed for lab ID (Yes or No)
SAMPLE_RES	Text	25	-	-	Sample result (positive or negative)
HAB_SUIT	Text	25	-	-	Habitat suitability at sample point
FOSS_HAB	Text	10	-	-	Fossitt (2000) habitat code
RELEVE_Y_N	Text	3	-	-	Relevé completed for spot sample Yes/No
GRAZERS_P	Text	15	-	-	Grazers Present/Absent/Evidence
GRAZER_TYP	Text	15	-	-	Grazer type, e.g. cattle
GRAZER_N	Text	8	-	-	Number of grazers (if known)
X_GRID	Long (numeric)	7	7	0	X-coordinate of sample point in Irish Grid
Y_GRID	Long (numeric)	7	7	0	Y-coordinate of sample point in Irish Grid

Table A5: Field definitions for the *Vertigo moulinsiana* subsample shapefile

Field name	Type	Length	Precision	Scale	Description
FID	Object ID	-	-	-	Reserved ArcGIS object ID field
Shape *	Text	-	-	-	Reserved ArcGIS object type field
DATE_	Date	8	-	-	Date of transect
SITE_CODE	Text	254	-	-	Site code of *Vertigo moulinsiana* site (VmCAMXX)
SITE_NAME	Text	254	-	-	Name of *Vertigo moulinsiana* site
SAC_CODE	Text	10	-	-	Site code of SAC
SAC_NAME	Text	254	-	-	Name of SAC
SAMPLE_ID	Text	15	-	-	ID number of sample
VEGETATION	Text	150	-	-	Plant species recorded at sample point
VEG_CLASS	Text	4	-	-	Vegetation class (I-IV)
VEG_HT_CM	Short (numeric)	3	3	0	Vegetation height in cm
GRD_MOIST	Short (numeric)	1	1	0	Ground moisture class (1-5)
VMOULI_AD	Short (numeric)	4	4	0	Number of *Vertigo moulinsiana* adults
VMOULI_JUV	Short (numeric)	4	4	0	Number of *Vertigo moulinsiana* juveniles
X_GRID	Long (numeric)	7	7	0	X-coordinate of sample point in Irish Grid
Y_GRID	Long (numeric)	7	7	0	Y-coordinate of sample point in Irish Grid

Appendix III – Site summary paragraphs

In each site summary (based on the site report discussion), the current and previous conservation assessments are presented, along with a brief note if there has been a change in the assessment between the two reporting periods (2007-2012 and 2013-2018). This is followed by a brief overview of the site, including issues and management recommendations. Note that for some sites, reference to the GIS shapefiles submitted as part of this project will be necessary to gain a full understanding of the issues raised. In order to simplify the text, Favourable (green), Unfavourable-Inadequate (amber) and Unfavourable-Bad (red) are referred to as 'Green', 'Amber' and 'Red', respectively.

Vertigo angustior

VaCAM01 – Beal Point

The assessments for Beal Point remain unchanged for all parameters, with an Overall conservation assessment of Amber in the monitoring periods 2007-2012 and 2013-2018

The population of *V. angustior* at Beal Point appears to be very limited geographically, with two recent surveys finding the snail only in the very central section of the site. This makes the population quite vulnerable. Lack of grazing is the most serious issue affecting the site, and all three polygons would benefit from an increase in grazing level. This change in management should be instigated immediately and in conjunction with the landowner/manager, and should be monitored regularly to ensure a successful outcome. This is particularly important given the fact that in the past (reported in Moorkens & Killeen (2011)) this site was damaged by grazing levels which were too high. This site is probably capable of good recovery, and also likely to be able to support a good population of *V. angustior*, but this will only be the case with an appropriate grazing regime in place.

VaCAM02 – Derrynane

Derrynane has seen a decline in the assessment results for all parameters from Green to Amber. The Overall conservation assessment has dropped from Green in 2007-2012 to Amber in 2013-2018. These declines appear to represent real change, with the Population and Habitat deteriorating between the two monitoring periods.

The area mapped as having potential habitat for *V. angustior* at Derrynane was expanded significantly. The species was found in two sample locations relatively distant from what had originally been understood to be its core area. Overall however, this site needs some changes in management to continue to provide suitable habitat for the species. This involves immediately relaxing the grazing regime across much of the area to allow the growth of grasses (particularly *Ammophila arenaria* and *Festuca rubra*) and also to allow the build-up of *Festuca rubra* thatch in places. In contrast, at the south-western end, grazers may need to be introduced as *Ammophila arenaria* is quite rank there.

VaCAM03 – Dooaghtry

While the Population and Habitat assessments for Dooaghtry have remained Green, the Future prospects, and therefore the Overall conservation assessment, has dropped from Green to Amber between the 2007-2012 and 2013-2018 monitoring periods. The decision to assess the Future prospects as Amber is due to the fact that the management regime has changed, with sheep replacing cattle as grazers on the site. The tight sward that results from sheep grazing is less suitable for supporting *V. angustior*.

This is a small site, with a small core area supporting the target species. This means that the species is vulnerable, but it also means that instigating changes in land management and subsequent monitoring

are achievable. Contact needs to be made immediately with the land-owner and negotiations into changing land management begun. This site needs to be monitored carefully over the coming years.

VaCAM04 – Glencolmcille

The *V. angustior* site at Glencolmcille sees the Population assessment remain Red, the Habitat assessment remain Amber, while the Future prospects drops from Amber to Red. The Overall conservation assessment remains Red between the 2007-2012 and 2013-2018 monitoring periods. The assessment is an accurate reflection of the site, as the target species was not recorded in either monitoring period. The drop in the Future prospects is due to this fact, along with negative activities present at the site.

Vertigo angustior has not been recorded at this site since 2006, in spite of dedicated surveys. The site sees significant human use - e.g. sports grounds (now excluded), arable plots, grazing and walkers. These activities occur piecemeal across the site, making management particularly challenging. *V. angustior* may still occur at this site in low numbers and immediate changes in management are needed to increase the area of potentially suitable habitat for the species. Contact should be made immediately with local landowners to begin this process.

VaCAM05 – Kilshannig

The Population and Habitat assessments for Kilshannig dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects dropped from Green to Amber. This has resulted in the Overall conservation assessment dropping from Green to Red between the two monitoring periods. The population has shown a true decline, while the habitat has been grazed too tightly, leading to it drying out and becoming less suitable for supporting *V. angustior*.

This site has considerable habitat which has good potential for *V. angustior*. In their 2011 report, Moorkens & Killeen stated that it was being grazed by cattle, and at an optimal level to provide habitat for the snail. In 2014, much of the habitat was grazed too tightly - there was little *Festuca rubra* thatch build-up. Consequently, there needs to be a slight relaxation in grazing at the site. However, the change needed is small, and great care must be taken when organising this with the landowner/land manager - abandonment of grazing would also quickly become detrimental to the species' habitat. There is very good scope for the species at this site, pending slight management changes.

VaCAM06 – Kinlackagh Bay

There has been no change in the Population, Habitat or Future prospects assessments for Kinlackagh Bay, with the Overall conservation assessment for the site remaining Red between the 2007-2012 and 2013-2018 monitoring periods.

There are large areas of habitat with good potential for *V. angustior* at Kinlackagh, and the snail has been found in low to moderate numbers across Polygon A (2008 and 2014 surveys), as well as in low numbers in polygons B and C (2014 survey). Polygon A, the main and largest area, appears to have had varying management regimes, with no grazing apparent in 2006, very heavy usage and damage reported in 2008, and a mixed picture in 2014. In 2014, the after-effects of excessive grazing were apparent at the western end, with only scattered small plants of *Ammophila arenaria*, and little to no *Festuca rubra* thatch. Extensive, though localised, clumps of nettles pointed to past supplementary feeding sites, though no current supplementary feeding was noted. The only grazer noted was a single horse. At the eastern end things were quite different, with well-developed *Ammophila arenaria*, as well as *Festuca rubra* thatch. In fact, in places the vegetation was a little rank and under-grazed. Overall, however, there is good scope for the target species across this polygon, and small changes in management would be likely to yield good results for the species.

Polygon B is small and vulnerable, and being seriously damaged by human trampling. Fencing and the creation of a pathway to funnel human traffic is recommended immediately. The eastern section of Polygon C has good potential for *V. angustior*, but management needs careful consideration here.

Liaison with landowners/land managers is required to ensure the correct balance is met. Polygon D is likely to be too altered by agricultural use to hold much suitable habitat, either now or in the future.

VaCAM07 – Maharees

There has been no change in the Population, Habitat or Future prospects assessments for the Maharees, with the Overall conservation assessment for the site remaining Red between the 2007-2012 and 2013-2018 monitoring periods.

This is a large site, with eight polygons, stretching over 9km. There are differing management regimes in almost all polygons, and this results in a mixed picture for *V. angustior* across the site. The species was found in three polygons, F, G and H, all in the central portion of the site. The 2007-2012 survey found the species only in polygons E and F. Given that the species is also known from the adjacent site VaCAM05 (Kilshannig), it can be assumed that the species has a widespread, if sparse, distribution across suitable habitat in this area.

