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MONITORING AND ASSESSMENT OF KILLARNEY FERN (*VANDENBOSCHIA SPECIOSA* (WILLD.) KUNKEL) IN IRELAND, 2015–2018

Emer Ní Dhúill, Fionnuala H. O'Neill & Rory L. Hodd

An Roinn Tithíochta, Rialtais Áitiúil agus Oidhreachta
Department of Housing, Local Government and Heritage

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Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Killarney Fern *Vandenboschia speciosa* (sporophyte), Population TS24, Co. Kerry, Emer Ní Dhúill

Monitoring and Assessment of Killarney Fern (*Vandenboschia speciosa* (Willd.) Kunkel) in Ireland, 2015–2018

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Executive Summary

This report presents details of the Rare Plants Monitoring Survey conducted between 2015 and 2018 to assess the conservation status of the EU Habitats Directive Annex II species *Vandenboschia speciosa* (Willd.) Kunkel (synonym *Trichomanes speciosum* Willd.), commonly known as Killarney Fern.

Prior to commencement of the survey, a review was carried out of the methodology used in the previous (baseline) survey. Amendments to the survey and assessment methodology are outlined in the report. These updated methods were followed in the Rare Plants Monitoring Survey.

V. speciosa is listed in Annex II and IV of the EU Habitats Directive. It is a member of the Filmy Fern family (Hymenophyllaceae) and is the only European representative of the genus *Vandenboschia*. *V. speciosa* is most abundant in the Azores, outside of which it is most frequently found in Ireland and Britain.

V. speciosa differs from 'typical' ferns in that the sporophyte and gametophyte generations can live independently of each other by reproducing vegetatively, the gametophyte by means of gemmae, which are asexual propagules, and the sporophyte by means of rhizome spread. The ability of the gametophyte generation to live independently and reproduce by means of gemmae is considered rare in homosporous ferns [ferns that produce spores of one kind only] and is considered unique among European ferns. Whilst the sporophyte has been known from Ireland since 1804, the gametophyte was first recorded in the wild in Ireland as recently as 1992. The reported rare occurrence of sporophytic recruitment in conjunction with the persistence of both generations of *V. speciosa* often occurring independently has led to the conclusion that there has been a breakdown in the link in the life cycle between the sporophyte and gametophyte generations.

V. speciosa is restricted to damp, shady and humid habitats and is extremely sensitive to desiccation. In Ireland, when the sporophyte and gametophyte generations occur together they occupy similar habitats in dripping caves, cliffs, crevices and gullies by waterfalls, crevices in woodland, and occasionally the floor of damp woodland; all deeply shaded humid habitats. Sporophyte colonies, however, are more limited in their distribution in Ireland than gametophyte colonies. Niches that the gametophyte can occupy are not always suitable for the growth of sporophytes, i.e. shallow crevices in otherwise open habitats that provide adequate shade for gametophyte, but not for the larger sporophytes.

A survey of 40 *V. speciosa* populations was conducted between 2015 and 2018 to monitor and assess this species as part of the Rare Plants Monitoring Survey. The outputs of the survey fed into Ireland's 2019 EU Habitats Directive Article 17 submission. The conservation status of this Annex II species was assessed under four parameters: (1) *Range*, (2) *Population*, (3) *Habitat for the species* and (4) *Future prospects*. Each parameter can receive an assessment of Favourable, Unfavourable-Inadequate or Unfavourable-Bad. The individual parameter assessments were then combined to give an overall national assessment of conservation status for the species.

This assessment resulted in seven populations receiving an Unfavourable-Inadequate conservation assessment. This outcome was due to significant impacting activities recorded at those populations, e.g. invasive non-native species, vigorous native species, loss of canopy cover, bank slippage and pathogen attack. These activities often related to a single colony in multiple-colony populations; however, if one colony within a population had an Unfavourable-Inadequate conservation status, then this followed for the whole population. These impacting activities were considered to be local issues and are not currently regarded as a threat at the national level. The remaining 33 monitored populations received a Favourable conservation assessment. The overall conservation status for *V. speciosa* in Ireland was assessed as Favourable.

The presence of invasive non-native species and vigorous native species in particular is a difficult impacting activity to quantify or to manage for populations where *V. speciosa* occurs. The presence of such species often provides shelter and canopy cover, and helps maintain sufficient relative humidity at locations where *V. speciosa* colonies occur. However, their presence is also likely to become problematic and to negatively impact upon the habitats where they occur. Any control plan implemented must be undertaken sensitively and with the requirements of *V. speciosa* in mind, as the complete removal of such species in the immediate vicinity of *V. speciosa* colonies may pose a greater threat to the *V. speciosa* colonies than would leaving the invasive species *in situ*. Management of the spread, rather than eradication, of these invasive non-native and vigorous native species in locations where *V. speciosa* colonies occur is recommended.

The presence of fertile sporophytes and juvenile sporophytes emerging from gametophytes were considered to be good indicators of colony health as these provided an indication that historic or recent sexual reproduction may have occurred. During the previous reporting period, juvenile sporophytes were rarely observed within the Irish populations, being recorded in five of the 27 monitored populations (18%). Since then, there has been an increase in recording of *V. speciosa* juvenile sporophytes emerging from gametophytes, which may be the result of sexual reproduction or apogamy. During the Rare Plants Monitoring Survey juvenile sporophytes were recorded at 12 of the 40 monitored populations (30%). The trigger for the development of these juvenile sporophytes emerging from gametophytes is unclear, but may, at least in part, be due to climatic factors.

Because of the specific nature of its habitat and its specialised ecology, and as both generations of *V. speciosa* are very slow-growing, the species is potentially threatened by a wide variety of activities which are detailed in the report. Monitoring, management and protection of sites and populations is thus of prime importance for the maintenance of the conservation status of the species.

The report concludes with recommendations for refining the methodology for future monitoring cycles.

Acknowledgements

The authors wish to thank the landowners for permission to access their land to carry out the surveys and to the NPWS Conservation Rangers for assistance in the field, with special thanks to Dominic Berridge, Dr Kathryn Freeman, Clare Heardman, Dr Elaine Keegan and Dr Áine Lynch who accompanied us on a number of the site visits. We would also like to thank Dr Deirdre Lynn and Dr Mike Wyse Jackson of the NPWS Scientific Unit who provided support and direction during the course of this project. A special thanks to Dr Maria Long for advice and assistance during field work.

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We wish to thank Dr Fred Rumsey of the Natural History Museum, London for forwarding information on *Vandenboschia speciosa* populations collected by himself and other botanists.

Finally, we are grateful to Dr James Merryweather who kindly gave permission to use his microscope images of gametophytes to aid identification in the field of this cryptic phase in the life cycle of *V. speciosa*.

1. Introduction

Killarney Fern (*Vandenboschia speciosa* (Willd.) Kunkel) is a large filmy fern in the family Hymenophyllaceae. It is restricted to damp, shady and humid habitats and is extremely sensitive to desiccation. It has a typical fern two-stage life cycle. Both the sporophyte (typical fern frond) and gametophyte (filamentous structure) are capable of asexual reproduction, by mean of rhizomes in the former and gemmae in the latter. Gametophyte colonies can exist and reproduce in the absence of sporophytes.

In Ireland, when the sporophyte and gametophyte occur together they occupy similar habitats in dripping caves, cliffs, crevices and gullies by waterfalls, crevices in woodland, and occasionally the floor of damp woodland; all deeply shaded humid habitats. Sporophyte colonies, however, are more limited in their distribution in Ireland than gametophyte colonies. Niches that the gametophytes can occupy, e.g. shallow crevices in otherwise open habitats that provide adequate shade for the gametophytes, are not always suitable for the growth of the larger sporophytes. Many colonies of the species contain a mixture of sporophyte and gametophyte generations. In Ireland most sites are located in the south-west and south, particularly Counties Kerry, Cork and Waterford, but populations also occur in the east, west and north-west. The known Irish population comprises 290 colonies in 86 populations.

See Table 1 below for the colony type abbreviations which will be used throughout this report:

Table 1 Abbreviations for *Vandenboschia speciosa* colony types.

Colony Type	Colony Type Abbreviation
Sporophytes and gametophytes co-occurring	S&G
Sporophytes, gametophytes and juvenile sporophytes co-occurring	S&G&J
Sporophytes-only	S
Gametophytes-only	G
Gametophytes and juvenile sporophytes	G&J
Mature sporophytes with juveniles (without gametophytes observed)	S&J

V. speciosa was monitored between 2015 and 2018 as part of the Rare Plants Monitoring Survey, hereafter referred to in this report as the RPMS.

1.1 Description of *V. speciosa*

V. speciosa is commonly known as the Killarney Fern or the Bristle Fern. The more familiar scientific name for the species is *Trichomanes speciosum* Willd. and this was used, under species code 1421, during the 2007-2012 EU Habitats Directive reporting cycle (NPWS, 2013). Since then the name *Vandenboschia speciosa* has been recommended for the species (Hassler, 2015) and this, along with a new species code (6985), was included in the 2018 Article 17 checklist for use during the 2013-2018 reporting cycle. The name *Vandenboschia speciosa* is used for the species throughout this report.

Other synonyms for this species include: *Trichomanes speciosum* Willd., *Trichomanes radicans auct. non* Sw., *Trichomanes radicans sensu* P. Fourn. *non* Sw., *Trichomanes andrewsii* Newman, *Trichomanes radicans* var. *andrewsii* (Newman) H.C. Watson & Dennes, *Hymenophyllum alatum* Sm., *Trichomanes alatum* (Sm.) Hook., *Trichomanes brevisetum* R. Br., *Trichomanes europaeum* Sm., *Trichomanes hibernicum* Spreng. and *Trichomanes pyxidiferum sensu* Huds. *non* L.

V. speciosa differs from 'typical' ferns in that both generations can live independently of each other by reproducing vegetatively, the gametophyte by means of gemmae, which are asexual propagules (Vogel *et al*., 1993; Sheffield, 1994; Rumsey *et al.*, 1999) and the sporophyte by means of rhizome spread (Rumsey *et al.*, 1999). Such perennial growth in gametophytes has been reported in the Vittariaceae, Grammitidaceae and Hymenophyllaceae, which are all predominantly tropical families (Farrar, 1967; Raine *et al.*, 1991). Whilst the sporophyte has been known from Ireland since 1804, the gametophyte was first recorded in Britain in 1989 (Rumsey *et al*., 1990; Rumsey, 1994) and in Ireland in 1992 (Rumsey *et al*., 1998).

1.1.1 *V. speciosa* sporophyte generation

The *V. speciosa* sporophyte is a medium-sized perennial fern with translucent membranous fronds that are light green when young and a deep, dark green when they mature. Images of *V. speciosa* fronds are shown in Figure 1. Fronds often hang from vertical rock surfaces but are also known to occur on the floor of damp woodlands. Frond length is reported to range from 20 to 45 cm (Page, 1997). The fronds are ovate to ovate-lanceolate in outline with a stipe (stalk) that typically occupies a third of the total frond length (Page, 1997).

The fronds are finely dissected with acutely tapering pinnae and a very thin lamina which extends down the pale green, rigid stipe forming a wing on either side (Page, 1997). This winged stipe is a characteristic feature of the sporophyte (Figure 2).

Fertile fronds have sporangia that develop within small urn-shaped receptacles that typically occur on the upper edge of each pinna (Page, 1997). The sporangia are attached to a hair-like bristle within these receptacles (Page, 1997). The spore-bearing, bristle-like receptacle is a characteristic feature of the genus *Vandenboschia* (Figure 2).

The rhizome of *V. speciosa* is covered in characteristic dark, hair-like scales (Page, 1997; Rumsey, 1997; Parnell & Curtis, 2012). The fronds arise singly from a creeping rhizome which can spread to form a branching rhizome network that can cover considerable areas in colonies that are undisturbed (Page, 1997). Sporophytes are easily identified in the field by a combination of the characteristic features mentioned above (see Figure 1 and Figure 2).

Juvenile sporophyte fronds emerging from gametophytes can be easily overlooked. These growths may arise from sexual reproduction or apogamy (it is not possible to determine their origin in the field). The fronds are simple with no pinnae pairs and no visible rhizome, and are usually ≤ 1 cm in length at this stage. They are light green in colour and easily blend in with the gametophytes. Figure 3 shows juvenile sporophytes emerging from gametophytes.

Figure 1 Top left: Unfurling *Vandenboschia speciosa* frond, National Botanic Gardens, Glasnevin, 2010. Top right: *V. speciosa* young expanding frond, population TS08, Co. Cork, 2010. Bottom: Mature *V. speciosa* frond, population TS07, Co. Carlow, 2011. Photographs Emer Ní Dhúill.

Figure 2 Top left: Fertile *Vandenboschia speciosa* frond, population TS08, Co. Cork, 2010. Top right: Close-up of bristles of fertile frond, population TS08, Co. Cork, 2010. Centre: *V. speciosa* colony with many fronds, population TS08, Co. Cork, 2010. Bottom: *V. speciosa* rhizome and winged stipe, Azores, 2010. Photographs Emer Ní Dhúill.

Figure 3 Top left: Juvenile *Vandenboschia speciosa* sporophytes emerging from gametophytes on a rock with sparsely occurring gametophytes, population TS26, Co. Waterford. Top right: Juvenile sporophytes emerging from a dense mat of gametophytes, population TS26, Co. Waterford. Bottom: Juvenile sporophytes emerging from a dense mat of gametophytes interspersed with bryophytes, population TS24, Co. Kerry. Photographs Emer Ní Dhúill.

1.1.2 *V. speciosa* gametophyte generation

The bright green gametophytes of *V. speciosa* form mats (sometimes termed "wefts") of repeatedly branching, interwoven filaments that can cover extensive areas (Rumsey *et al*., 1990) and that have a felt-like texture when touched. This filamentous perennial gametophyte is considered unique among European fern genera (Rumsey *et al*., 1998). Key identifying features of *V. speciosa* gametophytes are green filaments, the presence of short brown unicellular rhizoids, gemmae (asexual propagules) and gemmifers (specialised cells upon which gemmae are produced) (Rumsey *et al*., 1990, 1998). Figure 4 is a microscope image of the gametophyte filaments showing the rhizoids and Figure 5 shows gemmifers and a gemma in close-up (Merryweather, 2012). The individual cells of the filaments are typically 40-55 µm wide and 150-300 µm in length and are never more than three times longer than their width (Rumsey *et al*., 1998). Each cell contains numerous discoid chloroplasts (Rumsey *et al*., 1990). The gametophyte can often be identified by experts or those trained in its identification based on touch (the felt-like texture). Gametophytes are identifiable in the field using a hand lens (x 10 or x 20) or a portable microscope (x 35), the latter being particularly useful for definitively identifying gametophytes that are heavily intermingled with bryophytes.

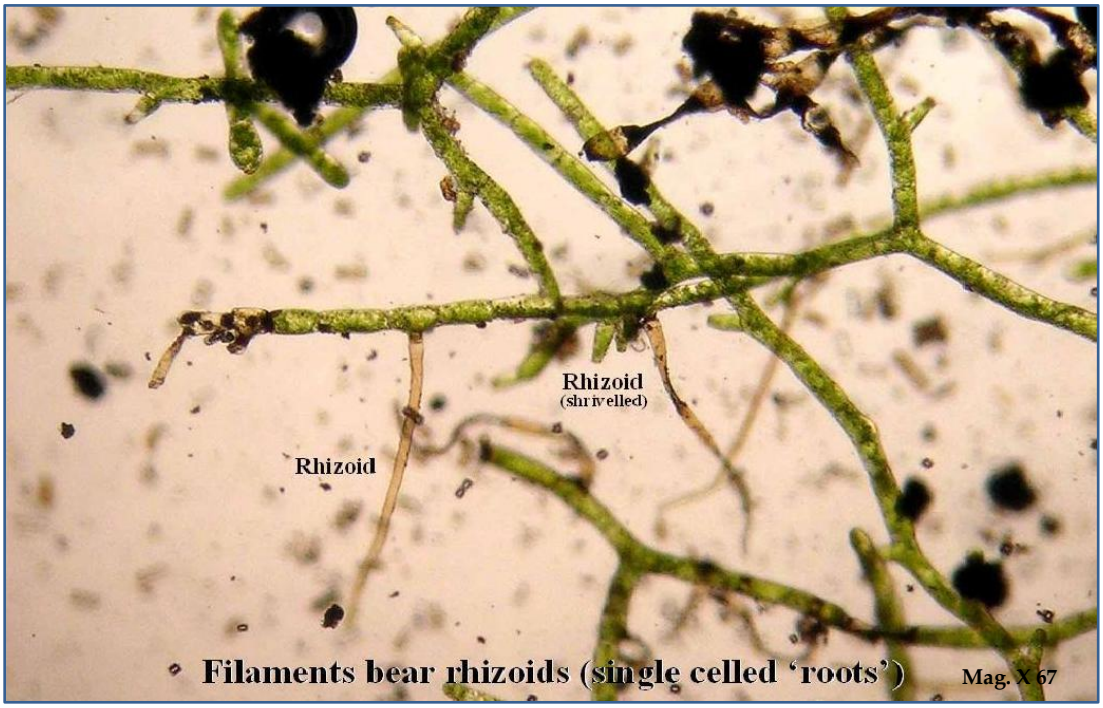

Figure 4 Microscope image of *Vandenboschia speciosa* gametophyte filaments showing brown unicellular rhizoids (magnification x 67). Image from Merryweather (2012), reproduced with permission (note: magnification has been amended to reflect the size of the image copied to this document).

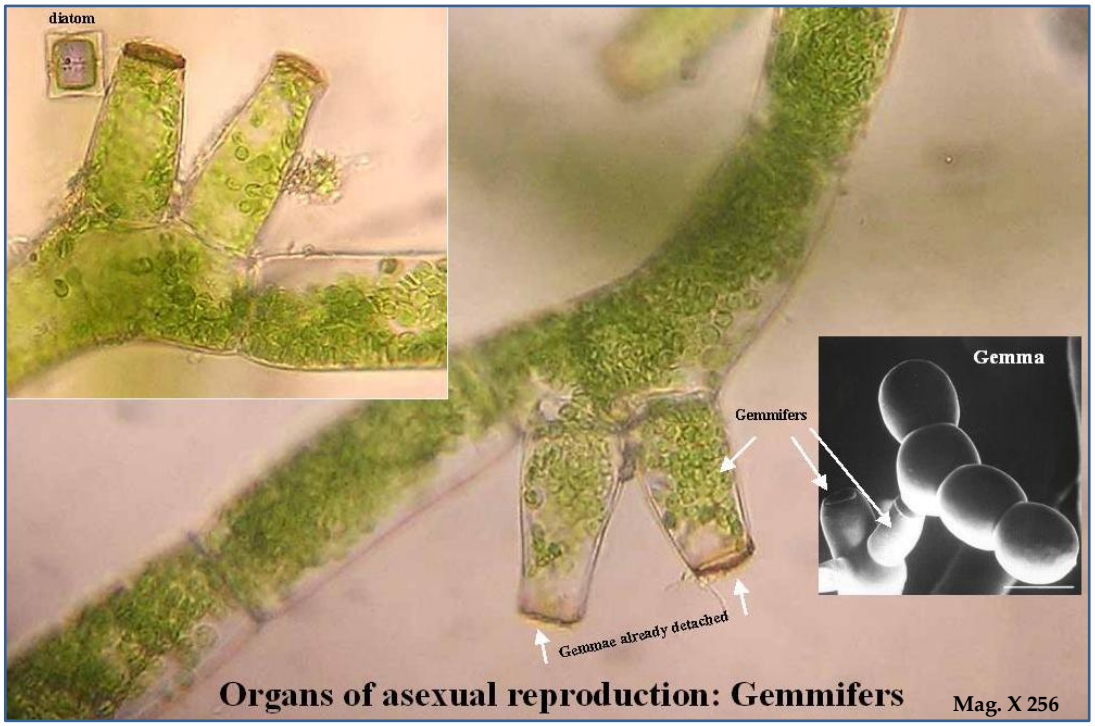

Figure 5 Microscope image of *Vandenboschia speciosa* gametophyte filament (magnification (Mag) x 256) showing gemmae (asexual propagules) and gemmifers (specialised cells upon which gemmae are produced). The upper left-hand corner of the image shows a diatom beside the gemmifers for scale. Images from Merryweather (2012), reproduced with permission (note: magnification has been amended to reflect the size of the image copied to this document).

An image of an extensive gametophyte colony observed hanging from a ravine wall at population TS26, Co. Waterford is shown in Figure 6. A smaller, patchy gametophyte colony observed at population TS24, Co. Kerry is shown in Figure 7. The density, patchiness and spread of gametophyte colonies can vary hugely. Under no circumstances should gametophytes be detached from the substrate on which they are growing, other than under licence from NPWS.

Figure 6 *Vandenboschia speciosa* gametophyte colony hanging from ravine wall, population TS26, Co. Waterford, 2017. Photograph Emer Ní Dhúill.

Figure 7 Patchy *Vandenboschia speciosa* gametophyte colony on a ravine wall, population TS26, Co. Kerry, 2017. Photograph Emer Ní Dhúill.

1.2 Distribution and range of *V. speciosa*

V. speciosa is a Macaronesian-European endemic (Webb, 1993; Rumsey *et al*., 2000). The distribution of *V. speciosa* sporophytes is believed to be confined to a limited area of Europe (Ireland, Britain, Western France, Spain, Italy) and the Atlantic Islands of the Azores, Madeira and the Canaries (Ratcliffe *et al*., 1993). The gametophyte generation has a wider distribution and is reported also in Belgium (Christenhusz *et al*. 2017), on the Czech-German border (Vogel *et al*., 1993), Germany (Rumsey *et al*., 1998), Luxembourg (Krippel, 2001) and Poland (Krukowski & Świerkosz, 2004). *V. speciosa* is the only European representative of the genus *Vandenboschia* (Vogel *et al*., 1993; Rumsey *et al*., 2000; Makgomol & Sheffield, 2001) and is most abundant in the Azores, outside of which is it most frequently found in Ireland and Britain (Ratcliffe *et al*., 1993; Rumsey *et al*., 2000). Ireland holds over 25% of the European sporophyte population (Wyse Jackson *et al*., 2016).

There is great secrecy surrounding the exact locations of this species in Ireland and Britain due to historic over-collection to the point of extinction of the sporophyte in some localities (Rumsey, 1994; Rumsey *et al*., 1998). Although the threat of deliberate collection of the species is much reduced from levels pertaining heretofore during the "Victorian Fern Craze" (see Allen (1969) and Whittingham (2009)) there remains a low-level threat to some colonies from this activity. For this reason, the precise locations of colonies of the species are not made generally available.

The range of *V. speciosa* in Ireland is centred on the extreme south in Kerry and West Cork. There are outlying sites with sporophytes in Counties Carlow, Donegal, Limerick, Sligo, Tipperary and Waterford (Curtis & McGough, 1988; Rumsey *et al*., 1998; Preston *et al*., 2002; NPWS, 2013, 2018, 2019). The gametophyte range is similar but is more widespread and also occurs in Counties Cavan, Galway, Kilkenny, Mayo, Wexford and Wicklow (Rumsey *et al*., 1998; Preston *et al*., 2002, NPWS, 2013, 2018, 2019).

All Connacht populations comprise gametophytes-only colonies except for one population in Co. Sligo (TS17), where both sporophyte and gametophyte colonies are found. All extant populations in Leinster are represented by gametophytes-only populations, with the exception of one population in Co. Carlow (TS07) where both generations occur. Previously, *V. speciosa* sporophyte also occurred in Counties Clare and Wicklow, but it has not been recorded from here since the 19th century, probably on account of being lost to over-collection and/or habitat change. The gametophyte currently occurs in three populations in Co. Wicklow (Populations TS03, TS04 and TS56), but there are no recent records of either generation from Co. Clare. Despite these losses, the geographical range of the species is still very well represented. The map in Figure 8 shows the current distribution and range of *V. speciosa* in Ireland.

There are currently 57 Irish National Grid 10 km x 10 km squares (hectads) in the Republic of Ireland in which *V. speciosa* has been recorded between 1960 and 2018, covering an area of 5,700 km^2.

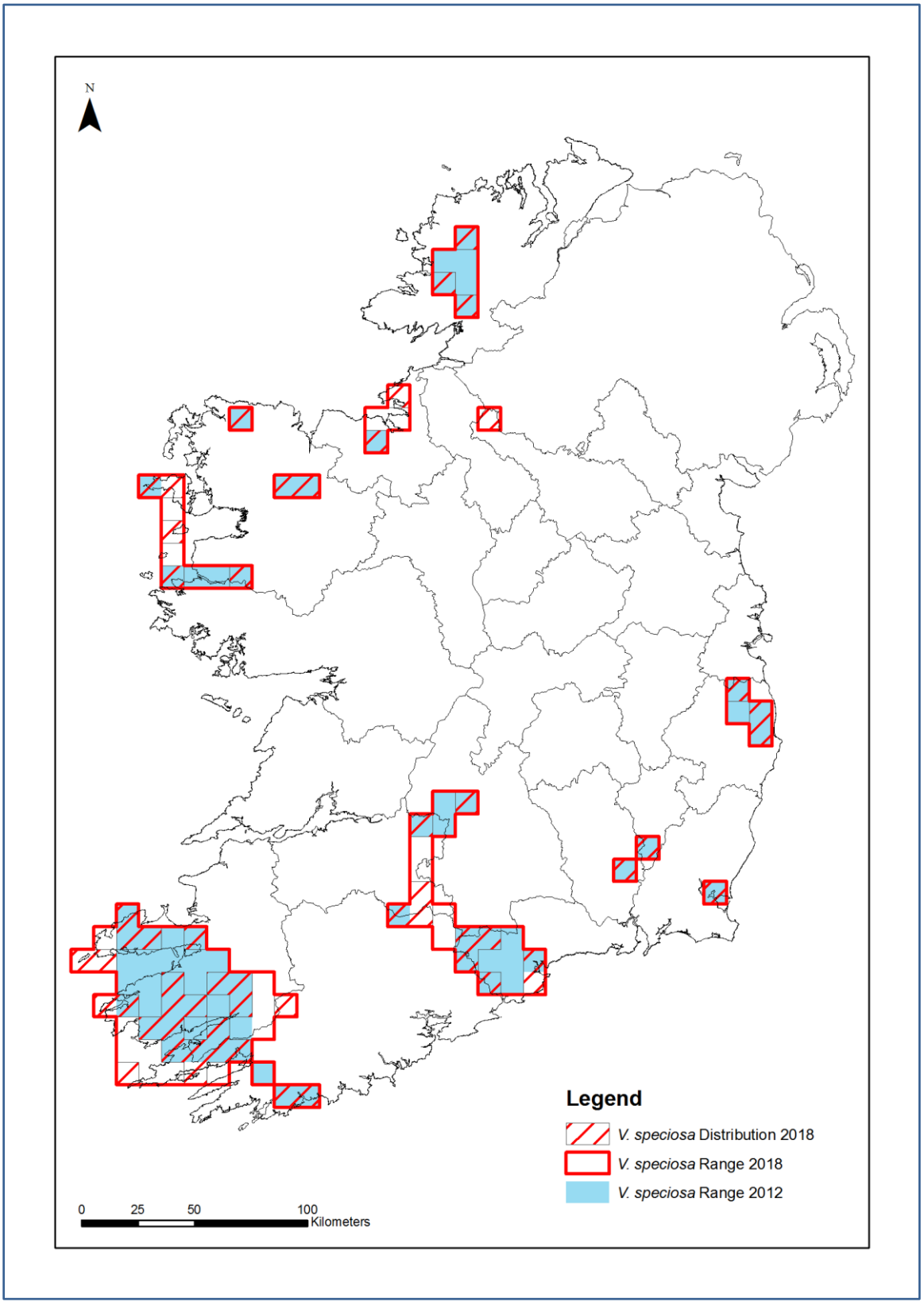

Figure 8 Range and distribution map of *Vandenboschia speciosa* in Ireland (10 km x 10 km grid squares), based on 1960-2018 records from 86 populations, as documented in NPWS (2019). Red diagonal lines and red outline represent the 1960-2018 distribution and range respectively, and the blue shading, the 1960-2012 range.

1.3 Habitat of *V. speciosa*

V. speciosa occurs at a range of altitudes in Ireland from sea level to 700 m (population TS85, Co. Kerry). This high-altitude gametophyte record is a recent [2017] find. In Ireland, *V. speciosa* occurs in both open and wooded habitats where relative humidity is constantly high. In the open habitats, shade is usually provided by aspect and often by boulders, cliff overhangs or crevices where *V. speciosa* occurs. In wooded habitats, shading is also provided by the overhead canopy. *V. speciosa* occurs on sites with a predominantly north or north-east-facing aspect, and on acidic substrates such as quartzite, slates and sandstones (Ratcliffe *et al.*, 1993; Page, 1997; Kingston & Hayes, 2005). Whilst the sporophyte has been known from Ireland since 1804, the gametophyte was first recorded in Britain in 1989 (Rumsey *et al*., 1990; Rumsey, 1994) and in Ireland in 1992 (Rumsey *et al*., 1998).

In Ireland, *V. speciosa* sporophyte and gametophyte generations occur together in dripping caves, cliffs, crevices and gullies by waterfalls, crevices in woodland, and occasionally sporophytes occur on the floor of damp woodland – all deeply shaded humid habitats (Ratcliffe *et al*., 1993; Rumsey, 1994; Johnson *et al*., 2000; Kingston & Hayes, 2005; Ní Dhúill, 2014). Sporophyte colonies, however, are more restricted in the habitats in which they occur in Ireland than gametophyte colonies. Sporophytes usually occur on permanently wet rock faces, caves or river/stream banks, with constant dripping of water a typical feature of their habitat. Gametophyte colonies have been reported from less humid habitats (Ratcliffe *et al*., 1993; Rumsey, 1994; Kingston & Hayes, 2005, Ní Dhúill, 2014). Gametophytes can grow in very dark habitats where there is little competition from other species. However, niches that the gametophyte generation can occupy may not always be suitable for the growth of sporophytes, i.e. shallow crevices in otherwise open habitats that provide adequate shade and relative humidity for gametophytes, but not for the larger sporophytes.

V. speciosa sporophytes often occur in ravines and near streams in damp woodland habitats and near mountainous cascades and waterfalls in open upland habitats, all very specific micro-habitats, which aids determining likely locations for this generation. The habitat of the gametophyte generation, however, is not as easily determined as it can survive in drier, although still very humid, microhabitats.

The difficulty in adequately and categorically describing the habitat of this species reflects the wide variety of situations in which it occurs. Sporophytes-only and gametophytes-only colonies occupy slightly different ecological niches, with gametophytes-only colonies occurring in deeper shade with rock seepage being the main water source, whereas sporophytes-only colonies tend to occur in higher light conditions with constant dripping water a typical feature of its habitat (Ní Dhúill, 2014). That work also found relative humidity levels to be generally uniform throughout study sites, regardless of habitat type, with constant high levels of relative humidity (on average > 90%) recorded at all of the populations visited during the RPMS.

Although there are many apparently suitable sites around Ireland, especially in the south-west of Ireland, there is no real understanding of why this species is restricted to particular sites. Ratcliffe *et al.* (1993) found the absence of the species from many apparently suitable habitats in its range to be puzzling. A lack of suitable continuous habitat and the effects of historic depredation of the sporophyte generation during the "Victorian Fern Craze", also known as "Pteridomania", which was at its height in the 1850s–1890s (Allen, 1969; Whittingham, 2009), may, at least partly, explain the distribution of this species in Ireland. There are a number of other factors that may explain the absence of this species from seemingly ideal habitats, such as a lack of suitable substrate, inadequate shading, inadequate temperature and inadequate relative humidity levels, i.e. high relative humidity levels may only be intermittent rather than constant.

1.4 Rationale for the survey

1.4.1 Article 17 of EU Habitats Directive

The EU Habitats Directive aims to maintain at or restore to a Favourable conservation status the habitats and species that are of Community importance (European Commission, 1992; Evans & Arvela, 2011; DG Environment, 2017). This is one of the most important pieces of legislation for the conservation of biodiversity in Europe and was transposed into Irish law in the European Communities (Natural Habitats) Regulations (S.I. No. 94 of 1997). The Directive lists threatened habitats in Annex I and species in Annexes II, IV and V. Article 17 of the Habitats Directive requires that each member state must report to the European Commission every six years on the conservation status of listed habitats and species. The last round of reporting, covering the period 2013-2018, was submitted in 2019 (NPWS, 2019) and is the third round of reporting carried out under Article 17 where the conservation status is assessed.

V. speciosa is listed (as *Trichomanes speciosum*) in Annexes II and IV of the Habitats Directive. For species listed in Annex II of the Directive, member states are required to designate Special Areas of Conservation (SACs). To date, Ireland has designated 28 SACs which contain 59 populations of *V. speciose* comprising 223 colonies. *V. speciose* is listed as a qualifying interest (QI) in 18 (64%) of these SACs which reflects 48 populations comprising 194 recorded colonies. All populations of *V. speciosa* are also protected under the Flora (Protection) Order, 2015 (S.I. No. 356 of 2015). The species is currently categorised as Least Concern (LC) on the All-Ireland Red List based on separate assessments for sporophyte, gametophyte and both generations combined (Wyse Jackson *et al*., 2016). However, due to its specific habitat requirements and the fact that both generations of *V. speciosa* are very slow-growing, the species is potentially threatened by a wide variety of activities (outlined in Section 2.3.4); monitoring, management and protection of sites and populations is thus of prime importance for the maintenance of the conservation status of the species.

The National Parks & Wildlife Service (NPWS) of the Department of Housing, Local Government and Heritage (formerly of the Department of Culture, Heritage and the Gaeltacht) commissioned BEC Consultants Ltd, in conjunction with independent consultants, to carry out a three-year survey conducted between 2015 and 2018 to monitor and assess the populations of the Annex II species '6985 *Vandenboschia speciosa* (Willd.) Kunkel'. The outputs of the survey informed the 2019 EU Habitats Directive Article 17 report (NPWS, 2019).