At this site, the main management issue is cattle grazing, and associated activities (e.g. supplementary feeding). Some polygons are undergrazed in places (e.g. western end of Polygon E), but more commonly, polygons are overgrazed (e.g. parts or all of E, G, H, I, J and K). In particular, the polygons at the west of the site (I, J, and K) are particularly heavily grazed, with K being so much so that there are extensive areas of bare ground. Clearly these areas are highly unsuitable for *V. angustior* as it needs a build-up of moist thatch or moss. Within polygons D, E, G and H in particular, liaison is needed immediately with landowners/land managers to negotiate more appropriate management regimes.

Polygon F contains a golf course, and management here should remain as it is. The roughs are in excellent condition as *V. angustior* habitat.

VaCAM08 – Dog's Bay

Dog's Bay has seen its Habitat assessment drop from Green to Red and its Future prospects drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018. While the Population assessment remains Green, the Overall conservation assessment drops from Green to Red. This decline relates to real change at the site, with overgrazing by cattle and damage to the site.

Although the habitat suitability status of the only polygon at this site remains unchanged at Suboptimal-Unsuitable, the site has decreased in quality since the 2007-2012 monitoring period. This is evident by a comparison with previous photographs taken at individual sample points. There is now very little *Ammophila arenaria* across the entire site, where previously large stands were present. The vegetation is very short throughout the site (i.e. ≤3 cm), with large areas with open sand/blown sand. There is little or no thatch anywhere. One small area (S06) is fenced and is the only place with *Ammophila arenaria* in fixed dune, indicating that overgrazing is a problem. The snail continues to survive in a small hollow, but this is showing signs of damage from erosion, putting the future survival of the species at this site at risk.

VaCAM09 – Fanore

Fanore has seen its Population assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects remain Amber. This has resulted in the Overall conservation assessment dropping from Amber to Red. The fact that the target species was not found at the site in the current monitoring period suggests that this is a real decline, the cause of which is not clear.

The site at Fanore comprises an extensive dune system, though much of it has been affected by the operation of a caravan park. In the previous monitoring period, the northern section of the site provided the best habitat for *V. angustior* and had numerous positive sample locations, while the southern section had few positives. The current survey failed to find the snail at any of the sampling locations, indicating a dramatic reduction, or possibly loss, of the *V. angustior* population at the site. It is evident that

overgrazing is impacting the previously suitable habitat in Polygon A, with signs that the rabbit population is having a particular impact on the sward height and development of the much needed *Festuca rubra* thatch, while cattle grazing is also evident. Extensive rabbit warrens are present where none were noted previously.

A large proportion of the site has been developed as a caravan park, with concrete bases for mobile homes built into the fixed dunes. The caravan park has extended further to the north into the dunes since the 2009 survey, and this issue needs to be tackled. Other features associated with the caravan park are tracks and paths, toilet blocks, and other buildings. While the caravan park has resulted in the loss of fixed dune habitat, much of the area at the south of this site seems to be less suitable for *V. angustior* due to the presence of a deep moss layer, with limited *Festuca rubra*, which is likely to be indicative of aging dunes. Nevertheless, further expansion of the caravan park should not take place.

This site needs an immediate re-visit to endeavour to re-find the snail. It also needs an immediate management plan - this should be between NPWS, the owner of the caravan park, the landowner(s) and the people managing the grazing stock (these final three may all be the same person). NPWS should take the lead on this and issues such as the rabbit population; frequency, timing and species of domestic grazer; supplementary feeding; as well as the operation and expansion of the caravan park all need to be included for discussion.

VaCAM10 – Killanley Glebe

The assessments for Killanley Glebe remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

The site was split into two polygons after the current survey, due to the clear difference between the open habitat to the north and the wooded area to the south, with the northern polygon classed as Optimal and the southern as Unsuitable. The population and habitat in the northern polygon suggests that the current management regime is ideal for maintaining the site in favourable conservation status. The snail was not been recorded from the southern polygon during surveys in 2006 and 2009 by Moorkens & Killeen, nor in the current 2015 survey.

VaCAM11 – Lahinch

Lahinch has seen its Population assessment drop from Green to Red and its Future prospects drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018. While the Habitat assessment remains Green, the Overall conservation assessment drops from Green to Red. This decline appears to indicate a real problem at the site, as the target species was only found at one sample location on the eastern golf course, and was absent from the western golf course.

This is a large site that, although consisting of two heavily used golf courses, has supported a population of *V. angustior* for at least 100 years (and probably very much longer). Prior to the current survey, the species was found to be relatively widespread and common at the site. However, in 2016 a dramatic decrease was seen, with only 1 out of 15 samples positive. The reasons are unclear, as management does not appear to have changed. The site was inundated by the sea in 2010, but while it is difficult to be certain, the impact of this event on the population is unlikely to have been massive (due to relatively short inundation duration, and the height of many of the dune hills above the level of the inundation). A repeat survey is needed immediately to investigate the population further, and both the golf course managers and NPWS need to meet to discuss options for this large and important site.

VaCAM12 – Malin Dunes

While the Population assessment and Future prospects for Malin Dunes remain Green, the Habitat assessment has dropped from Green to Red between the monitoring periods 2007-2012 and 2008-2018. The Overall conservation assessment drops from Green to Red as a result of the Habitat assessment result. The negative assessment for the site is considered to be overly harsh and due to the fact that the assessment criteria for habitat are too heavily weighted towards the transect given the large size of the

site. Given the healthy population of *V. angustior* recorded at the site and the expanse of suitable habitat, it is likely that a more realistic Overall conservation assessment for the site would be Green.

This site represents an extensive area of *V. angustior* habitat, most of which is in good condition and suitable for supporting the species. Monitoring criteria based heavily on the 60m transect have resulted in an Overall Assessment of Unfavourable-Bad (red). However, this result should be interpreted in the context of the site as a whole, which is both in good condition more or less throughout, and likely to continue to be so (particularly following discussion with landowner who has no plans to change farming practices).

VaCAM13 – Pollardstown Fen

The population and habitat assessments for Pollardstown Fen have dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects drop from Amber to Red. The Overall conservation assessment drops from Amber to Red and this reflects real problems at the site that are causing a drop in the *V. angustior* population and a decline in habitat suitability.

This site has seen a considerable deterioration in terms of its suitability for *V. angustior* in the period between 2009 and 2014. Polygon A has become rank and overgrown (not to mention overshadowed by growing trees), to such an extent that it is hard to imagine it ever having been suitable for *V. angustior*. Polygons B and D are overgrazed, and for the most part lack areas with a suitable thatch/moss layer to host the species. The species was found in only one sample point, within Polygon C. Management intervention is urgently needed to attempt to reverse the deterioration. Polygon A needs some targeted tree removal and immediate instigation of grazing, whereas polygons B and D need a relaxation of grazing in general, and perhaps also some fencing out of animals from lower parts at wet times of year. Overall, the prospects for the species at this site are poor. The area of potentially suitable habitat at the site has always been very limited, and given the deterioration in quality across most of its area, for a variety of reasons, the species has been put under significant pressure.

VaCAM14 – Streedagh Point Dunes

The Population assessment and Future prospects for Streedagh Point Dunes remain Green across the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment drops from Green to Amber. The Overall conservation assessment drops from Green to Amber. Streedagh Point Dunes remains an excellent site for *V. angustior* and, while the Habitat assessment result reflects real change at the site, with *Juncus subnodulosus* dominating the lower part of the transect, it appears that the transect is too heavily weighted in the assessment given the large size of the site. It is suggested that an Overall conservation assessment of Green would be a more appropriate for this site.

The site at Streedagh Point Dunes supports extensive habitat suitable for supporting *V. angustior* and the snail was found to be common and widespread. In terms of the impacts, cattle grazing is having a positive effect at the current levels, though horse grazing on Conor's Island should be reduced.

VaCAM15 – Bartraw

The assessments for Bartraw remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

The site at Bartraw consists of an isthmus, supporting a narrow strip of dune habitat, connecting to an island that supports abundant fixed dune habitat suitable for supporting *V. angustior*. The snail was found across much of the island, as well as the northern part of the isthmus, but the dunes further south are too mobile to provide suitable habitat. Some pressures were identified for the site, but all are considered to be relatively small in scale. They include walking/trampling, horse-riding and storm-thrown shingle. Overall, *V. angustior* is expected to continue to survive at the site. The site would benefit from the removal of horse-riding in the dunes, and a programme of dune restoration to repair damage caused along the isthmus by trampling and blow-outs.

VaCAM16 – Inishmore Island

Inishmore Island has seen its Population assessment, Habitat assessment and Future prospects drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018. The Overall conservation assessment drops from Green to Amber. This decline is considered to reflect a real change at the site with a drop in the population of *V. angustior*, and the grazing level across a large portion of the site being too high.

The *V. angustior* site of Inishmore comprises two well-separated areas: Cill Mhuirbhigh and the airport. The Cill Mhuirbhigh area includes fixed dune habitat close to the coast, while further inland it becomes machair grassland. The species was found frequently on the machair in the previous survey, but only in a few of the most seaward sample locations were positive for the snail during the current survey. *V. angustior* was only found in one sample from the large area of Polygon B, previously noted to be dominated by 'a dense, springy thatch of *Festuca rubra'*, but now no longer supporting such a micro-habitat. No *V. angustior* were recorded at the airport and much of the habitat there has either a dense moss layer in the understorey, or is too mobile. Overgrazing at Cill Mhuirbhigh appears to have resulted in the loss of much of *Festuca rubra* litter, leading to a drop in the suitability of the habitat and so management of grazing levels is required to allow the habitat to improve.