1.4.2 Assessment of EU Habitats Directive Annex II species

The most recent guidelines for assessing the conservation status of habitats and species are provided in DG Environment (2017). The conservation status of Annex II species is assessed under four parameters: (1) *Range*, (2) *Population*, (3) *Habitat for the species* and (4) *Future prospects*. Evaluation of conservation status requires the separate assessment of the four parameters. Each parameter can receive an assessment of Favourable (green), Unfavourable-Inadequate (amber) or Unfavourable-Bad (red). The individual parameter assessments are then combined, with the aid of an evaluation matrix (Table 2), to give an overall National Conservation Status Assessment for the species.

Table 2 General evaluation matrix for assessment of Conservation Status of a species (from DG Environment (2016, 2017)).

	Conservation Status			
Parameter	**Favourable ('green')**	**Unfavourable - Inadequate ('amber')**	**Unfavourable - Bad ('red')**	**Unknown**
Range	Stable (loss and expansion in balance) or increasing AND not smaller than the 'favourable reference range'	Any other combination	Large decline: equivalent to a loss of more than 1% per year within period specified by Member State OR more than 10% below 'favourable reference range'	No or insufficient reliable information available
Population	Population(s) not lower than 'favourable reference population' AND reproduction, mortality and age structure not deviating from normal (if data available)	Any other combination	Large decline: equivalent to a loss of more than 1% per year (indicative value Member State may deviate from if duly justified) within period specified by Member State AND below 'favourable reference population' OR more than 25% below 'favourable reference population' OR reproduction, mortality and age structure strongly deviating from normal (if data available)	No or insufficient reliable information available
Habitat for the species	Area of habitat is sufficiently large (and stable or increasing) AND habitat quality is suitable for the long-term survival of the species	Any other combination	Area of habitat is clearly not sufficiently large to ensure the long-term survival of the species OR habitat quality is bad, clearly not allowing long-term survival of the species	No or insufficient reliable information available
Future prospects (with regard to population, range and habitat availability)	Main pressures and threats to the species not significant; species will remain viable on the long-term	Any other combination	Severe influence of pressures and threats to the species; very bad prospects for its future, long-term viability at risk.	No or insufficient reliable information available
Overall assessment of Conservation Status	All 'green' OR three 'green' and one 'unknown'	One or more 'amber' but no 'red'	One or more 'red'	Two or more 'unknown' combined with green or all 'unknown'

Elements of this national assessment approach can be scaled down to assess the status at a population level by assessing *Population*, *Habitat for the species* and *Future Prospects*. *Range* was assessed separately for the final National Conservation Status Assessment report (NPWS, 2019). The results are combined to provide an overall National Conservation Status Assessment.

Population assesses the number of colonies of each generation at each population (sporophytes and gametophytes co-occurring; sporophytes, gametophytes and juvenile sporophytes co-occurring; sporophytes-only; gametophytes-only; gametophytes and juvenile sporophytes; or mature sporophytes with juvenile sporophytes (without gametophytes observed)), frond counts for colonies where sporophytes occur (actual or estimated) and whether a population is reproductively viable by observation of fertile fronds or juvenile sporophytes emerging from gametophytes. Colony losses (if any) are expressed as a percent loss since the last reporting period. Current values are compared with baseline target values to assess if the population is in a Favourable condition.

Habitat for the Species assesses the area and quality of the habitat in which the species occurs. It is assessed by means of several criteria devised by Ní Dhúill *et al.* (2015) which include water source, relative humidity, shade, canopy cover (in woodland locations) and the presence of invasive non-native or vigorous species within close proximity of the sporophyte generation. Current values are compared with baseline target values that assess if the habitat for the species is in a Favourable condition.

Future prospects are assessed by examining whether any activities are affecting the other parameters (i.e. *Population* and *Habitat for the species*) and what their impact would be if they continue unchecked. *Future prospects* should balance any positive and negative activities to determine if they are likely to impact the species or habitat within the next two reporting cycles (12 years) and likely to affect the long-term viability of the species or its habitat.

1.5 *V. speciosa* surveys in Ireland

1.5.1 Baseline survey of Ní Dhúill (2014)

In 2008, the National Parks and Wildlife Service commissioned a Ph.D. research project (Ní Dhúill, 2014) to monitor *V. speciosa* to determine the conservation status of the Irish populations and to assess the genetic variability of the species in Ireland. The research aimed to fulfil the aspirations of the Species Action Plan (Anonymous, 2008) and also to develop a monitoring protocol to help fulfil national obligations on reporting under the EU Habitats Directive. The areas of research dealt with gathering baseline data on the habitat and ecology of both generations of this species in Ireland. This followed on from a previous study on the ecology and conservation of the gametophyte generation in Ireland (Kingston & Hayes, 2005). Genetic identity and genetic diversity of the Irish *V. speciosa* populations, and the frequency of sporophytic recruitment were assessed.

Visits to 27 Irish populations revealed a higher occurrence of fertile colonies (57%) than had been previously recorded. The rarely-observed juvenile sporophytes emerging from gametophytes were recorded at five Irish populations. Site surveys revealed that the majority of populations that support sporophytes typically have gametophytes growing intimately or in close association with the sporophytes. The presence of fertile sporophytes, juvenile sporophytes emerging from gametophytes and gametangia (organs producing male and female gametes) were considered to be good indicators of colony health as these provided an indication that historic or recent sexual reproduction may have occurred.

The research found no associated species that would unequivocally indicate the presence of either generation, as supported by previous studies (Ratcliffe *et al*., 1993; Rumsey, 1994; Kingston & Hayes, 2005).

Genetic analysis of Irish populations of *V. speciosa* using Amplified Fragment Length Polymorphism (AFLP) revealed that genetic diversity was partitioned within and among populations of both generations analysed (Ní Dhúill, 2014). Samples analysed showed the majority of *V. speciosa* populations to be genetically distinct and as such each is of conservation importance throughout its distribution range in Ireland (Ní Dhúill, 2014). Genetic diversity was revealed in both generations, with the gametophytes exhibiting genetic diversity not present in the sporophyte generation. This is a potential source of novel genetic variation in a future sporophyte generation in the event of sexual reproduction resulting in successful sporophyte recruitment. The gametophyte generation is acting as a potential 'genetic-bank' and as such is of conservation importance (Ní Dhúill, 2014).

Recommendations to maintain the species in favourable conservation status *in situ* were proposed and included six-yearly monitoring periods to assess the condition of each population. Population structure was assessed based on colony area, frond types and numbers, frond measurements, presence of associated gametophytes, fertility and presence of juvenile sporophytes. *Habitat for the species* was assessed based on relative humidity, shading, canopy cover, bare rock and vegetation plots to assess the presence of invasive species in the vicinity of sporophyte colonies. *Future prospects* were assessed based on the observation of any activities impacting on the population or habitat. Pressures and threats mostly related to the presence of the invasive non-native species, *Rhododendron ponticum* (Rhododendron) and *Prunus laurocerasus* (Cherry Laurel) at a number of populations. The overall conservation status for the national population was assessed as Favourable.

The results provided baseline data on the Irish *V. speciosa* populations and a monitoring protocol relevant for informing reporting structures to the EU under Article 17 of the EU Habitats Directive.

1.5.2 Monitoring Protocols (Ní Dhúill *et al.*, 2015)

Based on the results of the surveys and recommendations of the Ph.D. research (Ní Dhúill, 2014), a monitoring manual was published that included refined monitoring protocols to assess the conservation status of the Irish populations in order to meet EU Habitats Directive obligations. The four parameters assessed were *Range*, *Population*, *Habitat for the species* and *Future prospects*, all of which were deemed to be Favourable nationally. The results of the assessments were used to inform the National Conservation Status Assessment for the 2007-2012 reporting cycle (NPWS, 2013). There were five populations for which overall conservation status was assessed as unfavourable, the result of localised impacts that were not regarded as a threat at the national level.

1.6 The 2015-2018 survey

The NPWS of the Department of Housing, Local Government and Heritage (formerly of the Department of Culture, Heritage and the Gaeltacht) commissioned BEC Consultants Ltd, in conjunction with independent consultants, to carry out the survey detailed in this report, the aims of which were as set out by NPWS as follows:

- Review and revise where necessary the monitoring methods developed by Ní Dhúill *et al.* (2015);
- Refine, where necessary, indicators and targets to assess *Population* and *Habitat for the species;*
- Undertake a field survey of 41 *V. speciosa* populations of which 27 were previously assessed (Ní Dhúill *et al*., 2015);
- Compare results for 27 populations previously assessed to determine if there has been any change in the conservation status of the individual populations;

- Determine the current conservation status of each individual monitored population;
- Complete a National Conservation Status Assessment and audit trail for the species using the latest available EU Commission and NPWS guidance.

The survey was required to gather assessment data on populations and colonies of both generations of *V. speciosa* in Ireland, using data from the baseline survey of Ní Dhúill (2014) and the conservation assessment from the last reporting period (Ní Dhúill *et al*., 2015). The assessment process used is outlined in this report.

1.6.1 Review of survey methodology and assessment for the 2013-2018 reporting period

1.6.1.1 Definition of a colony

On reviewing the definition of a *V. speciosa* colony, it was found that the previous definition of a colony was sufficient only for the sporophyte generation, i.e. the most suitable unit for measuring population size was considered to be the colony, which was simply defined as a discrete, i.e. unconnected, "patch" or "plant" (Ratcliffe *et al*., 1993; Rumsey, 1997). With the sporophyte generation, each discrete colony is usually very obvious, occupying a crevice, wall or woodland floor. However, with the gametophyte generation the discrete "patches" are not always obvious – the best unit for defining a gametophyte colony is the niche in which the gametophytes occur, e.g. a particular boulder or crevice, cave, or section of cliff wall. These niches may contain a discrete gametophyte patch or numerous patches.

1.6.1.2 Reporting on frond numbers

For the purpose of reporting total living frond numbers for the RPMS, the numbers reported exclude juvenile sporophytes that may have arisen from gametophytes (via sexual reproduction/apogamy). Juvenile sporophyte frond numbers are reported separately as, when present, these numbers may skew the overall frond numbers, as not all juveniles would be expected to survive to reach maturity.

Juvenile frond numbers were counted or, in the case of larger juvenile colonies, estimates were carried out based on counts using a 5 cm x 5 cm quadrat (one to three quadrats were used depending on colony size). These quadrats were placed at different sections of the colony to ensure an accurate reflection of density of a colony, and the number of juvenile fronds in each quadrat counted. The density of juvenile fronds per 0.0025 m^2 and the estimated area of occupancy of each colony were used to estimate total colony juvenile frond number.

1.6.1.3 Area of occupancy and maximum area of gametophyte colonies

An addition to the *Population* assessment for the RPMS was the reporting of the maximum gametophyte colony area – to be reported as a separate indicator to the area of occupancy.

Quite often, in a particular niche, there are dense patches of gametophytes that peter out and are sparse at the peripheries, but continue on into other gametophyte patches, e.g. running along horizontal or vertical crevices. These sparse gametophytes are often difficult to see but may be observed with a good torch and hand lens. Gametophyte patches may also be connected beneath bryophyte mats, making them difficult to observe. At other times, there are many discrete gametophyte patches within a given niche; however, it is not always feasible to measure every single patch.

For gametophyte patches that are not obviously discrete, or that are too numerous to measure individually, as is often the case, it is more efficient and effective to measure the maximum extent of the area of the particular niche occupied by gametophytes and assign an estimated percentage area of occupancy based on a visual inspection. The estimated area of occupancy in m^2 can then be calculated. If there are a small number of discrete patches in a given niche (up to three), the overall percentage gametophyte area of occupancy may instead be calculated by combining the maximum areas of each

discrete gametophyte patch and expressing this sum as a percentage of the overall maximum colony area (e.g. if a gametophyte colony had a maximum area of 0.25 m² and contained two patches, each covering an area of 0.01 m², the percentage area of occupancy would be 8% [0.02/0.25 x 100]). Recording a percentage area of occupancy gives a more accurate impression of the spread of gametophytes within a colony. It is important to record whether percentage area of occupancy has been estimated or calculated.

A description of the colony is important, i.e. sparse, dense, wefts (felted mats of interwoven filaments), or patchy, and to note, if observed, where the dense and sparse parts of the colony are, i.e. floor, wall, ceiling, and their location within the colony (left, centre, right). If heavily interspersed with bryophytes, this also should be recorded. This will aid future monitoring to determine if there has been any change in this extremely slow-growing generation. Comparisons of estimated areas of occupancy for the gametophyte generation can be difficult as such estimates can be very subjective. Therefore, expert opinion should be used when determining whether a colony passes or fails on the target for area of occupancy. The maximum area would not be expected to be reduced unless there was some pressure impacting on it, e.g. landside or bank slippage.

In the *Population* assessment (Table 6) for this current report, the combined areas of occupancy for both generations are being reported for comparative reasons, but the assessment takes into account the issues regarding the subjectivity of the gametophyte area of occupancy in terms of the target passing or failing. This target has been refined as follows: *'No reduction in population size (area of occupancy) for sporophytes. Expert judgement regarding gametophytes'*. See the recommendations in Section 5.3 regarding the separate reporting of the generations for future reporting cycles.

1.6.1.4 Correcting Domin scale for canopy cover *Habitat for the species*

Canopy cover target was incorrectly input as ≥ 6 in the previous survey (Ní Dhúill *et al.*, 2015). This target should have been ≥ 8. This was due to an error in numbering of the Domin scores on the original field survey sheet used from 2009 to 2011 which went from Domin score + to 8 instead of + to 10. While the percentage cover assigned was correct in the field sheets for both surveys, the corresponding Domin score was incorrect in the 2011 survey. See Table 3 below – red type. This error did not, however, affect the overall results for *Habitat for the species*.

Table 3 Domin scale scores used in 2009–2011 and 2015–2018 surveys.

2009–2011 Surveys Field Sheet	
Domin scores:	**+** = no measurable cover **1** = < 4% **2** = 5–10% **3** = 11–25% **4** = 26 – 34% **5** = 35–50% **6** = 51–75% **7** = 76–90% **8** = 91–100%
2015–2018 Surveys Field Sheet	
Domin scores:	+ = no measurable cover 1 = < 1% 1–2 individuals, no measurable cover 2 = < 1% with several individuals 3 = 1–4% 4 = 5–10% 5 = 11–25% 6 = 26–33% 7 = 34–50% 8 = 51–75% 9 = 76–90% 10 = 91–100%

2 Methodology

2.1 Site selection

Forty-one populations were selected by NPWS prior to commencement of the survey. Twenty-seven of these populations had been surveyed during the baseline survey of Ní Dhúill (2014). Populations were

selected to cover the geographic range of the species in Ireland and also the occurrence of the different generations, i.e. sporophyte, gametophyte and co-occurring generation populations. The map in Figure 9 shows the locations of 40 *V. speciosa* populations monitored during the RPMS with different coloured dots indicating the generations occurring within each population. One of the selected populations (TS47, Co. Kerry) was not monitored due to adverse weather conditions which deterred a thorough search of this waterfall population and this population is not mapped in Figure 9.

2.2 Survey preparation

2.2.1 Site packs

Data on *V. speciosa* populations, published and unpublished sources, and information held by NPWS were collated and studied prior to commencement of field work. NPWS Conservation Rangers were contacted in advance of the survey. Permission from landowners was sought on privately-owned land. All surveys were carried out under licence from NPWS.

A site pack was set up for each of the 41 populations proposed for survey. For the 27 populations previously surveyed, the site pack contained the baseline site report produced by Ní Dhúill *et al*. (2015), a field map consisting of an aerial photograph of the site showing the location of populations, and an Ordnance Survey map. In addition to this, a blank site survey card for the population to be completed by the ecologists (see Appendix 1) was included, along with blank monitoring sheets to be completed for every colony within the population (Appendix 2).

For the 14 populations not previously monitored, the site packs contained an aerial map showing the approximate location of the populations based on historic grid references, which were often only accurate to within 100 m. An Ordnance Survey map was included to aid the assessment of access, especially for upland populations where access can be difficult. Also included were available details of the locations of populations, their habitats and colony status.

2.2.2 Trimble Nomads

Hand-held Trimble Nomad GPS receivers were set up to record GPS points for each colony within a population. Vegetation data were recorded in Turboveg CE (Alterra, The Netherlands) for baseline surveys. The shapefiles created during the baseline survey were uploaded onto the Trimble Nomads to enable the surveyors to navigate directly to the *V. speciosa* populations.

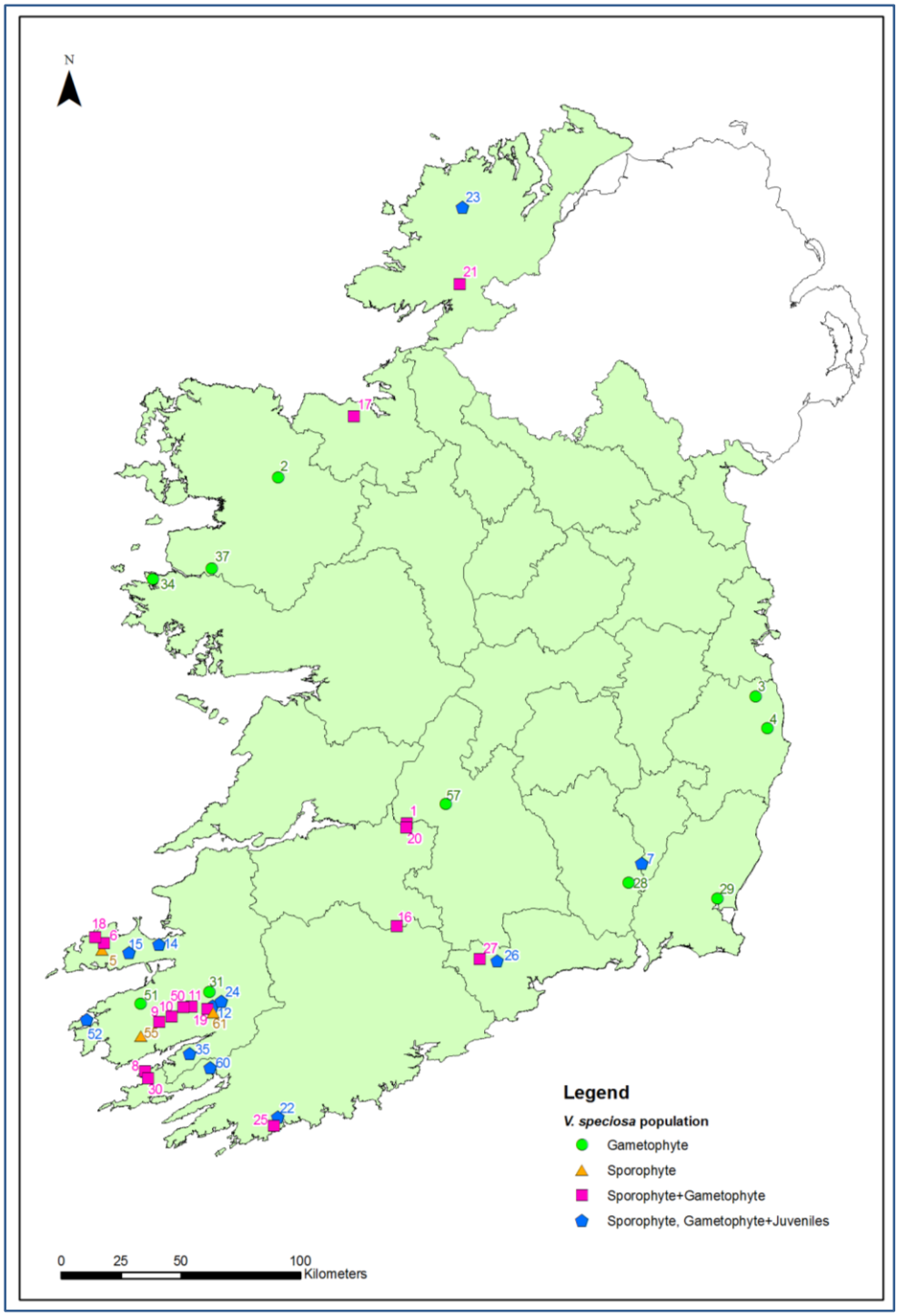

Figure 9 Distribution of the 40 *Vandenboschia speciosa* populations monitored during the RPMS. Points for populations are coloured based on the generations they contain (see legend). Not all populations are accurately mapped in order to protect *V. speciosa* population locations.

2.3 Site surveys

Sites were surveyed between May and September of each survey year. Survey teams consisted of two ecologists. A Rope Access Specialist was contracted to aid access at one population (TS05, Co. Kerry). Population TS47, Co. Kerry was not surveyed as the population was inaccessible due to adverse weather conditions. As such, a total of 40 populations were successfully monitored. Details of two recently recorded sporophyte colonies at population TS15, Co. Kerry (TS15.02.01, 2015 and TS15.03.01, 2018)

were communicated to the RPMS. The locations for these were visited but the colonies were found to be inaccessible due to adverse weather conditions and exceptionally high water levels. However, three other colonies within this population were successfully monitored.

Photographs of site overview and colony location were taken at each visit, including close-up images of individual colonies, fronds and gametophytes. Photographs of any impacting activities were also taken, such as evidence of presence of invasive non-native species, landslides, bank slippage and loss of canopy cover. All photographs were included in the project's Image Databank.

For baseline surveys, the vegetation in 2 m x 2 m plots was recorded and any notable plants (e.g. Red List or Flora (Protection) Order species) noted, along with a full species list.

In addition to site survey packs and suitable waterproof field work attire, field survey equipment included: hand lens x 10 and x 20 (with light), Trimble Nomad GPS receiver, walking stick, head torch, hand-held hygrometer, measuring tape, compass, forceps (for removal of small amounts of gametophyte filaments, if necessary, for identification), 25 cm x 25 cm quadrats divided into 5 cm x 5 cm squares for mature and juvenile frond number estimates, and a 1 m x 1 m quadrat for baseline assessments and for assessing encroachment of invasive/vigorous species (a 1 m^2 quadrat can be dismantled and used to define the area for a 2 m x 2 m plot). It is recommended that waders or thigh-high wellington boots are used when surveying populations near rivers or streams.

The survey methodology can be broadly divided into four main tasks, with one additional task for baseline surveys:

1. Initial search for colonies of both generations of *V. speciosa*, either co-occurring or gametophytes-only or sporophytes-only;
2. Completing the site monitoring sheet (Appendix 2) for direct attributes of the sporophyte generation of each colony within a population, i.e. sporophyte colony structure;
3. Completing the site monitoring sheet (Appendix 2) for direct attributes of the gametophyte generation of each colony within a population, i.e. gametophyte colony structure;
4. Monitoring the direct attributes of the individual colonies, i.e. habitat for the species and impacting activities (Appendix 1);
5. For baseline surveys, recording of vegetation data for each colony using 2 m x 2 m plots, with data held in Turboveg CE (Alterra, The Netherlands).

2.3.1 Initial search for colonies

Depending of the accuracy of the population location details, some time may be required to carry out a thorough search for both generations. The locations where the sporophytes occur include ravines, cliffs and by waterfalls. Searching such terrain must be carried out with care, as some colony locations can be very difficult to access. In populations where sporophytes occur, a thorough search for the often-associated gametophyte generation was conducted in the immediate vicinity of rocky substrate, crevices, overhangs and boulders, even if the population was previously recorded as sporophytes-only.

For gametophytes-only populations, a thorough search of any likely niches was conducted for other gametophyte colonies, such as any rocky substrate, crevices, overhangs and boulders.

Sporophytes and gametophytes were monitored as separate entities, even when both generations were co-occurring.

2.3.2 Monitoring direct attributes of the sporophyte generation

At each population and colony where sporophytes occurred, the population structure was observed and recorded to include investigation of presence of gametophytes occurring intimately or in close

association with the sporophyte generation, presence of fertile fronds, presence of juvenile sporophytes emerging from gametophytes and presence of young or unfurling fronds.

At populations that were historically recorded as sporophytes-only based on NPWS records, it was important to search likely niches for gametophytes within any sporophyte colonies recorded prior to 1992, which is when the gametophyte generation was first recorded in Ireland. During the baseline survey (Ní Dhúill, 2014), gametophytes were observed at 9 of the 12 populations that were historically recorded as being sporophytes-only (75%) making it likely that gametophytes would be observed in the vicinity of sporophytes during the RPMS.

The extent of each colony was measured with a measuring tape or graduated callipers. As the colonies (both gametophytes and sporophytes) are irregular in shape, they were measured as a rectangle, one measurement across the maximum dimension and another perpendicular to this. A 20 m measuring tape is generally suitable, though for small mature/juvenile sporophyte or gametophyte colonies a smaller measuring tape (5 m) or graduated callipers may be more suitable. These measurements of extent define a rectangle which encompasses the colony, which is considered the maximum colony area. The percentage of the area within the rectangle occupied by *V. speciosa* was visually estimated to allow calculation of the area of occupancy (in m^2) within this rectangle. For inaccessible colonies, e.g. at the back of a deep, narrow crevice, where use of a measuring tape or callipers was not feasible, maximum area and area of occupancy were visually estimated.

Full frond counts were carried out where possible at each colony, and estimates were calculated where counts were impractical. In the case of actual frond counts, these could be carried out on easily accessible colonies that are usually < 1 m^2. The following frond types, and the numbers of each present, were recorded:

- Mature sterile fronds (> 50% green, fully expanded);
- Mature fertile fronds (> 50% green, fully expanded);
- Young fronds (still unfurling, not fully expanded);
- Unfurling fronds (Croziers);
- Juvenile fronds (emerging from gametophyte);
- Dying fronds (< 50% green);
- Dead fronds (blade ± intact but frond all brown).

In the case of larger colonies, estimates were carried out based on counts using 25 cm x 25 cm quadrats (1-3 quadrats used, depending on colony size). These quadrats were placed at different sections of the colony to ensure an accurate reflection of density variation of a colony, and the number and types of fronds in each quadrat were recorded. The density of fronds per 1 m^2 and the estimated area of occupancy of each colony were used to estimate the total colony frond numbers. For populations that comprised multiple sporophyte colonies, frond counts for each colony were added together to give the full frond count for the population. For inaccessible colonies, frond numbers were based on estimates from a colony of similar density.

The number of juvenile fronds were counted or estimated and reported separately, as detailed in Section 1.6.1.2.

It has been reported that fertile fronds begin to brown and wither after complete spore discharge (Ratcliffe *et al*., 1993; Page, 1997). This may occur over a number of years and colonies may show a significant reduction in fertile frond numbers compared to the baseline. Percentage fertility of colonies was calculated based on living frond counts. Analysis of colony frond counts during the baseline survey suggested that fertile fronds had a shorter life span than sterile fronds as they tended to brown and die after all sporangia have been released (Ní Dhúill, 2014). This may have implications on future monitoring of frond numbers as fluctuations in counts may reflect natural mortality of fertile fronds rather than any other factor impacting the colony.

2.3.3 Monitoring direct attributes of the gametophyte generation

The rectangle defining the extent of each colony, i.e. maximum area, was measured with a measuring tape, as outlined in Section 2.3.2.

The area of occupancy within this rectangle was then either calculated or estimated (%), i.e. the percentage extent of the area within the rectangle occupied by *V. speciosa*. The method for measuring or estimating area of occupancy is described in Section 1.6.1.3.

It is important for future comparisons to record on the field sheet if the colony area of occupancy was estimated or calculated. Where the gametophyte colony occurs with sporophytes, the proximity of the gametophytes to the sporophytes should be recorded, i.e. within or around. A good description of the gametophyte colony will give any future recorders a sense of the expected appearance of the overall colony, and any changes may be more easily observed.

During monitoring visits, investigation by an expert for the presence of gametangia and also emergence of juvenile sporophytes is recommended if this can be achieved with minimal disturbance; this will require a hand lens or portable field microscope. Niche availability in terms of available bare rock in the vicinity was investigated for the presence of adjacent unrecorded gametophytes. If no sporophytes occur in the vicinity of the gametophytes, proximity to the nearest mature sporophyte can be calculated using GPS points.

2.3.4 Monitoring *Habitat for the species* and impacting activities

The *Habitat for the species* was assessed based on the area and quality of the habitat in which the species occurs. The suitable area of habitat corresponds to the area where populations occur, such as a ravine, an area of woodland, cliff-face or crevice.

The area of occupancy and maximum area figures were based on detailed research, targeted surveys and measurement of all colonies conducted since the 2012 assessment.

Proximity to a water source, high relative humidity, adequate shade/shelter and adequate canopy cover (in woodland locations) are necessary for both generations of *V. speciosa*. In addition to assessing canopy cover, shade (Shade Index) and water source, indicators for assessing the *Habitat for the species* also included the occurrence of vigorous native species or invasive non-native species in association with sporophyte colonies.

Gametophytes-only populations can occur at drier locations than those in which the sporophyte generation typically occurs. A water source is not always visible at gametophytes-only populations. At these drier locations, running water would not always be expected to be observed; however, relative humidity levels should still be comparable with those found at the sporophyte colonies in wetter habitats. A handheld hygrometer was used to measure relative humidity at gametophytes-only colonies.

A water source is usually clearly visible at populations where sporophytes occur and include rivers, streams, waterfalls, cascades, dripping rock-faces or dripping banks. These water sources are very important in terms of maintaining high relative humidity where *V. speciosa* colonies occur. At sporophyte colonies that occur on river/stream banks, the main source of water for the colonies is typically seepage. These banks are permanently wet, which also aids maintenance of high relative humidity. In cases where a water source is not clearly visible, the substrate upon which *V. speciosa* sporophytes occur should be wet/damp to touch.

Shading at woodland colonies where sporophytes occur is mainly provided by canopy cover. Gametophytes at co-occurring generation or gametophytes-only populations in woodland habitats typically occur in crevices, except in more deeply shaded ravines where gametophytes have been observed growing in large mats on ravine walls (Ní Dhúill, 2014). Canopy cover (Domin scale scores,

Table 4, below), which is the estimated proportion of the colony area covered by the vertical projection of the tree canopy, and Shade Index values (as per Table 5, below) were assigned for each colony (with canopy cover measured in woodland populations only). These would be expected to remain relatively stable when compared to baseline data for the previous reporting period.

Table 4 Domin scale, adapted from Kent (2012), used to assess canopy cover at *Vandenboschia speciosa* colonies occurring in woodlands.

Domin scale	Percentage cover
10	91-100%
9	76-90%
8	51-75%
7	34-50%
6	26-33%
5	11-25%
4	5-10%
3	1-4%
2	< 1% with several individuals
1	< 1% 1-2 individuals, no measurable cover
+	< 1% 1 individual with no measurable cover

Table 5 Shade Index values recorded at each *Vandenboschia speciosa* colony monitored in woodland and open upland habitats.

Shade Index value	Details
1	Fully exposed to sunlight all day
2	Sunlit for > half the day
3	Significant sunlight, but for < half the day
4	Moderate shade, e.g. light-medium deciduous canopy
5	Permanently shaded from direct sunlight but otherwise open to sky
6	Deep woodland (e.g. broadleaf, coniferous or in ravine) shade
7	Perpetual deep shade, e.g. cave entrance, beneath boulder

The site survey card and monitoring sheet (Appendix 1 and Appendix 2) contain sections to record impacting activities. Such impacting activities are considered pressures if they are currently negatively impacting the species or habitat and they are considered threats if it is considered that they are likely to impact the species or its habitat in the foreseeable future. Not all impacting activities are negative and there can be some that may have a positive impact on a species. Continued and standardised assessment of the local threat status is important to monitor trends over time and to help inform management decisions and strategies.

V. speciosa is potentially threatened by a wide variety of activities and impacts including road schemes, buildings and other developments, hydro-electric schemes, modification of watercourses, pollution, land reclamation, grazing, woodland management activities, fire, encroachment by invasive non-native or problematic native plant species, sample collecting, and recreational activities, amongst others. These can affect populations directly or indirectly as outlined in Section 3.3.

The main threats are loss of habitat, exposure, encroachment by vigorous native species (such as *Rubus fruticosus* agg.) and invasive non-native species (such as *R. ponticum* and *P. laurocerasus),* and humidity changes due to clearance of invasive species. Any impacting activities were recorded, and if there was measurable damage (frond loss, colony area reduction), this was also recorded.

2.3.5 Encroachment by invasive non-native and/or vigorous native species

Encroachment of sporophyte colonies by vigorous native species or by invasive non-native species was investigated at all populations.

For sporophyte colonies < 1 m x 1 m in area, invasive non-native species and/or vigorous native species occurring in a 1 m x 1 m quadrat centred on the colony were recorded and assigned a Domin score (Table 4). For sporophyte colonies ≥ 1 m x 1 m in area, Domin scores for such species were assigned for the extent of the colony. If any colony within a population fails for this indicator, then the whole population fails for this indicator.

Gametophytes grow in very dark microhabitats where there is little competition from other species and, as such, invasive non-native species or vigorous native species are not regarded as posing a significant threat to this generation at present.

2.3.6 Vegetation plots

Studies of the vegetation occurring with either *V. speciosa* generation have found no associated species that unequivocally indicate the presence of either generation (Ratcliffe *et al*., 1993; Rumsey, 1994; Kingston & Hayes, 2005; Ní Dhúill, 2014). In the present survey, species found to regularly occur in association with *V. speciosa* included the bryophytes *Calypogeia arguta, Conocephalum conicum, Diplophyllum albicans, Dumortiera hirsuta, Fissidens* spp., *Heterocladium heteropterum, Hookeria lucens, Kindbergia praelonga, Marchantia polymorpha, Mnium hornum, Pseudotaxiphyllum elegans*, *Riccardia chamedryfolia, Thamnobryum alopecurum, Thuidium tamariscinum* and the vascular plants *Chrysosplenium oppositifolium, Hedera helix*, *Molinia caerulea*, *Potentilla erecta*, *Saxifraga hirsuta* and *S. spathularis.* Although most species recorded were relatively common in the habitats in which they occur (woodland or open upland), there were a number of less common species recorded, such as the liverwort *Jubula hutchinsiae,* which shares a similar range to *V. speciosa* (Rumsey, 1994; Atherton *et al*., 2010) and the rare, Flora (Protection) Order liverwort species, *Radula holtii* and *Lejeunea hibernica.* Detailed surveying of vegetation was not included in the monitoring of *V. speciosa*; however, for baseline surveys, vegetation relevés were recorded in which all plant species and their percentage cover within a 2 m x 2 m plot centred on the *V. speciosa* colony were recorded and stored in Turboveg CE (Alterra, The Netherlands).