VaCAM17 – Curragh Chase

The *V. angustior* site at Curragh Chase has seen its Population assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment has dropped from Amber to Red. The Overall conservation assessment has dropped from Amber to Red. This decline reflects a real problem at the site, as the target species was not found in the current monitoring period, and the habitat has shown decline due to overgrazing/trampling and dumping.

The previous monitoring survey, in 2010, found that the site had deteriorated since the species was discovered there in 2005. This decline in quality was attributed to trampling and grazing by cattle. The current survey has shown that the site continues to decline in terms of habitat quality, and particularly in terms of population, with no *V. angustior* found in the course of sampling in 2016. The failure to find the species does not mean that the population is extinct, but it does raise serious concerns, and repeat surveying is needed immediately.

A slightly higher-than-desirable level of grazing and trampling by cattle continues to have a negative effect on the site, and scrub clearance and dumping has also occurred (within the SAC boundary). The effects of the grazing is particularly notable along the transect, as a shift from fen to grassland can clearly be seen to have occurred since the last monitoring period. While grazing pressure, dunging, and associated agricultural effects are undoubtedly important in driving this change, it may be facilitated and/or accelerated by changes in hydrological regime (however studies are needed to confirm this).

As noted by Moorkens & Killeen (2011), the site is important as it is the only known *V. angustior* site in County Limerick, and is one of only a handful of inland sites in Ireland. Furthermore, there are no known sites at all in the neighbouring counties of Cork, Tipperary, Waterford, nor further towards the south-east of Ireland. It is also vulnerable as it is partly outside the boundary of the Curraghchase Woods SAC (the western portion of the polygon, including the transect, is outside the SAC). Immediate contact needs to be made between local NPWS staff and the landowner/land manager about stock management and scrub removal and dumping, as small changes would be very beneficial. Extending the SAC boundary slightly should also be considered to afford this important site some added protection.

VaCAM19 – Louisa Bridge

The Habitat assessment for Louisa Bridge drops from Amber to Red between the monitoring periods 2007-2012 and 2013-2018, while the Population assessment and Future prospects remain Red. The Overall conservation assessment remains Red. This result is an accurate reflection of the site, as the

target species was not recorded in the current monitoring period, nor the previous one, and the habitat is not in good condition for supporting the species.

The area which supported *V. angustior* at this site in the past was always relatively small and marginal (i.e. at the interface between the swamp vegetation of the river floodplain and the tufaceous slopes above). Here the snail would have been found in unshaded vegetation consisting mostly of *Iris pseudacorus*, with a mossy understorey. This vegetation type is now largely lost, being limited to a shaded strip adjacent to willow trees. This may be due mostly to natural changes taking place in the absence of management - i.e. a build-up of tall dense vegetation, and a development of a line of willows leading to shading, but alterations along the Rye River catchment may also have had an influence on the hydrological regime at the site. Even with management, it would likely have been difficult to have retained suitable habitat at this site for *V. angustior*. Experimental cutting of vegetation at the site was carried out by Kildare County Council in the past, but does not appear to have had long-term benefits (Moorkens & Killeen 2011).

Given that the species has not been found here since the late 1990s, in spite of repeated surveys, the continued occurrence of *V. angustior* at this site is far from certain. Given the importance of this site (the most eastern site in Ireland, also one of only a handful of inland sites, and the fact that *V. moulinsiana* is also found here), and the fact that the species is difficult to detect, particularly in small populations, short surveys should be continued for at least another two rounds.

VaCAM20 – Ballysadare Bay

The assessments for Ballysadare Bay remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

The site at Ballysadare Bay supports extensive *V. angustior* habitat and a good population of the snail, with adult snails found at all but one of the twelve sample locations (and a juvenile *V. angustior* was found at this sample location within the golf course). The habitat comprises extensive fixed dune, with a good *Festuca rubra* thatch in places under *Ammophila arenaria*. While the habitat is good for the snail, there is some indication that it may be becoming rank, particularly in Polygon A. Some areas have been affected by trampling and blowouts (polygons B and C), while the maintenance of the golf course has limited suitable habitat to areas of rough within its footprint (Polygon E). Management actions are necessary to address some of the issues at the site including potentially introducing light cattle grazing to Polygon A, a more sensitive mowing regime for roughs on the golf course, and measures to address the negative effects of trampling and to allow the revegetation of blowout areas.

VaCAM21 – Strandhill Airport

Strandhill Airport has seen the Population assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment has dropped from Amber to Red. The Future prospects remain Amber. The Overall conservation assessment for the site drops from Amber to Red. This decline in status reflects real change at the site, with an apparent decline in the population of *V. angustior*, while the habitat is becoming less suitable, possibly as a result of succession and decalcification due to the aging dune system.

The *V. angustior* population at Strandhill Airport appears to have declined since the 2007-2012 monitoring period, with some decline in habitat quality evident along the transect and in Polygon C. The high cover of *Arrhenatherum elatius*, particularly polygons B and E, suggest the habitat has become rank through lack of grazing (by rabbits or livestock), and therefore is less suitable for supporting the target species. Natural succession to a more stable fixed dune habitat is also occurring. Lack of grazing has been identified as the main threat to the site, with coastal erosion also of concern. Historical conifer planting along the eastern boundary of the site has led to the loss of potentially suitable habitat, as has construction of the airport and the sewage treatment works.

Management of the site should include the introduction of grazing to counter the transition to rank vegetation, and to encourage a return to a more *Ammophila arenaria-Festuca rubra* dominated sward. Monitoring of the grazing level would be required to ensure a positive effect.

Site managers, site users and NPWS staff should meet in the near future to discuss the conservation issues and challenges at this important site, and to decide on the relative priorities. This site is important for a suite of other uncommon plants, animals and habitats, any actions taken must bear this in mind.

VaCAM22 - Waterstown Lough

No conservation assessment was carried out for *V. angustior* at Waterstown Lough in the monitoring period 2007-2012. In the monitoring period 2013-2018, the site was assessed as Green for all parameters, with an Overall conservation assessment of Green.

Waterstown Lough is an important site, as it supports all three Annex II *Vertigo* species (*V. angustior*, *V. geyeri* and *V. moulinsiana*), one of only two sites to do so in Ireland, the other being Pollardstown Fen. The *V. angustior* population is limited in size and distribution, with the habitat restricted to the transition zone between wet grassland and fen along the north-eastern side of the site. Cattle currently have access to the habitat, which helps to maintain an open sward suitable for *V. angustior*. Negative impacts are thought to be small in scale, but it should be noted that slow-paced hydrological change (i.e. the site drying out) cannot be ruled out. Therefore, monitoring of this site on a regular basis is important.

Vertigo geyeri

VgCAM01 – Meenaphuil

The assessments for Meenaphuil remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

Vertigo geyeri was found in both samples along the transect located on a north-facing, flushed slope. The habitat along the transect improved from Suboptimal in 2005 to Optimal in 2008, due to reduced grazing, and remains Optimal in the current survey. Sheep grazing was the only activity noted in the area, and was considered to be at a level that was having a positive effect. A nearby small quarry, accessed by a recently cleared and sprayed track, presents a potential future impact on the flush site, though currently no issues were noted.

VgCAM02 – Tievebaun

The assessments for Tievebaun remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

Vertigo geyeri was recorded at all nine locations sampled, and in good numbers throughout, and suitable habitat is found across the site in the form of numerous often expansive flushes, seepages, springs and lawns. The current level of sheep grazing is considered to be having a positive effect on the *V. geyeri* habitat, by maintaining a short, open sward, but without any signs of overgrazing. As long as conditions remain as they are, this is an important site for *V. geyeri*, and is likely to remain so.

VgCAM03 – Brackloon

The Habitat assessment and Future prospects for Brackloon remain Amber between the monitoring periods 2007-2012 and 2013-2018, while the Population assessment drops from Amber to Red. The Overall conservation assessment has dropped from Amber to Red. This decline seems to reflect a real change in the population at the site with only one of four samples positive for *V. geyeri*, though the number of samples taken was small.

The site is limited in size, and comprises an area of calcareous flushing on the margins of an almost infilled lake, in an otherwise acid bog habitat. As the lake continues to infill, natural succession processes mean that some areas are becoming drier, and consequently dominated by vegetation unsuited to supporting *V. geyeri*. Thus the polygon currently includes areas that are too dry for the snail, and dominated by species such as *Molinia caerulea* and *Calluna vulgaris*, and also very wet areas of quaking vegetation. While the site requires continued monitoring, no management recommendations are made and the snail's future survival will depend to a large extent on natural factors. As succession continues at this site, the condition of the habitat on the transect in particular is likely to deteriorate in terms of suitability for *V. geyeri*. For this reason, effort may be better diverted to an increased number of spot samples in future years. Exploration of the nearby record at G072180 (Holyoak 2005) is recommended.

VgCAM04 – Clonaslee Eskers

The Population assessment and Future prospects for Clonaslee Eskers remain Red between the monitoring period 2007-2012 and 2013-2018, while the Habitat assessment dropped from Green to Red. The Overall conservation assessment remains Red. A decline in the habitat suitability is apparent on the ground, with former spring/flush areas now dry and vegetation becoming rank across much of the site.

In 2014, this site was found to be too dry and too overgrown to be suitable for *V. geyeri*. However, very small remnants of suitable habitat patches were evident (e.g. small pockets of typical mosses, small areas of tufa, and patchy low-growing sedges). These were generally between and/or shaded by large *Schoenus nigricans* tussocks. Some areas (polygons C, D and E) appeared not to be grazed. Some grazing is necessary in most cases to maintain habitat suitable for *V. geyeri*. Other areas (polygons A and B) appear to receive some grazing (though no evidence was seen at the time of survey), but nonetheless

tussocks of *Schoenus nigricans* were very large. *V. geyeri* requires open habitats, with low-growing sedge/moss lawns. This site was characterised by large tussocks, which, in ungrazed areas were, growing close together and thus completely shading out the ground underneath, and in grazed areas were separated by areas of nearly bare ground with some water movement. Neither situation is suitable for *V. geyeri*.

It is unclear to what extent drying (due to the drain noted in Moorkens & Killeen (2011)) and grazing regime have interacted to produce this result, and thus it is difficult to make management recommendations. As noted in Moorkens & Killeen (2011), a hydrological study is needed to confirm the hydrological situation. A drain was recently dug, and they noted that this may be directly drying the site, or may have caused changes in the seepage springs.

Grazing needs to be introduced to the areas not currently grazed, but great care needs to be taken that poaching is not occurring and damaging the remnant potentially suitable pockets. This is an issue particularly because when large tussocks exist, animals often move between tussocks causing excessive poaching in between, but leaving the tussocks themselves largely unchanged.

VgCAM05 – Dooaghtry

The *V. geyeri* site at Dooaghtry has seen the Population and Habitat assessments drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects remains Green. The Overall conservation assessment drops from Green to Amber. The apparent decline in the population may be due to the fact that the assessment criteria are too strict.

Overall, Dooaghtry is a good site for *V. geyeri*, with extensive areas of flushes and fen capable of supporting the species. Extensive areas of habitat such as this are uncommon. The site is sheep grazed, and the key to the continued survival of *V. geyeri* at the site will be the continuation of an appropriate level of grazing. Over much of the site, grazing has probably been too heavy in the past, although the wetter fens and flushes, which support *V. geyeri*, have been the least affected. In Polygon F, however, the reverse is the case, with undergrazing being a severe issue, in terms of *V. geyeri* at least. The area is so undergrazed and overgrown that the flushes were no longer visible in 2014. Much of the characteristic flora, and dependent fauna species such as *V. geyeri*, are being squeezed out. This is the area that needs the largest and quickest intervention at this site.

VgCAM06 – Drimmon Lough

Drimmon Lough has seen its Population assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment has dropped from Green to Amber and the Future prospects remains Green. The Overall conservation assessment drops from Green to Red. While the habitat at the site is generally good, though with some areas drier than is optimal for *V. geyeri*, the population does appear to have shown a real decline when compared to the previous monitoring period, mainly due to the much reduced numbers of *V. geyeri* individuals found in the samples.

This is a small site, but one which is very important as it supports populations of both *V. geyeri* and *V. angustior*. It is vulnerable because of its small size, and because the ground is very wet - thus any changes in management could quickly have detrimental effects (e.g. a reduction in grazing could quickly render the site too over-grown to support either species, whereas an increase in grazing pressure would quickly damage the fragile vegetation and soil in such a wet location). However, the current grazing levels appear to be striking the balance well. *V. angustior* was found here unexpectedly by Moorkens & Killeen (2011). It was not sampled for specifically in 2014, but it is recommended that this be prioritised.

A re-survey of this site is recommended immediately in order to assess if the low numbers represent a trend. An increase in the monitoring frequency to every two years is also recommended based on its vulnerability as outlined above.

VgCAM08 – Sheskinmore Lough

Sheskinmore Lough has seen its Habitat assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects drops from Green to Amber. The Population assessment for the site remains Green. The Overall conservation assessment for Sheskinmore Lough drops from Green to Red. While the site is broadly in good condition, heavy poaching along part of the transect has caused the decline in the Habitat assessment, Given the healthy population of *V. geyeri* recorded at the site and the expanse of suitable habitat, it is likely that a more realistic Overall conservation assessment for the site would be Amber..

This site hosts an extensive area of suitable habitat for *V. geyeri*, and this current survey has further extended the already significant area identified by Moorkens & Killeen (2011). Thus this site is a very important one in a national and even international context. Good numbers of *V. geyeri* were found along the transect (five positive samples out of five), and in two of the three spot samples taken, indicating a healthy population. However, the site has dropped in conservation status and this is because of the poaching damage in the vicinity of the transect. Some areas here are very heavily poached, and now consist of bare mud and open water - clearly not suitable for *V. geyeri*. The damage is localised, but severe, and resulted in both the Habitat assessment and the Future prospects assessment being poorer than previous. Immediate action is needed at this part of this site to allow recovery, but in doing so managers must be mindful of the continued need for light grazing across the remainder of the site (specifically, those areas that are currently grazed). This site is managed for conservation (understood to be jointly by NPWS and BirdWatch Ireland), and thus making the necessary changes should be possible. There appears to have been a change from cattle to horse grazing in recent years, but this should not be an issue in relation to *V. geyeri* - rather it is the levels and timing of grazing that matter.

VgCAM09 – Annaghmore Lough

The *V. geyeri* site at Annaghmore Lough has seen the Population assessment and Future prospects drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment drops from Green to Amber. The Overall conservation assessment for Annaghmore Lough is Red. The decline in status for this site reflects the fact that there has been a clear decline in the population and habitat quality at the site. The target species was not recorded in the current monitoring period and the suitability of the habitat been reduced by a combination of undergrazing, overgrazing and, potentially, flooding and the development of a thick film of gelatinous algae.

Much of the habitat continues to be apparently suitable for supporting the species, so it is unclear what is happening to result in the population suffering such a drop. The overall habitat suitability of the site's polygons has remained unchanged, though localised effects have seen the habitat deteriorate in some places, in particular overgrazing at Transect 3. The vegetation at Transect 4 was covered in unidentified slimy substance (likely to be largely algal), which may have been deposited by receding flood waters, and if so, this flooding may have had a negative effect on the *V. geyeri* population. Some changes to the grazing regime at the site are recommended in order to combat the effects of overgrazing and undergrazing. Until a clearer picture emerges of the status of the species at this site, repeat surveying is recommended immediately, and within three years at the latest.

VgCAM10 – Ballyness Bay

The Population assessment for Ballyness Bay has dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects have remained Green. The Overall conservation assessment for Ballyness Bay has dropped from Green to Red. While the site appears to still be in good condition, the population has shown a decline from the previous survey with species found only at one (rather than two) samples out of four on the transect, but the reason for this apparent decline is not clear and the number of samples involved is low to make a strong judgement from.

This site appears to be in good condition and so the result of the Overall conservation assessment may be a little harsh. Light grazing needs to be maintained to keep the vegetation open, particularly as signs of rankness were noted. The site is currently grazed by cattle, and any increase in grazing level would risk poaching damage. The desired habitat conditions would probably be best achieved by sheep grazing at this site, due to their light weight. It is recommended that Polygon B should be dropped from future monitoring as the habitat is too acid to support *V. geyeri*, and to the best of our knowledge, the species has not been recorded there.

VgCAM13 – Easkey Valley

The Population assessment for Easkey Valley has dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects remain Green. The Overall conservation assessment for Easkey Valley has dropped from Green to Red. While the site appears to still be in good condition, the population has shown a real decline from the previous survey, but the reason for this decline is not clear.

While some parts of the site have seen significant changes (e.g. Polygon A - presumed recent agricultural improvement; Polygon I - land clearance), most of the site appears to have remained the same. Future monitoring may benefit from an increased number of samples, but this needs to be weighed against the potential impacts of over-sampling or trampling damage in the most sensitive and/or smaller habitat areas.

VgCAM14 – Polaguil Bay

The *V. geyeri* site at Polaguil Bay has seen the Population and Habitat assessments drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects remains Green. The Overall conservation assessment drops from Green to Amber. There has been a real decline in the population and habitat quality at the transect, but this limited area is not representative of the expanse of good quality habitat at the site, and so the drop in the assessment should be interpreted with caution and the criteria should be revised to reduce the weighting of the transect area in the context of this large and suitable site.

The drop in the Overall conservation assessment is due to the results of the population and habitat assessments for the transect area (Polygon E). There has been a decline in habitat quality here (related to past fencing out of grazers), and this has had a negative effect on the *V. geyeri* population, with no positive samples recorded in 2015. With abundant Optimal habitat across other polygons (notably B and C), the weighting of the transect in the population and habitat assessment may paint an unfair picture of the site. Because of the good condition of most of the site, the Future prospects continue to be Favourable (green), as there is no reason to think that the continued presence of *V. geyeri* at this site is at risk. The current management is ideal for maintaining the habitat for *V. geyeri* across most of the site, though some intervention in the form of hand cutting or grazing is required to improve areas that have become rank (Polygon E and parts of polygons A and D). This should be instigated immediately, and the landowner is amenable to taking conservation management actions with some supports.

VgCAM15 – Silver River

The Population assessment and Future prospects for Silver River remain Green across the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment drops from Green to Amber. The Overall conservation assessment drops from Green to Amber. The drop in the Habitat assessment reflects real change at the site, with a small section of the transect becoming less suitable for supporting *V. geyeri*.