2.4 Assessments

The data recorded on the site survey card (Appendix 1) and monitoring sheet (Appendix 2) were used to complete an Individual Site Assessment sheet which comprises the *Population* assessment, *Habitat for the species* assessment and *Future prospects* assessment, full details of which are set out below. The combined data allow for the conservation status of each population to be determined, whether Favourable, Unfavourable-Inadequate or Unfavourable-Bad.

2.4.1 *Population* assessment for sporophyte population (with or without gametophytes)

The data for completion of the *Population* assessment, which was devised by Ní Dhúill *et al.* (2015) and updated for this current assessment (Tables 6 and 7), are derived from the *V. speciosa* monitoring sheets which were completed for each colony. For populations with multiple colonies, the *Population* assessment is based on the combined colony data from each *V. speciosa* monitoring sheet for a given population.

The assessment sheet comprises a number of indicators for assessing the population and a set target for each indicator to determine the conservation status of an individual population.

There are two different *Population* assessments depending on whether the population comprises sporophytes (with or without gametophytes) (Table 6) or gametophytes-only populations (Table 7). Sporophytes and gametophytes are measured as separate entities, even when the gametophyte is occurring intermingled with the sporophytes.

Population size was determined based on the number of colonies. For the *Population* assessment, the target is no reduction in colony numbers since the previous reporting period. For the area of occupancy, the target is no more than 10% reduction from the baseline reference value for each sporophyte colony, to allow for human error and recording variability.

One of the indicators is the presence of associated gametophytes, if previously observed, with the target being that they are present. If gametophytes are not observed at previously co-occurring generation populations, then the result is 'absent' and a fail for this attribute. If there are no gametophytes present in populations previously recorded as sporophytes-only, having conducted a thorough search in the immediate vicinity, the result is 'NA'. However, all subsequent visits of sporophytes-only populations must still include a thorough search for gametophytes in the immediate vicinity. For multiple colony populations, the result column for the indicator 'Frond types' states which colonies the frond types refer to, as not all colonies in a population may have fertile fronds. This would follow for the indicators 'Associated gametophytes' and 'Juveniles emerging from gametophytes'. See the example given below in Table 6.

For frond types (described in Section 2.3.2), the target is the presence of mature sterile/fertile fronds and/or young fronds and/or unfurling fronds at colonies where sporophytes occur. Fertile fronds have been included as an indication of colony health, productivity and viability. Fertile fronds have the potential to produce gametophytes, which in turn have the potential to produce juvenile sporophytes, which may increase the population size. Mature sterile, young and unfurling fronds also indicate growth by continued production of fronds. For the purpose of assessing this attribute as an indicator of a healthy viable population, any frond type or combination would be a pass.

For frond numbers, the target is no more than a 10% reduction in numbers for each sporophyte colony, where the reduction is due to an obvious pressure. Due to natural fluctuations in frond numbers, sporophyte colonies failing to reach the frond count target are considered to have failed under the frond count indicator only when there is an obvious pressure to which any frond loss can be attributed. Where a reduction cannot be attributed to an obvious pressure, the indicator should be recorded as passed; this should trigger a follow-up investigation into the cause of the decline and to determine whether or not

this is part of a natural fluctuation. This may require more frequent monitoring of any such colonies (initially annually) and should trigger actions to improve the conservation status of the colony. Any colony showing declines in frond numbers over two successive reporting cycles, even if the pressure is undetermined, should be deemed to have failed the frond number indicator. Living frond numbers are reported separately from juvenile fronds.

In the case of juvenile sporophytes emerging from gametophytes (via sexual reproduction/apogamy), their presence or absence should be recorded. Juvenile sporophyte frond numbers will be reported separately as, when present, these numbers may skew the overall figure for frond numbers, as not all juveniles would be expected to survive to reach maturity. It is unknown what the survival rates of juvenile sporophytes are, or the time it takes for them to reach maturity. For juvenile sporophytes no target value relating to reduction in frond number is given. Where such a reduction cannot be attributed to an obvious pressure, the indicator should be recorded as passed. However, where a reduction is attributable to an obvious pressure then a fail for that indicator will be returned. If juvenile sporophytes emerging from gametophytes were not observed during the previous monitoring period, then NA is input in the target box; however, if juveniles are observed during the current or future monitoring, the numbers should be counted or estimated as described in Section 1.6.1.2.

Table 6 shows an example of a completed *Population* assessment for a population (TS11, Co. Kerry) in which sporophytes occur with gametophytes.

The example *Population* assessment shows baseline results from the 2012 report in one column for comparison with the results from the RPMS in the next column. For RPMS baseline survey populations there is just one column with results and the conservation status is Favourable as it is the first time the population has been monitored.

The individual population condition is considered Favourable for populations containing sporophytes (including co-occurring generation populations) if six or more indicators are passed. It is considered Unfavourable-Inadequate if only three to five indicators are passed, and Unfavourable-Bad if zero to two indicators are passed. In cases where the indicator cannot be assessed, a value of NA should be returned, i.e. at colonies where gametophytes and/or juvenile sporophytes were historically absent and continue to be absent. This will equate to a pass for that indicator for the purpose of the target requirements for assessing the population.

An addition to the *Population* assessment for the reporting period 2013-2018 is the recording of the maximum gametophyte colony area, as described in Section 1.6.1.3.

Table 6 *Population* assessment indicators and targets for *Vandenboschia speciosa* (sporophyte population with or without gametophytes) at population TS11, Co. Kerry showing results for the previous and current reporting periods. *Favourable (Green)*: 6 - 7 passes; *Unfavourable-Inadequate (Amber)*: 3 - 5 passes; *Unfavourable-Bad (Red)*: 0 - 2 passes.

Indicator	Target	Result (2007-2012)	Result (2013-2018)	Pass/Fail (2013-2018)
Total number of colonies (of all generations)	No loss of colonies	1	1	Pass
Population size (combined area of occupancy of all colonies and generations)	No reduction in population size (area of occupancy) for sporophytes. Expert judgement regarding gametophytes	0.3 m^2	0.45 m^2	Pass
Maximum area of all gametophyte colonies.	No reduction in maximum gametophyte colony area size	0.003 m^2	0.003 m^2	Pass
Frond types	Mature Sterile/Fertile and/or Young fronds and/or croziers present	All frond types present	Sterile, Fertile and Young present	Pass
Associated gametophytes	No loss of associated gametophyte colonies, if previously observed	Present	Present	Pass
Total number of living fronds (excluding juvenile sporophytes) that may have arisen from gametophytes (counts)	No reduction. If there is a reduction in frond numbers with no obvious pressure attributable to loss, the result is a pass	35	53	Pass
Juveniles emerging from gametophytes: total number of juvenile sporophytes that may have arisen from gametophytes	If there is a reduction in juvenile frond numbers with no obvious pressure attributable to loss, the result is a pass	NA	NA	Pass
Individual population condition (sporophytes with or without gametophytes)			7 passes	**Favourable**

NA (not applicable): juveniles were not observed during the monitoring periods 2007-2012 or 2013-2018.

2.4.2 *Population* assessment for gametophytes-only populations

Population is assessed by combining the monitoring results for all gametophyte colonies within each gametophyte population and completing the *Population* assessment (Table 7). The assessment sheet comprises a number of indicators for assessing the population and a set target for each indicator to determine the conservation status of an individual population.

Population size was determined based on the number of gametophyte colonies. For the *Population* assessment, the target is no reduction in gametophyte colony numbers since the previous reporting period.

The target of '*no decline in area of occupancy below 10% of the baseline reference value for each colony*' (to allow for human error and recording variability) was recommended for gametophyte colonies during the

baseline survey (Ní Dhúill *et al*., 2015). However, during the RPMS it became clear that such an error margin was not appropriate for this extremely slow-growing generation. Comparisons of estimated areas of occupancy for the gametophyte generation can be difficult, as described in Section 1.6.1.3, as such estimates can be very subjective. Therefore, expert opinion should be used when determining whether a colony passes or fails on the target for area of occupancy. The maximum area, however, would not be expected to be reduced unless there was some pressure impacting upon it, e.g. landside or bank slippage. To capture this, a new indicator, "Maximum area of all gametophyte colonies", has been added (Table 7), the target for which has a 10% margin of error to allow for human error and recording variability.

The individual population condition is considered Favourable for populations containing gametophytes-only if at least three indicators are passed. It is considered Unfavourable-Inadequate if only one or two indicators are passed and Unfavourable-Bad if zero indicators are passed. In cases where the indicator cannot be assessed, a value of NA should be returned, i.e. at colonies where juvenile sporophytes were historically absent and continue to be absent. This will equate to a pass for that indicator for the purpose of the target requirements for assessing the population. If juvenile sporophytes are observed at such colonies during future monitoring, they should be recorded and frond numbers should be counted or estimated.

An addition to the *Population* assessment for the reporting period 2013-2018 is the recording of the maximum gametophyte colony area (see Section 1.6.1.3). Table 7 shows an example of a completed *Population* assessment for a gametophytes-only population, Population TS02, Co. Mayo, with columns showing results for the previous and current reporting periods.

Table 7 *Population* assessment indicators and targets for the gametophytes-only *Vandenboschia speciosa* population TS02, Co. Mayo showing results for the previous and current reporting periods. *Favourable (Green):* at least 3 passes; *Unfavourable-Inadequate (Amber):* 1 - 2 passes; *Unfavourable-Bad (Red):* 0 passes

Indicator	Target	Result (2007-2012)	Result (2013-2018)	Pass/Fail (2013-2018)
Total number of colonies	No loss in colonies	1	12	Pass
Population size (combined area of occupancy of colonies)	Expert judgement regarding area of occupancy	0.005 m^2	0.42 m^2	Pass
Maximum area of all gametophyte colonies	No reduction in maximum size of gametophyte colony area	0.005 m^2	1.30 m^2	Pass
Juveniles emerging from gametophytes	If there is no reduction in juvenile frond numbers, or a reduction but with no obvious pressure attributable to loss, the result is a pass	NA	NA	Pass
Individual population condition (gametophytes-only)			4 passes	**Favourable**

NA (not applicable): juveniles were not observed during the monitoring periods 2007-2012 or 2013-2018.

2.4.3 *Habitat for the species* assessment for sporophyte populations (with or without gametophytes)

In Ireland, both generations of *V. speciosa* occur in either woodland habitats or open upland habitats. Within these habitats, *V. speciosa* sporophytes and gametophytes occupy specific microhabitats that provide constant high relative humidity and shade.

For woodland habitats, the indicators used are canopy cover, with a pass target of Domin score ≥ 8; shade, with a target of Shade Index value of ≥ 4; humidity and substrate moisture, with a target that the substrate is damp/wet to touch; and encroachment of vigorous native species or invasive non-native species, with a target of Domin score of ≤ 4.

For open upland habitats, the indicators used are as above excluding the canopy cover indicator. This would be applicable for any exposed habitat where *V. speciosa* occurs such as exposed rock and open lowlands. The encroachment indicator is also excluded at present.

For habitats where the sporophyte generation occurs (with or without the gametophytes), Table 8 gives an example of a completed *Habitat for the species* assessment for woodland habitats and Table 9 gives an example of a completed *Habitat for the species* assessment for open upland habitats.

The individual *Habitat for the species* assessment is considered Favourable for woodland populations containing sporophytes (with or without gametophytes) if three to four indicators are passed. It is considered Unfavourable-Inadequate if only two indicators are passed and Unfavourable-Bad if zero to one indicator is passed.

Table 8 *Habitat for the species* assessment indicators and targets for woodland populations where sporophytes occur, with or without gametophytes, at *Vandenboschia speciosa* population TS12, Co. Kerry showing results for the previous and current reporting periods. *Favourable (Green):* 3 - 4 passes; *Unfavourable-Inadequate (Amber):* 2 passes; *Unfavourable-Bad (Red):* 0 - 1 passes.

Indicator	Target	Result (2007-2012)	Result (2013-2018)	Pass/Fail (2013-2018)
Canopy cover (Domin)	≥ 8	8	5 (colony TS12.01.01) 9 (colony TS12.01.02) 9 (colony TS12.02.01)	Fail
Shade (Shade Index)	≥ 4	4	3 (colony TS12.01.01) 7 (colony TS12.01.02) 6 (colony TS12.02.01)	Fail
Humidity and substrate moisture	Visible water source and/or substrate damp/wet to touch	Substrate damp/wet to touch	Substrate damp/wet to touch	Pass
Occurrence of vigorous native species or invasive non-native species within sporophyte colonies at *V. speciosa* populations *	Domin score ≤ 4 (0 – 10%)	+ (*Rubus fruticosus* agg.)	2 (*Rubus fruticosus* agg.)	Pass
Habitat condition (woodland)			2 passes	**Unfavourable - Inadequate**

* For sporophyte colonies < 1 m x 1 m, Domin score of ≤ 4 for such species that occur in a 1 m x 1 m quadrat centred on the colony is a pass. For sporophyte colonies ≥ 1 m x 1 m, Domin score of ≤ 4 for such species that occur within the extent of the colony is a pass. If any colony within a population fails for this indicator, then the whole population fails for this indicator.

For open upland populations containing sporophytes (with or without gametophytes), the individual *Habitat for the species* assessment is considered Favourable if two indicators are passed. It is considered Unfavourable-Inadequate if only 1 indicator is passed and Unfavourable-Bad if zero indicators are passed. See Table 9 below.

Table 9 *Habitat for the species* assessment indicators and targets for *Vandenboschia speciosa* where sporophytes occur, with or without gametophytes, at open upland population TS11, Co. Kerry showing results for the previous and current reporting periods. *Favourable (Green):* 2 passes; *Unfavourable-Inadequate (Amber):* 1 pass; *Unfavourable-Bad (Red):* 0 passes.

Indicator	Target	Result (2007-2012)	Result (2013-2018)	Pass/Fail (2013-2018)
Shade (Shade Index)	≥ 5	7	7	Pass
Humidity and substrate moisture	Visible water source and/or substrate damp/wet to touch	Visible water source and substrate damp/wet to touch	Visible water source and substrate damp/wet to touch	Pass
Habitat condition (open upland)			2 passes	**Favourable**

2.4.4 *Habitat for the species* assessment for gametophytes-only populations

For the *Habitat for the species* assessment of *V. speciosa* gametophytes-only populations, there are two attributes that need to be assessed – shade and relative humidity (Table 10). The target for shade is a Shade Index value of ≥ 6 and the target for relative humidity is ≥ 80%.

The individual *Habitat for the species* assessment is considered Favourable for populations containing gametophytes-only if two indicators are passed. It is considered Unfavourable-Inadequate if only one indicator is passed and Unfavourable-Bad if no indicators are passed.

Table 10 *Habitat for the species* assessment indicators and targets for the *Vandenboschia speciosa* gametophytes-only population TS02, Co. Mayo showing results for the previous and current reporting periods. *Favourable (Green):* 2 passes; *Unfavourable-Inadequate (Amber):* 1 pass; *Unfavourable-Bad (Red):* 0 passes

HABITAT TYPE: WOODLAND or OPEN UPLAND				
Indicator	Target	Result (2007-2012)	Result (2013-2018)	Pass/Fail (2013-2018)
Shade (Shade Index)	≥ 6	7	7	Pass
Relative humidity	Relative humidity ≥ 80%	91%	*92%	Pass
Individual habitat condition (gametophytes-only populations)			2	**Favourable**

*Average value for the 12 colonies (relative humidity was > 90% for 10 colonies and > 88% for two).

2.4.5 *Future prospects* assessment

As per the EU guidelines, '*Future prospects should be evaluated by individually assessing the expected future trends and subsequently future prospects of each of the other three parameters* (Range, Population and Habitat), *taking primarily into account the current conservation status of the parameter, threats (related to the parameter assessed) and the conservation measures being taken or planned for the future. Once the future prospects of each of the other three parameters have been evaluated, they should be combined to give the overall assessment of Future prospects* (DG Environment, 2017).

For the individual population *Future prospects* assessment, impacting activities should be recorded using the standardised EU-devised list of impact codes including their location, influence, intensity and area affected, if known. These standardised activity categories are assessed based on a visual examination of colonies within a population ("within") and the surrounding habitat ("outside"). The "surrounding habitat" is difficult to define, as the sphere of influence that may impact *V. speciosa* colonies/populations is not easily determined. It can be loosely defined as the vicinity around the population where activities may have an impact on the colony/ies within the population, e.g. tree felling and canopy loss in a woodland where *V. speciosa* colonies occur may affect relative humidity, or landslides or bank collapses may dislodge or even destroy colonies within populations. Expert judgement is to be used to determine the "surrounding habitat" and the approximate area of this should be recorded. The intensity of the activity is graded as low, medium or high. Any additional activities not in the list of impact codes should be recorded and included as observed. For the National Conservation Status Assessment (NPWS, 2019) the updated, 2018 EU list of impacting activity codes were used. The 2010 EU impacting activity codes (Ssymank, 2010) continue to be used for this report to allow for direct comparison with the last reporting period.