This is an important site for *V. geyeri*, with extensive areas of potentially suitable habitat, and being one of the most southerly sites in Ireland for the species. The site at Silver River has shown some reduction in habitat quality on the tufaceous slope within Polygon A, but this area is very limited in extent relative to the size of the site as a whole. This decline in quality is reflected in the result of the Habitat assessment.

In the previous survey, only dead *V. geyeri* shells were found in Polygon B, but this result was still used to give a pass for the related Population assessment criteria. While the habitat quality of Polygon B remains unchanged (being quite heavily poached), no *V. geyeri* (alive or dead) were recorded here in 2016. In 2016, an additional area of suitable habitat was discovered upslope and to the south-east of the existing polygons. While Optimal habitat appears to be limited here, nonetheless, *V. geyeri* was recorded.

Current activities at the site are limited to cattle, horse and deer grazing. Future management of the site should aim at reducing the impact of cattle grazing in Polygon B. It is important to note that Polygon C may be at risk from future land-use change as a result of an on-going land dispute. It is also important to note that this site is not within an SAC/NHA.

VgCAM16 – Fermoyle

The Population assessment and Future prospects for Fermoyle remain Green across the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment drops from Green to Amber. The Overall conservation assessment drops from Green to Amber. This drop is due to a decline in the habitat suitability at the site.

The broader landscape at Fermoyle comprises blanket bog (with peat extraction occurring nearby), with localised alkaline and iron-rich influences which create habitat suitable for *V. geyeri*. The nearby farm had cattle, and some extensive grazing of the bog and fen habitat was apparent. The habitat supporting *V. geyeri* would be considered atypical, being relatively acid and with few of the normal indicator species of vascular plants or mosses present (e.g. low-growing sedges such as *Carex viridula* subsp. *brachyrrhyncha* were uncommon, and typical 'brown mosses' were similarly patchy in occurrence). In many of the areas highlighted in the previous survey for sampling, the flushes consisted of tall, dense vegetation (e.g. stands of *Juncus subnodulosus*). *V. geyeri* needs open habitats, usually with short vegetation, or at least a mosaic, with some areas short/low. It is unclear what has caused the changes, though a change in grazing regime is one possible explanation. With all this said, however, the species continues to be present across the site.

While the threats and pressures identified do not appear to pose an immediate risk to the continued presence of the snail at the site, some actions should be considered. Invasive species should be removed from the habitat, and no further drainage should occur within or adjacent. The grazing regime should be queried, and if changes have been implemented in recent years, perhaps these could be reversed. Grazing management should be aimed at ensuring low, open vegetation at the flushes which are mostly at the edge of the floating mire, but great care must be taken to avoid over-grazing and trampling. A delicate balance is required, and local land-owners, in tandem with NPWS staff, are well-placed to implement such a regime. This site is important not just for *V. geyeri*¸ but also for other species (e.g. *Saxifraga hirculus*, and a suite of rare bryophytes), and in general, management recommendations are likely to be similar for these species and mutually beneficial.

VgCAM18 – Fin Lough (Offaly)

While the Population and Habitat assessments for Fin Lough have remained Green, the Future prospects, and therefore the Overall conservation assessment, has dropped from Green to Amber between the monitoring periods 2007-2012 and 2013-2018. There are a range of activities and pressures present at the site that may impact the future security of the *V. geyeri* population at Fin Lough, including cattle grazing in places and the lack of grazing in other places, resulting in the vegetation becoming rank, and also some localised nutrient enrichment.

Fin Lough continues to support a population of *V. geyeri* across the site, and has many areas of good quality habitat. A decrease in the numbers of *V. geyeri* was noted however, as well as in the number of positive sample locations. This means that this site is in need of careful monitoring.

Some parts of the site are grazed, and some are not (one land parcel is abandoned, and other areas are fenced off). In places the wetness at the edge of the infilling lake maintains an open vegetation sward, but in others where there is no grazing, the *Schoenus nigricans* tussocks are tall, rank and dense. Throughout, there are patches, though often small and sparse, of suitable moss and low vegetation. The extent and quality of these varies between polygons. The grazing at this site requires a delicate and careful balance - it would be very easy to overgraze and hence poach and damage the delicate tufa springs. Communication with the landowner/land manager and detailed monitoring is needed. Within the relatively large Polygon C, it is suggested that trial plots for manual cutting of tall tussocks of *Schoenus nigricans* could be carried out. This should only be done if the resources are available to allow detailed monitoring of the outcome, and repeat the management actions if necessary.

There is a sizeable drain running into the lake (between polygons D/E and B/C) which has dense algal growth suggestive of high nutrient levels, or perhaps of silt run-off. This issue is likely to be emanating from outside the SAC boundary (e.g. scrub clearance has occurred on the nearby esker, and some nearby grasslands are likely to be fertilised) and requires liaison between local NPWS staff and local landowners.

Of note is the fact that one of the positive samples at Fin Lough (in Polygon A) is outside the SAC boundary. Also, a small area of fen habitat at the northern side of the access road/track, which has apparently previously had a positive sample for *V. geyeri*, was not included for survey. It is recommended to include it in future monitoring.

VgCAM20 – Lisduff Fen

The *V. geyeri* site at Lisduff Fen has seen its Population assessment drop from Green to Red and its Future prospects drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018. While the Habitat assessment remains Green, the Overall conservation assessment drops from Green to Red. This decline appears to indicate a real problem at the site, as the target species was not recorded during the current monitoring period, despite the habitat appearing suitable and no obvious major impact on the site (though a suite of low to moderate impacts have been identified in and near the site).

Lisduff Fen is an important site - it supports both *V. moulinsiana* and *V. geyeri* (though only *V. moulinsiana* was recorded in the current survey), and inhabited marsh fritillary (*Euphydras aurinia*) larval webs were also recorded here as part of the current survey (apparently a new record). While the habitat appears to be still suitable for *V. geyeri* across most of the site (i.e. wetness was optimal, typical associated plant species were present, habitat structure looked good), the snail was not found in the course of the current monitoring period. It is not clear why this apparent decline in the population of *V. geyeri* has occurred. At first, the pressures and threats to the site appeared to be relatively limited, but given the apparent large decline (or even loss) of the species at the site, these impacts may be acting either more strongly or in combination to affect the site in ways that are not yet clearly apparent.

In terms of management - grazing levels are near ideal in the southern section of the fen, but the northern section appears to be abandoned, and grazing needs to be re-introduced. Activities happening directly adjacent to the fen, and relating to agriculture, may be combining to alter conditions in the fen just enough to make it less suitable to *V. geyeri*. These activities include scrub removal, silage production, water abstraction, drain modification, habitat reclamation and dumping of brash and spoil. While none are very dramatic if taken in isolation, all have the potential to negatively impact on the delicate balance that always exists in a calcareous fen. Silt run-off, chemical run-off, or hydrological regime alteration may all be happening.

This is an important site, and urgent action is needed to reduce the intensive agricultural activity happening within the SAC boundaries. It needs careful liaison with landowners, including time spent explaining the importance of the site as well as the rationale for management changes, and then dedicated monitoring when changes are implemented.

Of interest is the fact that the *V. moulinsiana* population has not seen such a drastic decline. It was found to be widespread along the spring-line habitat that runs along the south-western section of the site, though with a cluster of negative samples in one area.

VgCAM21 – Ox Mountains

The Population assessment for the Ox Mountains has dropped from Green to Amber between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects remain Green. The Overall conservation assessment drops from Green to Amber. The drop in the Population assessment is due to the fact that, while the target species was recorded at every sample location, the numbers did not meet the criterion set. Given that the habitat continues to be suitable for the species, and there are no threats to the site evident, it is suggested the Overall Conservation Status for this site should be Green.

The *V. geyeri* habitat in the Ox Mountains site comprises a wet runnel, with side channels, set in a matrix of wet heath. Suitable habitat for *V. geyeri* occurs in the base of the runnel and along the terraced sides, supporting 'brown mosses', low sedges and *Schoenus nigricans* tussocks. The habitat continues to be suitable for supporting the target species, though lower numbers were recorded in the current survey than in 2010. It cannot be determined whether this reflects a real drop in the population or is the result of natural fluctuations, which are common in small invertebrate populations.

A windfarm has recently been built on the site. It is unknown whether the existence of *V. geyeri* was taken into account when permission was granted, or during construction (in terms of appropriate mitigation measures). In spite of the huge disturbance and changes which have occurred on the site, when results from 2010 and 2016 are compared, there is no indication of a negative effect on the *V. geyeri* habitat. Given that some impacts may be delayed in becoming apparent, more regular monitoring is recommended. Some limited re-seeding and herbicide use were noted in nearby areas, as well as alteration to drains and the building of tracks. To ensure that the site is managed as well as possible for *V. geyeri*, as well as meeting the needs of the windfarm, a meeting between NPWS staff and the site managers is recommended immediately. The site is also sheep-grazed, which is having a positive effect on the habitat by maintaining a short, open sward, and it is important that this agricultural management is continued.

VgCAM22 – Pollardstown Fen

The *V. geyeri* site at Pollardstown Fen has seen its Population assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects drops from Amber to Red and the Habitat assessment remains Amber. The Overall conservation assessment for Pollardstown Fen drops from Amber to Red. This decline in status is reflective of real change at the site, with undergrazing/abandonment an issue in all polygons.

Pollardstown Fen is one of the most important and extensive fen sites in the country, and is exceptionally important for its populations of all three protected *Vertigo* species. Six of the eight polygons identified by Moorkens & Killeen (2011) as containing *V. geyeri* habitat were surveyed in 2014, and all are suffering from undergrazing or, more likely, abandonment. Three of the six had their suitability for the target species down-graded. As a result, broad-scale habitat management changes are needed across this site in order to prevent the loss of *V. geyeri*. This means that grazing needs to be introduced across the site as a matter of urgency. Moorkens & Killeen have given detailed information on past and recommended grazing management, and this continues to be relevant.

VgCAM23 – Waterstown Lough

No conservation assessment was carried out for *V. geyeri* at Waterstown Lough in the monitoring period 2007-2012. In the monitoring period 2013-2018, the site was assessed as Green for all parameters, with an Overall conservation assessment of Green.

Waterstown Lough is a very important site, as it supports all three Annex II *Vertigo* species (*V. angustior*, *V. geyeri* and *V. moulinsiana*); one of only two sites to do so in Ireland, the other being Pollardstown Fen. *V. geyeri* is found in the alkaline fen habitat between the grassland-fen transition zone and the reed beds at the lake shore, extending around to the east where it borders woodland. The species is distributed across much of the site, and was found in moderate numbers. While the Future prospects for the site are considered to be good, drying out of the habitat and grazing/poaching by cattle is something that must be monitored closely. Some grazing is required, however, to prevent the spread of species such as *Phragmites australis* and *Salix cinerea* subsp. *oleifolia*, and to maintain an open sward suitable for *V. geyeri*.

VgCAM24 – Duleek Commons

No conservation assessment was carried out for *V. geyeri* at Duleek Commons in the monitoring period 2007-2012. In the monitoring period 2013-2018, the site had a Population assessment of Green, a Habitat assessment of Red and Amber Future prospects. The Overall conservation assessment for Duleek Commons is Red.

The *V. geyeri* population distribution and abundance at Duleek Commons is extremely limited, with potentially suitable habitat found only in flushed areas in the fen south of the stream, and only one individual snail recorded in 2015. Many of the flushes appeared quite dry. However, this site is extremely important in a national context, being the most easterly known site for *V. geyeri* in the country. The cattle grazing level at the site is currently a little too high, and this is having a negative impact on the suitable habitat due to poaching, excessive dunging and tight grazing of vegetation. The site was also quite dry at the time of surveying, and so the hydrological regime at the site needs investigation.

Vertigo moulinsiana

VmCAM01 – Borris

The Population assessment for Borris has dropped from Amber to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects remain Green and Amber, respectively. The Overall conservation assessment for this site drops from Amber to Red. The fact that the target species was not found during the current monitoring period in spite of a good number of samples suggests that there is a real problem at the site. However, looking at the habitat present and at the potential threats, it is not clear what the cause of this problem might be.

This is a small site, but the habitat appears to be in good condition and potentially suitable for *V. moulinsiana*. However, the species was not found in spite of 31 samples taken at nine locations in 2014. Moorkens & Killeen (2011) noted low numbers for the species at the site in two previous surveys (2006 and 2008). It is not clear whether this site may always have harboured a small population, in low and difficult-to-detect numbers, or whether the species is lost, or nearly so, from the site. The site is likely to be subject to occasional flooding from the adjacent River Barrow, and perhaps this regime has altered, causing the loss/decline of the species. Only careful and dedicated monitoring will help elucidate this. No active management is recommended at this time for the site, but scrub encroachment is a potential issue and may need action by the time of the next monitoring (two years' time).

VmCAM02 – Fin Lough (Offaly)

The Population assessment for Fin Lough has dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects have remained Green. The Overall conservation assessment for Fin Lough has dropped from Green to Red. While the site appears to still be in good condition, the population has shown a decline from the previous survey, but the reason for this apparent decline is not clear. It may be that the Population assessment criteria for the site are too stringent. An overall assessment result of Amber may be more appropriate for this site.

This site consists of an infilling lake, and so contains a wide variety of transitional habitats. It also has areas of calcareous fen with *Schoenus nigricans* along its northern shore. There are large areas of habitat suitable for *V. moulinsiana*. The site continues to have habitat in good condition and shows good Future prospects, but received an Unfavourable (Red) assessment for its population. Only approximately half of sample locations were positive for the target species in 2014, compared to three-quarters when Moorkens & Killeen last surveyed. The abundances were lower also. As the habitat appears to still be in good condition, it is hoped that these results are the result of weather or a poor breeding year for the species. Monitoring in three years' time will be very important in terms of assessing whether the population is indeed declining.

VmCAM03 – Lough Owel

The *V. moulinsiana* site at Lough Owel has seen its status drop from Green for all parameters to Amber for population and habitat between the monitoring periods 2007-2012 and 2013-2018. Future prospects remains Green. Real change is evident at the site, with the habitat at the transect drier than previously recorded, with less suitable vegetation. The population has also declined, though the drop in the Population assessment may also to be due to the criteria being too stringent.

Numbers of *V. moulinsiana* recorded at this site, as well as the number of locations from which it was found, both decreased compared with the previous survey. 2014 was a relatively dry year, and this may have had an effect on numbers. Apart from Polygon C, where the transect is located, the site appears to still be suitable. The location of the transect at this site should be re-considered as it is sited in an isolated area that is atypical for the site as a whole. No changes in management are recommended currently, but monitoring within three years is imperative to investigate if weather or other factors are responsible for the low numbers recorded.

VmCAM04 – Mountmellick

Mountmellick has seen its Population assessment drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects have dropped from Green to Amber. The Overall conservation assessment drops from Green to Red. While the habitat at the time of surveying seemed a little drier than in the previous monitoring period and the population has declined, part of the drop in the status of the site may be due to overly demanding criteria and prevailing weather conditions. It may be that an Overall Assessment of Amber would be a fairer result for this site.

This site possesses a significant length of disused canal bed which was all classed as Suboptimal or better, with two-thirds of its length containing some Optimal habitat. Consequently it was surprising that only 50% of samples were positive (compared to 93% in 2008), and also that numbers were generally low (apart from three samples at the southern end). Moorkens & Killeen (2011) raised the issue of succession and drying out at this site, threats which face many disused canal beds. It may be that this site is beginning to show signs of these processes (e.g. only 73% of samples in 2014 were classed as having Optimal wetness for *V. moulinsiana*, compared to 90% in 2009). However, 2014 was a very dry year, and 2008 was a very wet one. Monitoring must be carried out at this site within three years to attempt to ascertain if the lower numbers constitute a trend, and if so, measures must be taken to maintain the sites wetness (e.g. blocking of outflow).

VmCAM05 – Louisa Bridge

The Population assessment for Louisa Bridge has dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects have remained Green. The Overall conservation assessment for Louisa Bridge has dropped from Green to Red. While the site appears to still be in good condition, the population has shown a decline from the previous survey – but this is in terms of absolute numbers of individuals recorded (the number of positive samples remains the same). The reason for the decline in numbers is not clear, and it may be that the Population assessment criteria for the site are too stringent. A result of Amber for the Population assessment would be fairer.

Vertigo moulinsiana was found at 6 out of 10 sample locations, though in lower numbers than in 2008. The population appears to have decreased, but habitat conditions remain good, and in the lower valley area they appear to have improved such that three out of the four samples in Polygon E were positive. Overall, this site needs no management change or intervention, but it does need to be protected from potentially well-meaning, though damaging, uses such as tree-planting, path creation or other increases in amenity usage. Re-survey in three years' time is important in order to gain further information to allow a fuller assessment of the population trend.

VmCAM06 – Ballybeg Lough

The Population assessment for Ballybeg Lough has dropped from Green to Amber between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects remain Green. The Overall conservation assessment drops from Green to Amber. The drop in the Population assessment is due to the fact that the target species was not recorded in sufficient frequency or numbers to meet all three assessment criteria. Given the habitat continues to be suitable for the species and the species is still widespread at the site, the decline in status may be due to overly demanding assessment criteria. Therefore, it is recommended that population is assessed as Green to give an Overall conservation assessment of Green.

The reason for the apparent drop in the *V. moulinsiana* population is unclear, as suitable vegetation is still present, and the wetness continues to be favourable. It may be, therefore, that the apparent drop is due to natural variation in the population or overly demanding assessment criteria. The habitat polygons at the site have been assessed as the same or better quality than the previous monitoring period, and this, along with the lack of major threats, has resulted in favourable Future prospects.

Polygon A is likely to benefit from intermittent grazing to prevent scrubbing over, with no management currently required for Polygon B, which is wet and supports abundant tall sedge and reed habitat.

VmCAM08 – Cappankelly

The Population assessment for Cappankelly has dropped from Green to Amber between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects remain Green. The Overall conservation assessment drops from Green to Amber. The drop in the Population assessment is due to the fact that the target species was not recorded in sufficient numbers to meet all of the assessment criteria. Given that the habitat continues to be suitable for the species and the species is still widespread at the site, the decline in status may be due to overly demanding assessment criteria. Therefore a more realistic Overall conservation assessment for the site would be Green.