The *Future prospects* assessment (Table 11) should be completed to record current pressures and future threats at populations where *V. speciosa* occurs. The column for 'area affected' is to be completed if there is a measurable impact from a pressure. If the impact cannot be measured or if there is no current impact, then the '*unknown*' category can be assigned. If the influence and intensity of a potential impacting activity is unknown then '*unknown*' should be completed in the relevant column. This flags potential issues that may arise based on the impacting activity and allows for such pressures and threats to be monitored at future visits to the population. An example of a *Future prospects* assessment for population TS12, Co. Kerry, is set out in Table 11 and proposed conservation measures for that population are shown in Table 12.

If there is no significant impact from the activities, *Future prospects* should be assessed as Favourable (green), medium impact should be assessed as Unfavourable-Inadequate (amber) and high impact as Unfavourable-Bad (red). For populations where there is more than one impacting activity recorded, if any of the impacting activities are having a medium impact, the overall *Future prospects* assessment is amber for that population. Likewise, if any of the impacting activities are having a high impact on an individual population, the overall *Future prospects* assessment is red for that population. It should be noted in the *Future prospects* assessment if the activity is a pressure (impacting the species or habitat within the current reporting period and impacting on long-term viability of the species or habitat) or if it is a threat (likely to impact the species or habitat within the next two reporting cycles and likely to affect the long-term viability of the species or habitat). Threats should reflect issues judged to be reasonably likely and not theoretical threats (DG Environment, 2017). For multiple colony populations, if any colony within a population has an Unfavourable status, then the whole population is assigned an Unfavourable status.

Table 11 *Future prospects* assessment of impacting activities (with EU code (Ssymank, 2010)) including location, influence, intensity and area affected for the *Vandenboschia speciosa* population at TS12, Co. Kerry. *Favourable (Green):* No significant impact; *Unfavourable-Inadequate (Amber):* Any medium impact; *Unfavourable-Bad (Red):* Any high impact.

Activity	Pressure or threat	Location Within or Outside	Influence Positive/ Negative/ Neutral	Intensity High/ Medium/ Low	Area affected (m^2)
A07 Use of biocides, hormones and chemicals (herbicides)	Threat	Outside	Negative	Low	Unknown
I01 Invasive non-native species	Threat	Outside	Negative (habitat) Neutral (species)	Low	Unknown
I02 Problematic native species	Threat	Outside	Negative	Low	Unknown
K04.03 Introduction of disease (microbial pathogens)	Pressure	Within	Negative	Medium (colony TS12.01.01) grey fungal attack	0.15 m^2 maximum area (colony TS12.01.01)
Future prospects status					**Unfavourable - Inadequate**

Set out below in Table 12 by way of example are proposed conservation measures to be implemented to address impacting activities where necessary at population TS12, Co. Kerry.

Table 12 Proposed conservation measures (using 2018 EU list of conservation measures codes) for *Vandenboschia speciosa* population TS12, Co. Kerry, arising from *Future prospects* assessment of impacting activities.

Measure from list	Extent	Explanation
CI03 Management, control or eradication of other invasive alien species	Particularly in vicinity of sub-populations 1 and 2	*Rhododendron ponticum* was cleared in the past, but many seedlings are re-emerging. Not considered a current threat to the *V. speciosa* colonies. However, its presence is likely to become problematic and negatively impact this woodland habitat.
CB09 Manage the use of chemicals for fertilisation, liming and pest control in forestry	Colony TS12.02.01	Re-assess use of herbicides in the vicinity of the *V. speciosa* colony.

2.4.6 Overall conservation assessment for *V. speciosa* in Ireland

The framework for assessing the conservation status at the individual population level allows for the amalgamation of results to assess conservation status at a national level, as required under Article 17 of the Habitats Directive. Expert judgment should be used when assessing attributes at each population, i.e. where there is a localised issue that is not regarded as a threat at the national level, this threat should be highlighted for that population, but may not necessarily reflect a negative impact on the national conservation status.

The overall Conservation Status Assessment for the Irish *V. speciosa* meta-population was made, utilising the survey results for the three parameters *Population*, *Habitat for the species* and *Future Prospects* and following the evaluation matrix criteria in Table 2, guidance provided by the EU (DG Environment, 2017) and criteria developed specifically for *V. speciosa* (Table 13). The *favourable reference population* (see Table 2) referred to in Table 13 is approximately equal to the current area of occupancy (239 m^2) recorded for the 290 known colonies of *V. speciosa* in Ireland (see NPWS, 2019). Expert judgment was exercised throughout the assessment process, in particular to take account of recording variability and the evaluation of natural/other processes.

Table 13 Assessing Overall Conservation Status for *V. speciosa* in Ireland.

Favourable (green)	Area of occupancy of population stable or above *favourable reference population* OR number of fronds stable, increasing or if declining* then by not more than 10% below that recorded in previous reporting period** (any decline attributable to natural frond turnover is acceptable).
Unfavourable-Inadequate (amber)	Decline* in area of occupancy of population of up to 25% below *favourable reference population* OR decline* in number of fronds of 11-25% below that recorded in previous reporting period**.
Unfavourable-Bad (red)	Decline* in area of occupancy of population of more than 25% below *favourable reference population* OR decline* in number of fronds of more than 25% below that recorded in previous reporting period**.

* for reasons other than natural frond turnover or other natural processes.

** 2013-2018 reporting period (see Tables 19 and 20).

3 Results

3.1 Overall statistics

3.1.1 Number of populations

There are currently 86 known extant *V. speciosa* populations in Ireland comprising 290 colonies. The population types and numbers of each are set out in Table 14. The definitions of 'colony' for both generations are given in Section 1.6.1.1.

Table 14 Summary of colony types at all currently known, extant *Vandenboschia speciosa* populations showing the numbers and percentages of the different population/colony types for 2018. Figures include populations monitored during the RPMS and populations that were not surveyed.

	No. of populations	% of total population	No. of colonies	% of total colonies
Sporophyte and gametophyte co-occurring (S&G)	30	35%	44	15%
Sporophytes, gametophytes and juvenile sporophytes co-occurring (S&G&J)	0	0	29	10%
Sporophytes-only (S)	20	23%	60	21%
Gametophytes-only (G)	35	41%	142	49%
Gametophytes and juvenile sporophytes (G&J)	1	1%	13	4%
Mature sporophytes with juveniles (without gametophyte observed) (S&J)	0	0	2	1%
Total extant *V. speciosa* populations and colonies	86		290	

In the previous reporting period (2007-2012) 64 populations, comprising 177 colonies, were recorded nationally. Since that reporting period the status of 28 colonies in ten populations has been changed:

a) Nineteen gametophyte colonies were amalgamated into extant colonies within two populations due to the redefining of a gametophyte colony, as outlined in Section 1.6.1.1 (populations TS24, Co. Kerry and TS34, Co. Galway).
b) At population TS12, Co. Kerry, two colonies were considered to be the same one (TS12.03.01).
c) One population (Poisoned Glen, Co. Donegal), now considered extinct, was erroneously included in the previous assessment, on the basis of a pre-1960 record.
d) Following an extensive search, five colonies within four different populations were considered lost since before the Directive came into force (TS06.02.03, TS40.01.01, TS50.01.01, TS51.01.01 and TS51.02.01, all in Co. Kerry). The loss of these historic records was attributed to natural processes, likely substrate instability, at the waterfall locations where they occurred (TS06.02.03, TS51.01.01, TS51.02.01, Co. Kerry). Sporophyte colony TS40.01.01 was originally recorded in 1881 and last seen in 1983, since which time it has been searched for unsuccessfully on numerous occasions and it is considered to be extinct. Sporophyte colony TS50.01.01 was last seen in 1967, when it was described as being moribund.
e) Two colonies that were monitored during the RPMS reflected genuine loss of colonies since the last reporting period (TS20.04.01, Co. Limerick due to removal of canopy cover provided by *R. ponticum* and TS22.01.07, Co. Cork due to trampling).

All colonies referred to above considered to be lost since before or after the Directive came into force, occurred in multiple-colony populations, bar the single-colony, pre-1960 population at the Poisoned Glen, Co. Donegal. The presence of gametophytes, which occur at all but one of the populations where colonies have been lost, is important for sporophytic recruitment under future favourable conditions. The loss of these colonies does not impact upon the range of the species in Ireland.

As of 2018, the total number of known, extant colonies within the 86 populations was 290, of which 141 were new records since the last reporting period. The increase in numbers of population and colonies is due to improved knowledge and more accurate data rather than expansion of newly established populations.

This report relates to results derived from all populations successfully monitored during the RPMS. Forty populations comprising 198 colonies were monitored during the survey period 2015 to 2018. See Table 15 below for details of the population and colony types and Table 16 for details of all populations visited during the RPMS.

Table 15 Summary of the population and colony types at the 40 monitored *Vandenboschia speciosa* populations for 2018.

Generation	No. Populations	% of total population	No. colonies	% of total colonies
Sporophyte and gametophyte co-occurring (S&G)	15	38	42	21
Sporophytes, gametophytes and juvenile sporophytes co-occurring (S&G&J)	12	30	28	14
Sporophytes-only (S)	3	7	26	13
Gametophytes-only (G)	10	25	88	44
Gametophytes and juvenile sporophytes (G&J)	0	0	12	7
Mature sporophytes with juveniles (without gametophyte observed) (S&J)	0	0	2	1
Total extant *V. speciosa* populations and colonies	40		198	

Table 16 Details of 40 monitored *Vandenboschia speciosa* populations monitored 2015-2018: population code, county, number of monitored colonies per population, generation at population, generation at colony (S&G; S&G&J; S; G; G&J; S&J); number of colonies of each generation and number of colonies with fertile fronds. Abbreviations for colony types are as given in Table 1.

Pop. code	County	No. of colonies monitored	Generation at population	S& G	S&G&J	S	G	G&J	S&J	No. of fertile colonies
TS01	Tipperary/ Limerick	11	S&G&J	2	0	0	8	1	0	0
TS02	Mayo	12	G	0	0	0	12	0	0	0
TS03	Wicklow	1	G	0	0	0	1	0	0	0
TS04	Wicklow	2	G	0	0	0	2	0	0	0
TS05	Kerry	1	S	0	0	1	0	0	0	1
TS06	Kerry	4	S&G	2	0	0	2	0	0	0
TS07	Carlow	2	S&G&J	0	1	0	1	0	0	0
TS08	Cork	3	S&G	2	0	0	1	0	0	2
TS09	Kerry	3	S&G	1	0	1	1	0	0	0
TS10	Kerry	2	S&G	1	0	0	1	0	0	0
TS11	Kerry	1	S&G	1	0	0	0	0	0	1
TS12	Kerry	3	S&G&J	2	0	0	0	1	0	0
TS14	Kerry	2	S&G&J	1	1	0	0	0	0	1
TS15	Kerry	3	S&G&J	0	1	1	1	0	0	1
TS16	Limerick	3	S&G	1	0	0	2	0	0	1
TS17	Sligo	2	S&G	1	0	0	1	0	0	0
TS18	Kerry	1	S&G	1	0	0	0	0	0	0
TS19	Kerry	2	S&G	1	0	0	1	0	0	0
TS20	Limerick	7	S&G	4	0	0	3	0	0	1
TS21	Donegal	5	S&G	1	0	0	4	0	0	0
TS22	Cork	7	S&G&J	2	5	0	0	0	0	1
TS23	Donegal	1	S&G&J	0	1	0	0	0	0	0
TS24	Kerry	22	S&G&J	4	8	1	1	8	0	0
TS25	Cork	4	S&G	1	0	1	2	0	0	1
TS26	Waterford	39	S&G&J	10	5	15	5	2	2	3
TS27	Waterford	2	S&G	1	0	0	1	0	0	0

Pop. code	County	No. of colonies monitored	Generation at population	S& G	S&G&J	S	G	G&J	S&J	No. of fertile colonies
TS28	Kilkenny	7	G	0	0	0	7	0	0	0
TS29	Wexford	6	G	0	0	0	6	0	0	0
TS30	West Cork	4	S&G	1	0	3	0	0	0	0
TS31	Kerry	6	G	0	0	0	6	0	0	0
TS34	Galway	3	G	0	0	0	3	0	0	0
TS35	Kerry	4	S&G&J	0	1	0	3	0	0	0
TS37	Mayo	1	G	0	0	0	1	0	0	0
TS50	Kerry	5	S&G	1	0	0	4	0	0	0
TS51	Kerry	3	G	0	0	0	3	0	0	0
TS52	Kerry	7	S&G&J	1	4	0	2	0	0	2
TS55	Kerry	2	S	0	0	2	0	0	0	0
TS57	Tipperary	1	G	0	0	0	1	0	0	0
TS60	Cork	3	S&G&J	0	1	0	2	0	0	0
TS61	Kerry	1	S	0	0	1	0	0	0	0
TOTAL		198		42	28	26	88	12	2	15

3.1.2 Frond counts and estimates

Frond numbers can fluctuate on an annual basis; therefore, presence or absence of a colony is a more reliable unit than frond numbers. Notwithstanding, recording the number of fronds in individual colonies during monitoring surveys does provide very useful information on the status of the colonies over the long-term. Frond numbers were recorded at each colony following the methods described in Section 2.3.2. Table 17 shows details of numbers and types of colonies, frond types and frond numbers for the 40 *V. speciosa* populations monitored. This table also includes results for the area of occupancy and maximum area of each population. Table 18 sets out results on frond fertility and observation of juvenile sporophytes emerging from gametophytes, comparing results from the previous survey with the RPMS.

Details of frond numbers recorded at the 27 populations monitored in the previous survey compared with the same 27 monitored in the RPMS are shown in Table 19. Included in this table are the results for the total 40 populations monitored during the RPMS (i.e. including the additional 13 populations monitored since the previous survey). This table also includes results for the area of occupancy and maximum area of the species recorded at each population.

Table 17 Details of 40 *Vandenboschia speciosa* populations monitored including, number of colonies per population, summary of colony types (generations: Gen.) at each population; total number of living fronds excluding juveniles (J); total number of juvenile (J) fronds; total number of fertile fronds; total area of occupancy (AoO) (m^2) and maximum (max.) area for sporophytes (S) and for gametophytes (G) (m^2). The results are based on monitored populations and do not include assigned areas for any colonies not located during the RPMS.

Pop. code	County	Gen.	Colonies per pop.	Living fronds (excl. J)	Total J frond count	Fertile frond count	S AoO	S max. area	G AoO	G max. area
TS01	Tipperary/Limerick	S&G&J	11	2,233	5	0	4.35	10.05	2.76	10.89
TS02	Mayo	G	12	0	0	0	0.00	0.00	0.42	1.30
TS03	Wicklow	G	1	0	0	0	0.00	0.00	0.003	0.10
TS04	Wicklow	G	2	0	0	0	0.00	0.00	0.33	1.00
TS05	Kerry	S	1	145	0	12	1.33	1.33	0.00	0.00
TS06	Kerry	S&G	4	62	0	0	0.33	0.43	0.21	9.28
TS07	Carlow	S&G&J	2	51	4	0	0.14	0.35	1.79	3.18
TS08	Cork	S&G	3	1,953	0	434	6.28	37.79	0.05	0.29
TS09	Kerry	S&G	3	237	0	0	1.63	1.71	0.20	1.21
TS10	Kerry	S&G	2	51	0	0	0.28	0.55	0.88	2.30
TS11	Kerry	S&G	1	53	0	10	0.45	0.56	0.003	0.003
TS12	Kerry	S&G&J	3	40	8	0	0.13	0.18	2.87	14.45
TS14	Kerry	S&G&J	2	1,808	239	98	4.65	7.08	0.71	7.08
TS15	Kerry	S&G&J	3	223	3	2	0.80	1.20	0.009	0.71
TS16	Limerick	S&G	3	649	0	145	1.60	4.00	0.08	0.49
TS17	Sligo	S&G	2	61	0	0	0.20	0.40	0.03	0.03
TS18	Kerry	S&G	1	479	0	0	1.54	2.32	0.26	0.50
TS19	Kerry	S&G	2	36	0	0	0.09	0.15	0.01	0.54
TS20	Limerick	S&G	7	230	0	13	1.03	1.84	1.75	4.56
TS21	Donegal	S&G	5	221	0	0	0.52	0.69	0.06	0.47
TS22	Cork	S&G&J	7	2,493	102	100	9.75	16.78	0.89	7.89
TS23	Donegal	S&G&J	1	43	1	0	0.08	0.11	0.03	0.05
TS24	Kerry	S&G&J	22	668	722	0	2.52	7.14	8.38	45.77
TS25	Cork	S&G	4	3,085	0	1,119	16.17	52.70	0.64	1.70
TS26	Waterford	S&G&J	39	29,683	213	1,105	112.50	231.36	16.74	90.78
TS27	Waterford	S&G	2	61	0	0	0.21	0.42	0.01	0.016
TS28	Kilkenny	G	7	0	0	0	0.00	0.00	1.96	10.29
TS29	Wexford	G	6	0	0	0	0.00	0.00	1.51	4.05
TS30	Cork	S&G	4	247	0	0	0.90	1.77	0.03	0.34
TS31	Kerry	G	6	0	0	0	0.00	0.00	0.17	0.49
TS34	Galway	G	3	0	0	0	0.00	0.00	2.46	12.30
TS35	Kerry	S&G&J	4	1	5	0	0.00	0.00	0.03	0.80
TS37	Mayo	G	1	0	0	0	0.00	0.00	0.004	0.005
TS50	Kerry	S&G	5	10	0	0	0.04	0.08	0.12	0.74
TS51	Kerry	G	3	0	0	0	0.00	0.00	0.13	0.32
TS52	Kerry	S&G&J	7	2,431	134	416	9.26	18.11	3.61	45.40
TS55	Kerry	S	2	160	0	0	0.25	0.58	0.00	0.000
TS57	Tipperary	G	1	0	0	0	0.00	0.00	0.001	0.001
TS60	Cork	S&G&J	3	3	31	0	0.02	0.02	0.05	0.19
TS61	Kerry	S	1	162	0	0	0.35	0.50	0.00	0.000
TOTAL			198	47,581	1,467	3,454	177.37	400.20	49.16	279.5

Table 18 Results for monitored *Vandenboschia speciosa* populations where juvenile sporophytes were recorded between the previous survey and the RPMS, and for fertile populations for the same periods, showing percentage (%) differences between the two reporting periods.