As the habitat and Future prospects for the site remain good, the drop in the Population assessment may also be the result of natural fluctuations in the snail's population, rather than reflecting a real decline. Further surveys at this site will help elucidate this. There is currently no requirement for a change to the management of the site, though scrub encroachment may be an issue in the future. It should be noted that this site floods to quite a depth some years (evident in aerial photographs). This is likely to help control scrub, but does not appear to be having a large impact on the target species, as evidenced by its continued widespread presence at the site.

VmCAM09 – Waterstown Lough

The Population assessment for *V. moulinsiana* Waterstown Lough has dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment and Future prospects have remained Green. The Overall conservation assessment for Waterstown Lough has dropped from Green to Red. While the site appears to still be in good condition, the population has shown a real decline from the previous survey, but the reason for this decline is not clear. The positive samples were few, and had low numbers of snail, but they were widely spread across the site. Therefore an assessment result of Amber may be more appropriate.

Waterstown Lough is a very important site, as it supports all three Annex II *Vertigo* species (*V. angustior*, *V. geyeri* and *V. moulinsiana*); one of only two sites to do so in Ireland, the other being Pollardstown Fen. The drop in the Overall conservation assessment is due to a dramatic drop in the abundance of this species at the site. It is unclear what has caused this drop, given that there appears to be extensive suitable habitat, and no obviously severe impacts were noted. The reduction in the *V. moulinsiana* population at the site may be due to natural fluctuations in the population, or it may be the case that some subtle change has taken place at the site. None of the activities identified at the site (e.g. cattle grazing, water abstraction at springs) are considered sufficient to cause such a widespread negative effect on the *V. moulinsiana* population at the site. The possibility that natural succession processes, leading to drying as the lake infills, cannot be ruled out; however, all areas with potential for *V. moulinsiana* appear adequately wet.

If the focus is shifted a little wider, land use in the surrounding area includes turf cutting and drainage on the raised bog to the west and south of the site, and forestry and its associated works to the north-west and south-east. Research is needed to ascertain if any of these activities may be resulting in changes to the water chemistry (e.g. becoming more acid), water quality (e.g. increased siltation) or hydrological/flooding regime (e.g. lowering of water table) of Waterstown Lough. Extreme care is needed in terms of any activities in the vicinity of this site (e.g. further turf-cutting, drainage or forestry plantings). These activities need to be carefully monitored, and further/new works should not be permitted. This site is currently designation as a pNHA (Waterstown Lake pNHA, 001732), but should be considered for SAC status based on the occurrence of all three *Vertigo* species.

VmCAM10 – Ballynafagh Bog

The Population and Habitat assessments for Ballynafagh Bog dropped from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects dropped from Green to Amber. This has resulted in the Overall conservation assessment dropping from Green to Red between the two monitoring periods. The population has shown a true decline, while the habitat has also deteriorated in places due to drying out, vegetation change and overgrazing.

As noted by Moorkens & Killeen (2011), this is an important site for *V. moulinsiana* given the loss of the snail from other canal-side locations in Co. Kildare. This is a site which has seen a serious decline in recent years, and is in need of immediate and broad-ranging conservation actions if the species is to continue to survive there. The decline in the population and habitat is considered to represent real decline (rather than interpretation or mapping issues), as the habitat has changed through drying out, vegetation change (e.g. succession, scrub encroachment) and heavy cattle-grazing (Polygon C). Actions required to improve the situation for *V. moulinsiana* at Ballynafagh Bog include an overall strategic hydrological plan aimed at increasing, or at least maintaining, water levels across the site. Also needed is some targeted scrub removal, particularly at Transect 1, and a reduction in grazing in the Blackwater Feeder.

It is worth noting that the Population assessment criteria in particular are set quite high at this site. Moorkens & Killeen (2011) mention that in 2006 numbers of *V. moulinsiana* were much lower across the site than in 2010. It may be that 2010 was an exceptionally good year for the species, and that the population criteria should be reduced/relaxed somewhat. However, even should these changes be made, the site would still struggle to pass assessment due to habitat changes (and this will continue to affect the snail's survival).

VmCAM11 – Charleville Lake

The assessments for Charleville Lake remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

Charleville Lake supports a good population of *V. moulinsiana*, with abundant suitable habitat around the fringes of the lake, and presumably also in parts of the inaccessible centre. In addition to the already known *V. moulinsiana* habitat, the species was found to be present in an area of wet woodland with an understorey of tall *Carex* species to the east, and this area has been added to the site as a new polygon. This is an important site, not only because of its healthy *V. moulinsiana* population, but also because it supports excellent examples of ancient and wet woodlands, and a range of uncommon plants, animals and fungi.

Discussions with the local NPWS Conservation Ranger revealed that the site is believed to be infilling more quickly over recent years, perhaps due to siltation arising from peat extraction on nearby raised bogs, and consideration has been given to dredging areas of the lake (in a manner sensitive to the *V. moulinsiana* population) in order to maintain the open water element. Our recommendation is to employ all other means possible to reduce/eliminate the silt reaching the lake, rather than to undergo dredging which is likely to be destructive of at least some habitat. We also recommend detailed hydrological and vegetation monitoring be instigated at the site to inform any and all future management at this important site.

VmCAM12 – Curragh Chase

The *V. moulinsiana* site at Curragh Chase sees its Population assessment increase from Red to Amber between the monitoring periods 2007-2012 and 2013-2018. The Habitat assessment drops from Green to Amber, while the Future prospects remains Green. The Overall conservation assessment for Curragh Chase increases from Red to Amber. The target species was found in good numbers at the site, but it's important to note that there was a small loss of habitat at the fen area within the site.

The best habitat for *V. moulinsiana* at Curragh Chase remains the fringing vegetation of the lakes in the forest park. The species is widely distributed around the lakes with the vegetation dominated by *Carex*

acutiformis, with *Sparganium erectum*, *Carex paniculata* and *Iris pseudacorus*. The water levels in the lakes maintain a suitable wetness for *V. moulinsiana* within the areas of suitable vegetation. There is no reason to think the species will not continue to occur around the lakes into the future. In contrast to this, the fen habitat to the south has been affected by cattle grazing, scrub clearance and the dumping of brash. The snail was not found here in the current survey and the habitat suitability has declined. Liaison with the landowner and changes to the grazing regime are required to allow the habitat to recover to a state that is more suitable for supporting *V. moulinsiana*.

VmCAM14 – Kildallan Bridge

The assessments for Kildallan Bridge remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

The core of the *V. moulinsiana* population at Kildallan Bridge is in the back-drain to the southeast of the bridge, but the species is also found in other locations in the back-drain and along the fringing vegetation of the canal itself, on both banks. *Glyceria maxima* is the dominant species in most of the locations where *V. moulinsiana* is found. The fringing vegetation of the canal is shorter and sparser than during the previous survey, and has evidently been subject to clearance and cutting. The grass of the towpath is mown, and it appears that the fringing vegetation may be cut in a similar manner. This is reducing the available habitat for *V. moulinsiana*, and is reducing the connectivity of habitat along the canal. The back-drain habitat is vulnerable to clearance by adjacent landowners or by Waterways Ireland as part of their regular maintenance, and the presence of the snail should be brought the attention of the appropriate staff within the organisation. Overall the *V. moulinsiana* population at Kildallan Bridge is in reasonable condition, and is expected to continue to survive at the site into the future.

VmCAM15 – Lisbigney Bog

The assessments for Lisbigney Bog remain Red for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Red. There is little to no suitable habitat remaining at this site.

The suitability of Lisbigney Bog for supporting *V. moulinsiana* has declined since the species was first discovered there in 1998. Large drains in the area have dropped the groundwater level, and previously suitable areas of swamp are now too dry to support the snail. Even former smaller drains on the site are now completely dry. Succession is also occurring with trees and scrub species spreading at this site, and there has been a significant shift towards more acid-loving heath species (e.g. *Molinia caerulea*, *Myrica gale*). No suitable habitat for the snail was found in the 2010 survey and there has been no improvement since. Even with serious intervention in the form of drain-blocking and scrub removal, the site would be unlikely to recover to a state which will allow it to support habitat suitable for *V. moulinsiana*, such are the changes which have taken place. Given the distance from the next nearest site supporting the snail, even if the habitat were to recover, it is likely that a re-introduction programme for the species at Lisbigney Bog would be necessary.

VmCAM16 – Lisduff Fen

The *V. moulinsiana* site at Lisduff Fen sees its Population assessment and Future prospects drop from Green to Amber between the monitoring periods 2007-2012 and 2013-2018, while the Habitat assessment remains Green. The Overall conservation assessment drops from Green to Amber. The drop in the Population assessment appears to reflect an issue for the population at the site, with a much greater number of sample locations positive for the target species in the northern half of the site compared to the southern half. While the habitat appears to still be suitable for the species across the site, there are a number of activities that may be impacting on the site in a way that is not readily apparent.

Lisduff Fen is an important site - it supports both *V. moulinsiana* and *V. geyeri* (though only *V. moulinsiana* was recorded in the current survey), and inhabited marsh fritillary (*Euphydras aurinia*) larval webs were

also recorded here as part of the current survey (apparently a new record). While the habitat appears to still be suitable for *V. moulinsiana* across most of the habitat polygon, some declines were noted, with a cluster of negative samples towards the southern end. It is not clear why this apparent decline has occurred, and it may be due to natural population fluctuations, but given the drastic decline recorded for *V. geyeri* at this site, it is important not to be complacent.

At first, the pressures and threats to the site appeared to be relatively limited, but, given the declines recorded for the species, these impacts may be acting either more strongly or in combination to affect the site in ways that are not yet clearly apparent.

In terms of management, grazing levels are near ideal in the southern section of the fen. Activities happening directly adjacent to the fen, and relating to agriculture, may be combining to alter conditions in the fen just enough to make is less suitable to *V. geyeri*, and may also, in time, affect *V. moulinsiana*. These activities include scrub removal, silage production, water abstraction, drain modification, habitat reclamation and dumping of brash and spoil. While none are very dramatic if taken in isolation, all have the potential to negatively impact on the delicate balance that always exists in a calcareous fen. Silt run-off, chemical run-off or hydrological regime alteration may all be happening.

This is an important site, and action is needed to reduce the intensive agricultural activity happening within the SAC boundaries. It needs careful liaison with landowners, including time spent explaining the importance of the site as well as the rationale for management changes, and then dedicated monitoring when changes are implemented.

VmCAM17 – The Murrough

The Murrough has seen its status drop from Green for all parameters to Amber for all parameters between the monitoring periods 2007-2012 and 2013-2018. The Overall conservation assessment for the site drops from Green to Amber. While there has been a drop in habitat suitability in the original area surveyed during the 2007-2012 monitoring period, and a drop in population, extensive additional areas of habitat with the target species present were identified by Long & Brophy (2013) and during the current monitoring period, which means the site's status may be considered better than the results suggest. With this in mind, a more appropriate assessment result for Future prospects would be Green.

This is a very important site, being the only east coast site for *V. moulinsiana* in Ireland. The population of *V. moulinsiana* at The Murrough, within the original area defined by Moorkens & Killeen (2011) (polygons A and B), has shown some decline. The habitat here is subject to various pressures including pony grazing, drying out and scrub encroachment. Additional polygons have been added to the north (Polygon C) and to the south (D and E) of these. It is in polygons D and E that the highest numbers of *V. moulinsiana* have been found. In these areas management is for hunting/shooting, and also cattle grazing, and it is, broadly speaking, appropriate for the species. Given the numbers of the target species found, particularly when compared to all previous surveys at Five Mile Point, it would appear that this is the core of the population at The Murrough. Further investigations to the south of this area may reveal further habitat that supports the species.

It should be noted that in Long & Brophy (2013) a different polygon naming system was used to that employed here.

VmCAM18 – Pollardstown Fen

The *V. moulinsiana* site at Pollardstown Fen has seen its Population and Habitat assessments drop from Green to Red between the monitoring periods 2007-2012 and 2013-2018, while the Future prospects drops from Green to Amber. The Overall conservation assessment drops from Green to Red. The change in status reflects a real change at the site with the population declining and the habitat less suitable for supporting the target species, due not least to changes noted in the vegetation (particularly on and near the transect).

Vertigo moulinsiana is present all across this site, albeit in low numbers in places. All six polygons sampled in 2014 were positive for the species. However, numbers of individuals recorded were much lower than in the previous survey (2010). This is particularly evident on the transect where hundreds of individuals were counted in 2010, but only one adult was found in 2014. It is much more difficult to draw comparisons across the remainder of the site - Polygon B had good results (though lower abundances) in 2014; all other areas were not sampled in 2010. Overall, there is some evidence to suggest that both drying out and vegetation change caused by lack of grazing may both be occurring in parts of this site. Recommendations for both of these issues have been made, and recommendations in Moorkens and Killeen (2011) still stand also. The dry year in 2014 may also have had an impact on numbers of snails recorded. Because this is such an important site, and there are a number of unknowns, it is crucially important that this site be re-surveyed in three years' time.

VmCAM19 – Portumna

The assessments for Portumna remain Green for all parameters between the monitoring periods 2007-2012 and 2013-2018, with an Overall conservation assessment of Green.

The habitats of the northern areas of lakeshore of Lough Derg, and its hinterland, supports abundant suitable habitat for *V. moulinsiana* in the form of fens and reedbeds, including areas forming a mosaic with the woodland habitats of Portumna Forest Park. The species continues to be widely present within the original area surveyed by Moorkens & Killeen (2011), and has also been found further south on the eastern shores of Lough Derg by Long & Brophy (2013) and again in the current survey. Further exploratory surveys would be likely to extend the range still further, on both the east and west shores of the lake - though much of the habitat is difficult to access (often consisting of floating vegetation, and/or deep standing water, or located beyond impassable drains/channels). While the water levels of Lough Derg are regulated by the ESB at Parteen Weir, balancing various social, economic and ecological pressures, flooding can be an issue on the lake and this may impact on the *V. moulinsiana* habitat. In the longer term, the proposed extraction of water from Lough Derg to supply the Greater Dublin Area, is something which has the potential to affect the *V. moulinsiana* habitat and should be closely monitored. Overall, this is a very important site for this species given its scale and the scope for further expansion of the known range of the species there.

VmCAM21 – Royal Canal, Longford Branch

No conservation assessment was carried out for *V. moulinsiana* at the Royal Canal, Longford Branch in the monitoring period 2007-2012. In the monitoring period 2013-2018, the site was assessed as Green for all parameters. The Overall conservation assessment for the Royal Canal, Longford Branch is Green.

The habitat for *V. moulinsiana* is in the canal bed of the disused Longford Branch of the Royal Canal. The canal bed supports extensive areas of suitable vegetation (including *Sparganium erectum*, *Glyceria maxima* and tall *Carex* species) and wetness, though shading and scrubbing over is occurring where *Salix cinerea* subsp. *oleifolia* and *Alnus glutinosa* have become established. The site supports a good population of *V. moulinsiana* along its length and sensitive management is required to maintain the habitat is favourable condition though scrub control and clearance. Hydrological monitoring is also recommended in order to understand if the habitat is drying out, or if there is enough water seepage to maintain current wetness levels.

VmCAM22 – Fiagh Bog

No conservation assessment was carried out for *V. moulinsiana* at the Fiagh Bog in the monitoring period 2007-2012. In the monitoring period 2013-2018, the site was assessed as Red for all parameters. The Overall conservation assessment for the Fiagh Bog is Red. There is no suitable habitat left at the site.

This site was included in the current monitoring round due to a record of *V. moulinsiana* from the road margin in 1970. Moorkens recorded a dead *V. moulinsiana* shell in 1995, but no live snails. The site has undergone extensive drainage and reclamation for agricultural land over the last number of years, particularly in the vicinity of the 1970 record, and this work is on-going. In terms of possible habitat, extensive stands of *Sparganium erectum* were recorded in a stream to the west of Fiagh Bog in the current survey. The stream had a water depth of over 50 cm and steep banks, so had limited ability to support the target species. Sparse stands of *Phragmites australis* were recorded from drains towards the east end of the bog (and the area of active reclamation), but these are likely to represent recent growth following the excavation of the drains. The site no longer appears to have any population of *V. moulinsiana*, does not support any area of potentially suitable habitat, and future surveys are not recommended.

VmCAM23 – Castletown

No conservation assessment was carried out for *V. moulinsiana* at the Castletown in the monitoring period 2007-2012. The site was surveyed and assessed in the interim by Long & Brophy (2013), and given a provisional assessment as follows: Population – Green; Habitat – Green; Future prospects – Green; overall - Green. In the monitoring period 2013-2018, the Population assessment was Green, the Habitat assessment was Red, while the Future prospects were Amber. The Overall conservation assessment for the Castletown is Red. While the *V. moulinsiana* population at the site appears to be doing well, there are some indications that the habitat quality is declining, due to drying out and vegetation change. This site is atypical however, in supporting a large population in apparently less than suitable habitat conditions, and with this in mind, an overall assessment of Amber is recommended pending further studies.

Castletown was first surveyed specifically for *V. moulinsiana* in 2012 by Long & Brophy (2013). Castletown is unusual among *V. moulinsiana* sites for a few reasons. It is one of two recently discovered sites in Co. Waterford, and so is an outlier in terms of the species' known distribution in Ireland. It is a small, isolated wetland, and has no conservation designation. The vegetation in Polygon A, the biggest area supporting the species at the site, is very grassy (it was unusually grassy even in 2012, but had become more so in 2016). This vegetation is atypical for *V. moulinsiana*, the species being more usually associated with tall-growing sedges and reeds. The site was also quite dry underfoot throughout polygons A and B in 2016. And yet the species was found to be common, widespread and abundant throughout polygons A and C in both years, and in small pockets in Polygon B. Based on a broader understanding of both the wetness and vegetation conditions thought to be necessary to support populations of *V. moulinsiana*, this site has dropped in status from Favourable (green) to Unfavourable-Bad (red). However, given that the species is present in high quantities throughout, this result may need to be interpreted with some caution. Repeat monitoring within two years is a priority at this site to assess if observed changes in habitat will begin to be reflected in decreasing snail numbers, or if indeed the species is surviving well in the apparently less than ideal conditions. Liaison with landowners is needed immediately to ensure no further drainage occurs. Some partial drain blocking may be necessary to slow the flow of water from this site. Liaison with Waterford County Council, Coillte and/or The Forest Service is also needed to ensure no inappropriate development or planting occurs at this site. Consideration should also be given to the fact that nutrient run-off from adjacent forestry or agricultural land may also be a contributory factor in the dense growth of *Holcus lanatus* seen in Polygon A in particular.