	JUVENILE SPOROPHYTES			SPOROPHYTE FERTILITY		
Year	Total populations monitored	Number of populations with Juveniles	% populations with Juveniles	Total populations with mature sporophytes	Number of populations with fertile fronds	% populations with fertile fronds
2011	27	5	19%	23	13	57%
2018	40	12	30%	30	11	37%
Difference	13	7		7	-2	
% difference	48%	140%		30%	-15%	

During the last reporting period, juvenile sporophytes were rarely observed within the Irish populations, being recorded in only five of the 27 monitored populations (19%). During the RPMS, juvenile sporophytes were recorded at 12 of the 40 monitored populations (30%), which reflects 21% of the 198 monitored colonies where either generation of *V. speciosa* occurs. The trigger for the development of these juvenile sporophytes from gametophytes is unclear but it may, at least in part, be due to climatic factors.

During the last reporting period, 13 of the 23 monitored populations where mature sporophytes occurred were fertile (57%). In the RPMS, 11 of the 30 monitored populations where sporophytes occurred were fertile (37%). This represents 15% of the 100 colonies where sporophytes occurred. Seven colonies that were fertile in the previous survey were no longer fertile: two colonies in population TS20, Co. Limerick, and a single colony in each of the following populations: TS15, Co. Kerry; TS18, Co. Kerry; TS22, Co. Cork; TS25, Co. Cork; and TS26, Co. Waterford. However, there were two additional colonies at which fertile fronds were recorded in the RPMS but not during the last reporting period: TS15, Co. Kerry (a newly recorded colony at this population) and TS05, Co. Kerry. Fluctuation in fertility is not considered problematic, and likely represents natural turnover of fertile fronds.

3.1.3 Area of occupancy (AoO) and maximum area for both generations

In addition to using colony numbers to determine population size, measures of area of occupancy and maximum area parameters were also used. For the 86 known *V. speciosa* populations, the area of occupancy and maximum area figures are based on detailed research, targeted surveys and measurement of all colonies conducted since the 2012 conservation assessment, data from Ph.D. research into the Irish *V. speciosa* populations (Ní Dhúill, 2014), historic records held by NPWS, and information from NPWS permanent/contract staff and other sources. In order to derive a national area of occupancy for the National Conservation Status Assessment, colony records where there was no information on area were set a minimum value of 0.22 m^2 for sporophyte colonies and 0.12 m^2 for gametophyte colonies. These figures were revised downwards from 1 m^2 for either generation assigned in the previous survey, which, on review, was considered to be excessive. For the National Conservation Status Assessment, the method used to derive the assigned areas is described in Appendix 3.

For the National Conservation Status Assessment (NPWS, 2019) the derived area of occupancy of all 86 *V. speciosa* populations was 239 m^2. The derived maximum area of both generations combined for all 86 populations was 695 m^2 and is considered to be the area for the habitat.

For the previous reporting period the derived area of occupancy for the National Conservation Status Assessment was 280 m^2 with a maximum area of 449 m^2 for all known 64 populations (NPWS, 2013). Although there was a significant increase in colony numbers since the last reporting period, the

apparent reduction in area of occupancy of 15% does not reflect a significant loss in area, but rather accounts for the accurate measurements of previously unmonitored colonies and the use of the revised assigned areas for colonies, as mentioned above. The above figures relate to the overall *V. speciosa* population area based on monitored and unmonitored populations for the purpose of the National Conservation Status Assessment.

In this updated monitoring manual, the results from the RPMS relate to monitored colonies only and do not include any assigned areas of occupancy for either generation. Table 19 sets out results for area of occupancy and maximum area of both generations for the 27 populations monitored during the previous survey compared to results for the same 27 populations monitored as part of the RPMS. Also included in Table 19 is the comparison between the 40 populations monitored during the RPMS and the 27 populations monitored in the previous survey period. Results for the area of occupancy and maximum area for each of the 40 individual populations monitored in the RPMS can be seen in Table 17.

Table 19 Comparison of the 27 populations monitored in previous survey period with results from the same 27 populations monitored during the RPMS showing total number of colonies, living frond numbers, with areas of occupancy (AoO) (m^2) and maximum (Max) areas (m^2) for both generations (S: sporophyte; G: gametophyte). Also included are the overall results for all 40 monitored populations from the RPMS showing the overall increases recorded since the previous survey period.

COMPARISON BETWEEN THE PREVIOUS SURVEY AND THE RPMS FOR THE SAME 27 POPULATIONS

Year	No. Pops	No. of Colonies	No. of living fronds	AoO S	Max area S	AoO G	Max area G
2011	27	113	32,931	140	270	58	95
2018 (same 27 pops as were monitored in 2011)	27	152	45,863	167	379	41	215
Difference since last reporting period	0	39	12,932	27	109	-17	120
% difference	0%	35%	39%	19%	40%	-29%	126%

COMPARISON BETWEEN THE 40 POPULATIONS MONITORED DURING THE RPMS WITH THE 27 POPULATIONS PREVIOUSLY MONITORED

Year	No. Pops	No. of Colonies	No. of living fronds	AoO S	Max area S	AoO G	Max area G
2011 Total monitored	27	113	32,931	140	270	58	95
2018 Total monitored	40	198	47,581	177	400	49	280
Difference since last reporting period	13	85	14,650	37	130	-9	185
% difference	48%	75%	44%	26%	48%	-15%	195%

Although there was a significant increase in the number of populations monitored since the last reporting period (48%), the apparent reduction of 15% in area of occupancy of gametophytes from 58 m^2 in the previous survey to 49 m^2 in the RPMS does not reflect a significant loss in area, but rather accounts for the accurate measurements of previously unmonitored colonies.

The area of occupancy and maximum area figures derived for the previous survey period included assigned areas of 1 m^2 for colonies where there was no available information on colony size. During the

previous survey, one gametophyte colony at population TS02 was monitored, with the remaining historically recorded 14 gametophyte colonies being assigned an area of occupancy and maximum area of 1 m² per colony. Likewise, the 19 gametophyte colonies that were amalgamated into extant colonies (see Section 3.1.1) were also assigned an area of occupancy of 1 m² per colony. These assigned areas would have greatly inflated the overall area of occupancy of *V. speciosa* in Ireland for the 2012 report. These assigned figures were revised for the RMPS, as outlined above.

During the RPMS, significant losses in area of occupancy were recorded at two colonies within population TS26, Co. Waterford, and were attributed to substrate movement. Loss of 69% area of occupancy of sporophyte colony TS26.01.19 was likely due to a portion of the colony being reduced due to movement of branches of the invasive *P. laurocerasus* on the steep slope. Loss of 87% area of occupancy of colony TS26.01.14 was likely also due to bank slippage.

Although there was a loss in area of occupancy at a number of colonies of both generations since the 2007-2012 reporting cycle, this reduction was attributed to local issues, such as bank slippage, at a number of populations (TS26.01.04, TS26.01.14, TS26.01.19, Co. Waterford and TS22.01.02, Co. Cork). Although these are considered local issues, such drastic reduction in colony area of occupancy at any colony in any population is of future concern at these locations. Area of occupancy had been reported in error as the maximum area in 2012 for colonies at populations TS04, Co. Wicklow and TS28, Co. Kilkenny, with the more accurate area of occupancy being reported in the RPMS.

3.2 Assessment

3.2.1 *Population* assessment

Many populations are comprised of multiple colonies. For the *Population* assessment, if any single colony within a population fails for any indicator, then the whole population fails for that indicator. See Section 2.4.1 and 2.4.2 for the indicators and targets for assessing the *Population* parameter for the different generations.

Table 20 shows the *Population* assessment for each *V. speciosa* population, showing results for colony numbers, living frond numbers and area of occupancy (AoO) for the RPMS. As the indicator 'maximum gametophyte area' was not included as a parameter for the assessment of *Population* in the previous reporting cycle, it is not in the results on *Population* assessment below. For baseline surveys, the conservation status for *Population* will be Favourable as there is no comparison with the previous reporting period.

Table 20 *Population* assessment for each monitored population showing results for colony numbers, living frond numbers and area of occupancy (AoO) as per the 2012 report and the RPMS. The overall Conservation Status Assessment ("STATUS") for each population for 2018 is set out. The asterisks * and ** relate to results that appear to be unfavourable/favourable respectively and are explained in the section below the table). Gen. = generations; na = not assessed.

Pop. Code	County	Gen.	2012 Total Colonies	2018 Total Colonies	2012 Total living fronds	2018 Total living fronds	2012 Total AoO	2018 Total AoO	STATUS
TS01	Tipperary/Limerick	S&G&J	4	11	1,835	2,233	7.4	7.109	Favourable
TS02	Mayo	G	1	12	0	0	0.005	0.423	Favourable
TS03	Wicklow	G	1	1	0	0	0.003	0.003	Favourable
TS04	Wicklow	G	2	2	0	0	0.37	0.328	Favourable
TS05	Kerry	S	1	1	226	145	1.31	1.330	Favourable*
TS06	Kerry	S&G	1	4	21	62	0.13	0.543	Favourable
TS07	Carlow	S&G&J	2	2	38	51	1.96	1.926	Favourable
TS08	Cork	S&G	2	3	1,882	1,953	6.13	6.330	Favourable
TS09	Kerry	S&G	2	3	28	237	0.12	1.821	Favourable
TS10	Kerry	S&G	1	2	35	51	0.33	1.150	Favourable
TS11	Kerry	S&G	1	1	35	53	0.3	0.451	Favourable
TS12	Kerry	S&G&J	2	3	26	40	0.47	3.002	Favourable
TS14	Kerry	S&G&J	2	2	850	1,808	3.4	5.356	Favourable
TS15	Kerry	S&G&J	1	3	79	223	0.6	0.812	Favourable
TS16	Limerick	S&G	2	3	340	649	1.3	1.678	Favourable
TS17	Sligo	S&G	2	2	57	61	0.2	0.219	Favourable
TS18	Kerry	S&G	1	1	529	479	2.16	1.796	Favourable*
TS19	Kerry	S&G	1	2	26	36	0.03	0.103	Favourable
TS20	Limerick	S&G	5	7	121	230	2.85	2.781	Unfavourable**
TS21	Donegal	S&G	1	5	83	221	0.49	0.575	Favourable
TS22	Cork	S&G&J	7	7	1,754	2,493	7.9	10.635	Unfavourable**
TS23	Donegal	S&G&J	1	1	38	43	0.33	0.109	Favourable*
TS24	Kerry	S&G&J	4	22	67	668	5.6	10.906	Favourable
TS25	Cork	S&G	4	4	2,224	3,085	10.78	16.802	Favourable
TS26	Waterford	S&G&J	22	39	22,152	29,683	104	129.243	Unfavourable**
TS27	Waterford	S&G	2	2	57	61	0.41	0.223	Favourable
TS28	Kilkenny	G	2	7	0	0	4.38	1.959	Favourable*
TS29	Wexford	G	na	6	na	0	na	1.506	Favourable
TS30	Cork	S&G	na	4	na	247	na	0.929	Favourable
TS31	Kerry	G	na	6	na	0	na	0.170	Favourable
TS34	Galway	G	na	3	na	0	na	2.464	Favourable
TS35	Kerry	S&G&J	na	4	na	1	na	0.032	Favourable
TS37	Mayo	G	na	1	na	0	na	0.004	Favourable
TS50	Kerry	S&G	na	5	na	10	na	0.158	Favourable
TS51	Kerry	G	na	3	na	0	na	0.127	Favourable

Pop. Code	County	Gen.	2012 Total Colonies	2018 Total Colonies	2012 Total living fronds	2018 Total living fronds	2012 Total AoO	2018 Total AoO	STATUS
TS52	Kerry	S&G&J	na	7	na	2,431	na	12.866	Favourable
TS55	Kerry	S	na	2	na	160	na	0.248	Favourable
TS57	Tipperary	G	na	1	na	0	na	0.001	Favourable
TS60	Cork	S&G&J	na	3	na	3	na	0.065	Favourable
TS61	Kerry	S	na	1	na	162	na	0.350	Favourable

Below are explanatory notes for the Favourable status of populations where there was an apparent reduction in the indicators for living frond numbers and/or areas of occupancy since the last reporting period. These populations have been highlighted in Table 20 with a single asterisk. Populations with an Unfavourable status where there was an overall increase in frond numbers and/or area of occupancy for the overall population are highlighted in Table 20 with a double asterisk.

***Favourable**

For population TS05, Co. Kerry, there was a 36% decrease in living frond numbers. This reduction in frond numbers was not attributed to an obvious pressure, but to natural turnover of fertile fronds. Therefore, this population is assessed as Favourable.

For population TS18, Co. Kerry, the total area of occupancy of both sporophyte patches combined was 1.54 m^2, which is a 22% decrease since the last reporting period. This reduction is not attributable to any pressure. In the previous report there was no percentage estimated area of occupancy recorded for sporophytes in Patch 2 (exposed bank), therefore the calculations were based on 100% of the measured area. In 2017, a 60% estimated area of occupancy was assigned to the sporophytes in Patch 2. The lack of recording of area of occupancy of sporophytes in Patch 2 would explain the significant difference in area size between the two reporting periods as there has been little obvious change in the intervening period other than natural turnover of fronds at the overall colony. Therefore, this population is assessed as Favourable.

For population TS23, Co. Donegal, the estimated area of occupancy was not recorded in 2011, therefore the maximum area was input. However, this did not reflect how sparse the gametophytes were within the sporophyte colony, which is likely to be ≤ 1%. The other G patch within this colony which occurs on the roof of this boulder is dense and reflects the overall area of occupancy of the G generation at this colony. Access to this S&G colony requires crawling beneath a boulder, making measurement often difficult in such a confined space.

For gametophyte population TS28, Co. Kilkenny, the apparent reduction in gametophyte area of occupancy was due to two errors in inputting the data in 2011 as follows: 1) In 2011, the gametophyte colony TS28.01.01 was divided into two patches with a distance of 3 m between them. They should in fact have been recorded as two separate colonies. The original maximum area of this colony, comprising two patches, was 17.75 m^2 in 2011, with an area of occupancy of 23%. The maximum area of each patch was assigned 100% area of occupancy, thereby greatly inflating the true area of occupancy. 2) Patch 2 should have been a separate colony, as it was 3 m from Patch 1 on a separate rock face. The maximum area was incorrectly input in 2011 as 0.8 m^2 instead of 0.08 m^2. Therefore, this population is assessed as Favourable.

****Unfavourable**

For population TS20, Co. Limerick, one sporophyte colony became extinct since the last reporting period, (TS20.04.01) and although three gametophyte colonies were newly recorded, the loss of any colony within a population results in a fail for the whole population, in this case due to failing the targets for colony numbers and area of occupancy. Loss of this colony was attributed to removal of canopy cover provided by *R. ponticum.* This population contains multiple colonies of both generations and the remaining colonies are expected to continue to survive as the anthropogenic impact was specific to the location of the now-extinct colony only.

For population TS22, Co. Cork, one sporophyte colony became extinct since the last reporting period, (TS22.01.07) and although a new S&G colony was recorded, the loss of any colony within a population resulted in a fail for the whole population. Loss of this colony was attributed to trampling. As with population TS20 above, this population contains multiple colonies of both generations and the remaining colonies are expected to continue to survive as the impact was specific to the location of the now-extinct colony only.

For population TS26, Co. Waterford, a significant loss of frond numbers and areas of occupancy of two colonies containing sporophytes (TS26.01.14 and TS26.01.19) and a significant reduction in area of occupancy of gametophytes at colony TS26.01.04 resulted in an unfavourable conservation assessment for this population. Details of losses are reported in Section 3.1.3 (above) and Section 3.3 (Pressures, threats and other activities).

3.2.2 *Habitat for the species* assessment

For the *Habitat for the species* assessment, if any single colony within a population fails for any indicator, then the whole population fails for that indicator.

Habitat for the species assesses the area and quality of the habitat in which the species occurs, with regard to proximity to a water source, relative humidity, shade, canopy cover (in woodland locations) and the presence of invasive non-native or vigorous native species within close proximity of the sporophyte generation. Current values are compared with baseline target values to assess the conservation status of each population. See Section 2.4.3 and 2.4.4 for details of the targets set for the different generations and different habitats.

Table 21 shows results for canopy cover (Domin scale scores), shade (Shade Index value), and encroachment of non-native invasive species or vigorous native species (Domin scale scores). No population failed on humidity/soil moisture, therefore the results for this attribute are not included below. The results for indicators set out in Table 21 show the lowest score for any colony within a population for canopy cover and shade, with the highest score reported for encroachment of non-native invasive species or vigorous native species. This does not mean that all colonies in a population have that score.

In the previous reporting period, encroachment of non-native invasive species or vigorous native species was not an indicator for gametophyte populations or for populations with sporophytes or gametophytes in open uplands. For 2018, this indicator was recorded for open upland populations that contained any sporophyte colonies and is included in the results below only for the RPMS. This is discussed in Section 3.3 (Pressures, threats and other activities).

Table 21 *Habitat for the species* assessment for 2018 for each population showing results for canopy cover (Domin scale scores), shade (Shade Index values) and encroachment of vigorous native or invasive non-native species (*Encroach* Domin scale scores) in sporophyte colonies, with overall Conservation Status Assessment ("STATUS") for each population. The asterisks * and ** relate to results that appear to be unfavourable/favourable respectively and are explained in the section below the table. Gen. = generations; na = not assessed.

Pop. Code	County	Gen.	2012 Canopy Cover	2018 Canopy Cover	2012 Shade Index	2018 Shade Index	2012 Encroach. at S colonies	2018 Encroach. at S colonies	STATUS
TS01	Tipperary/ Limerick	S&G&J	6	4	2	2	0	4	Unfavourable**
TS02	Mayo	G	na	na	7	7	na	na	Favourable
TS03	Wicklow	G	na	na	7	7	na	na	Favourable
TS04	Wicklow	G	na	na	7	7	na	na	Favourable
TS05	Kerry	S	na	na	5	5	na	0	Favourable
TS06	Kerry	S&G	na	na	7	7	na	0	Favourable
TS07	Carlow	S&G&J	9	7	7	7	0	4	Favourable
TS08	Cork	S&G	9	7	4	3	0	3	Unfavourable**
TS09	Kerry	S&G	na	na	5	5	na	0	Favourable
TS10	Kerry	S&G	na	na	5	5	na	1	Favourable
TS11	Kerry	S&G	na	na	7	7	na	0	Favourable
TS12	Kerry	S&G&J	8	5	4	3	+	2	Unfavourable**
TS14	Kerry	S&G&J	8	5	4	4	0	4	Favourable*
TS15	Kerry	S&G&J	na	na	5	5	na	4	Favourable
TS16	Limerick	S&G	na	na	7	7	na	4	Favourable
TS17	Sligo	S&G	na	na	5	5	na	3	Favourable
TS18	Kerry	S&G	na	na	5	5	na	0	Favourable
TS19	Kerry	S&G	8	9	4	4	0	0	Favourable
TS20	Limerick	S&G	8	7	4	4	+	5	Unfavourable
TS21	Donegal	S&G	9	8	4	4	0	0	Favourable
TS22	Cork	S&G&J	8	9	4	6	2	4	Favourable
TS23	Donegal	S&G&J	na	na	7	7	na	na	Favourable
TS24	Kerry	S&G&J	8	9	4	6	0	4	Favourable
TS25	Cork	S&G	9	8	4	3	9	10	Unfavourable**
TS26	Waterford	S&G&J	8	9	6	6	0	7	Favourable
TS27	Waterford	S&G	8	8	4	7	0	0	Favourable
TS28	Kilkenny	G	na	na	6	6	na	na	Favourable
TS29	Wexford	G	na	na	na	6	na	na	Favourable
TS30	Cork	S&G	na	9	na	4	na	4	Favourable
TS31	Kerry	G	na	na	na	7	na	na	Favourable
TS34	Galway	G	na	na	na	7	na	na	Favourable
TS35	Kerry	S&G&J	na	9	na	7	na	0	Favourable
TS37	Mayo	G	na	na	na	7	na	na	Favourable

Pop. Code	County	Gen.	2012 Canopy Cover	2018 Canopy Cover	2012 Shade Index	2018 Shade Index	2012 Encroach. at S colonies	2018 Encroach. at S colonies	STATUS
TS50	Kerry	S&G	na	5	na	5	na	0	Favourable
TS51	Kerry	G	na	na	na	7	na	na	Favourable
TS52	Kerry	S&G&J	na	9	na	6	na	0	Favourable
TS55	Kerry	S	na	na	na	7	na	na	Favourable
TS57	Tipperary	G	na	na	na	7	na	na	Favourable
TS60	Cork	S&G&J	na	8	na	7	na	0	Favourable
TS61	Kerry	S	na	na	na	5	na	0	Favourable

Below are explanatory notes for the Favourable status of one population highlighted in Table 21 with a single asterisk, and for the Unfavourable-Inadequate status for populations highlighted with a double asterisk.

***Favourable**

For population TS14, although canopy cover was lower than the target of Domin ≥ 8 at colony TS14.02.01, the overhanging vegetation provided adequate cover for this colony. The other colony (TS14.01.01) in this population had adequate canopy cover.

****Unfavourable**

For population TS01, Co. Tipperary & Limerick, loss of canopy cover significantly affected S&G colony TS01.02.01. Although recovering, this colony failed on the target for indicators canopy cover and shade, and thus failed on these indicators for the whole population, resulting in an overall Unfavourable-Inadequate assessment.

For population TS08, Co. Cork, recent loss of canopy cover and bank slippage at this location affected only one colony (TS08.01.02) exposing a section of this large S colony (*c.* 5 m²) to direct sunlight. Although there is no evidence at present of any impact on the sporophytes, this colony failed on the target for indicators canopy cover and shade, and thus failed on these indicators for the whole population, resulting in an overall Unfavourable-Inadequate assessment.

For population TS12, Co. Kerry, loss of canopy cover and grey fungal attack at colony TS12.01.01, in addition to the presence of the non-native, invasive species *R. ponticum* throughout this population, and evidence of herbicide use in the vicinity of colony TS12.02.01, resulted in an Unfavourable-Inadequate assessment for this multiple-colony population.

For population TS25, Co. Cork, encroachment of the vigorous native species *R. fruticosus* agg. is impacting colonies TS25.01.01 and TS25.01.02. Although it is providing essential shading to colony TS25.01.01, it is now encroaching on the adjacent colony TS25.01.01. Encroachment by this species has engulfed colony TS25.01.02, making it extremely difficult to see how it is impacting the colony beneath. The vigorous growth of *R. fruticosus* in this location is highly likely due to loss of canopy cover; however, this was not a recent occurrence and would have been before the previous reporting period 2007-2012. This colony failed on the target for the indicators shade and encroachment of vigorous native or invasive non-native species, and thus failed on these indicators for the whole population, resulting in an overall Unfavourable-Inadequate assessment.

3.3 Pressures, threats and other activities

Pressures are activities impacting the species or habitat within the current reporting period and impacting on the long-term viability of the species or habitat. Threats are activities likely to impact the species or habitat within the next two reporting cycles and likely to affect the long-term viability of the species or habitat (DG Environment, 2017). Threats should reflect issues judged to be reasonably likely and not theoretical threats (DG Environment, 2017). Prior to evaluating the *Future prospects* parameter, the activities, both positive and negative, recorded in the RPMS were examined. Not all impacting activities are negative and there can be activities that may have a positive impact on a species.

V. speciosa is potentially threatened by a wide variety of activities outlined in Section 2.3.4. These activities can affect the populations directly (e.g. the loss of plants through land clearance for developments, or removal by collection of samples) or indirectly by alteration of habitat conditions (e.g. removal of woodland, alteration of watercourses, etc. leading to a reduction in relative humidity and subsequent desiccation of plants). The main threats are loss of habitat, exposure, encroachment of vigorous native species (such as *R. fruticosus* agg.) and invasive species (such as *R. ponticum* and *P. laurocerasus)* and clearance of invasive species. The non-native *Epilobium brunnescens* (New Zealand Willowherb) was recorded in the vicinity of six open upland populations (TS06, TS09, TS10, TS50, TS51 and TS55, all in Co. Kerry); however, the impact, if any, of this species on the population or habitat is unknown. This species is not currently being recorded as a threat to the species or habitat; however, if any impact from these species is observed in future monitoring, it should be recorded.

Shown in Table 22 is the list of pressures and threats observed during the RPMS showing the number of populations affected by the pressure, threat or impacting activity. Pressures are recorded as having a negative influence, with threats considered negative, or neutral, depending on the likely impact on the species and the habitat, which may differ. Other activities may be recorded as having a neutral or positive influence, if observed. Depending on the context, the same activity may have either a positive or negative effect or its effects may be unknown. These standardised activity categories are assessed based on a visual examination of colonies within a population ("within") and the surrounding habitat ("outside") as defined in Section 2.4.5. The intensity of the impacting activity (high, medium or low) is recorded as well as the area affected in m^2, if known. If the impact of any of these activities is unknown, then 'unknown' is input for the relevant activities. If the activity is a threat, then the area that could potentially be impacted is recorded, if known. This figure is typically the maximum area of the colony, but may be greater. If there is a pressure recorded, the actual area impacted is recorded, if known.

Eleven different impacting activities were recorded at 24 populations out of the 40 visited (as either pressures or threats), which are listed in Table 22 below. Of the eleven impacting activities recorded, more than one was recorded at nine of these populations: TS01, Co. Tipperary/Limerick (B02.06; G01; I01; L05); TS08, Co. Cork (B02.06; L05); TS12, Co. Kerry (A07; I01; J01.01); TS17, Co. Sligo (A04; I01); TS19, Co. Kerry (A04; G01); TS20, Co. Limerick (I01; I02); TS22, Co. Cork (G01; I01; L05); TS26, Co. Waterford (I01; L05); TS27, Co. Waterford (I01; L05), while for the remaining 15 populations only a single impacting activity was recorded.

Impacting activities were having a medium impact pressure on *V. speciosa* at seven populations: TS01, Co. Tipperary (B02.06); TS08, Co. Cork (L05); TS12, Co. Kerry (J01.01); TS20, Co. Limerick (I01); TS22, Co. Cork (L05); TS25, Co. Cork (I02); and TS26, Co. Waterford (L05). At three of these populations (TS22, Co. Cork; TS25, Co. Cork; TS26, Co. Waterford) a positive impact on the species due to essential canopy cover provided by invasive non-native species (I01) and problematic native species (I02) was also recorded. The remaining 17 populations had impacting activities that were considered to be of low intensity.

Bank slippage (L05) was reported at six populations, being considered a low impact activity at populations TS01, Co. Tipperary, TS14, Co. Kerry and TS27, Co. Waterford, and a medium impact pressure at populations TS08, Co. Cork, TS22, Co. Cork and TS26, Co. Waterford. Significant reduction

in area of occupancy of two colonies at population TS26, Co. Waterford, was likely caused by substrate movement (L05). Loss of 87% area of occupancy and 85% reduction in frond numbers of colony TS26.01.14 was likely due to bank slippage (L05). Loss of 69% area of occupancy and 67% reduction in frond numbers at sporophyte colonies TS26.01.19 was likely due to a portion of the colony being reduced due to movement of branches of the invasive *P. laurocerasus* on the steep slope (I01; L05). The effect of bank slippage in sections of this population (TS26, Co. Waterford) is a cause for concern. In some cases, the bank slippage appears to be due to natural causes (L05). In other cases, it is likely that the movement of *P. laurocerasus* is causing instability at sections of these steep banks at population TS26 (I01). As a whole, population TS26, Co. Waterford, has an Unfavourable-Inadequate *Population* assessment and *Future prospects* assessment for the activities that are both pressures and threats at different locations in this population. The *Habitat for the species* at this location (TS26), although currently favourable, is of future concern. Any potential future management to deal with invasive non-native species within this habitat should be carried out with the utmost sensitivity and with due regard for the *V. speciosa* population, in order to avoid severe negative impacts on colonies of the species arising from possible reduction in relative humidity, bank slippage and habitat disturbance.

Non-native invasive species (I02) were recorded at ten populations (TS01, Co. Tipperary; TS12, Co. Kerry; TS17, Co. Sligo, TS20; Co. Limerick; TS22, Co. Cork; TS24, Co. Kerry; TS26, Co. Waterford; TS27, Co. Waterford; TS37, Co. Mayo; TS60, Co. Cork) and vigorous native species recorded at one population, TS25, Co. Cork. Invasive non-native species were considered to be having a low impact at all listed colonies with the exception of population TS26, where a medium impact pressure was reported due to movement of *P. laurocerasus* which significantly reduced the area and frond numbers of a colony within this population, as detailed in the previous paragraph. Vigorous problematic native species (I04) was recorded as a medium impact pressure at TS25, Co. Cork. The impacts of these pressures (I02 and I04) are difficult to determine, as the species involved often provide essential canopy cover to colonies in these locations.

Reynoutria japonica (syn. *Fallopia japonica*) (Japanese Knotweed) was recorded at two populations in the vicinity of *V. speciosa* sporophyte colonies (within 6 m of colony TS27.01.01, Co. Waterford and upstream of colony TS26.01.03, Co. Waterford), but is not considered to be impacting the colonies. However, this invasive species should be eradicated from these locations to prevent further spread. In relation to population TS17, Co. Sligo, the non-native *Acaena ovalifolia* (Two-spined Acaena) was recorded in the vicinity of both colonies in this population; however, the impact, if any, of this species on the *V. speciosa* population is unknown. This species is reported as a medium impact species in a report on Ireland's invasive and non-native species (O'Flynn *et al*., 2014), therefore, the spread of *A. ovalifolia* should be monitored in this location.

Impacts from exposure due to thinning of tree layer (B02.06) were recorded as having a medium impact at a colony in population TS01, Co. Tipperary and a colony in population TS08, Co. Cork. A colony in population TS12, Co. Kerry (TS12.01.01) is in danger of being severely impacted by the effects of a grey fungal attack (K04.03).

The use of herbicides (A07) was recorded as a low impact threat at two populations: TS12, Co. Kerry and TS29, Co. Wexford. Illegal dumping (E03.01) was considered to be a low impacting activity at two populations: TS07, Co. Carlow and TS57, Co. Tipperary. Four populations were identified in areas that are used for recreational purposes (G01) – three that are very close to popular well-used paths (TS19, Co. Kerry; TS22, Co. Cork; TS60, Co. Cork) and one near a docking area for kayakers (TS01, Co. Tipperary). Flooding and rising precipitations (M01.03) leading to erosion was highlighted as a low impacting threat due to the greater frequency of extreme weather events at five populations: TS05; TS06; TS11; TS35; TS55, all in Co. Kerry.

Grazing (A04) is considered to be a threat to sporophyte populations that are accessible to grazing livestock; however, there was no evidence of any impact from this activity at any of the populations visited during the RPMS. Grazing does not pose as much of a threat to gametophyte colonies, which are not usually within the reach of grazing livestock. Herbivory by invertebrates of the gametophyte

generation, although not a current pressure, may pose a threat to this generation; however, observation of this activity has not been reported to date. If such an impacting activity is observed in the future, it should be recorded and included in the *Future prospects* assessment.

Although the threat of deliberate collection of the species is much reduced from levels prevailing heretofore during the "Victorian Fern Craze" (see Allen (1969) and Whittingham (2009)) there remains a low-level threat to some colonies from this activity. For this reason, the precise locations of colonies of the species are not made generally available.

Climate change has not been included as an impact, but it is likely to affect the species and its habitat in Ireland in decades to come if average temperatures continue to rise. While the trigger for the development of juvenile sporophytes from gametophytes is unclear it may, at least in part, be due to climatic factors, e.g. warmer temperatures, which would be considered a positive impact. On the other hand, the extremes in predicted weather from warm wet winters to periodic droughts in summer could negatively impact *V. speciosa* colonies, particularly the sporophyte generation, which is more sensitive to desiccation.

There were no high impacting pressures/threats identified at any of the individual populations monitored. Any low to medium impacting pressures recorded during surveys were generally considered a local issue.

Table 22 List of impacting activities recorded at 40 *Vandenboschia speciosa* populations monitored during the RPMS, indicating whether a pressure or threat, whether the activity is within the population or outside in the surrounding habitat, and the influence and intensity of, and area (m²) affected by the activity. Numbers refer to the number of populations impacted. Pos = positive; Neg = negative; Neut = neutral; H = high; M = medium; L = low; Unk = unknown; na = not applicable.

						Influence on species			Influence on habitat			Intensity (species)			Intensity (habitat)			Affected area (if known)	
Impact code	Description of impacting activity	Pressure	Threat	Location within	Location outside	Pos	Neg	Neut	Pos	Neg	Neut	H	M	L	H	M	L	Species	Habitat
A04	Grazing		3	3	3		3				3			3			3	0.70	Unk
A07	Use of biocides, hormones and chemicals (herbicides)		2		2		2			2				2			2	Unk	Unk
B02.06	Thinning of tree layer	2		2			2				2		2				2	> 300	Unk
E03.01	Illegal dumping		2		2			2		2				2			2	na	Upper slopes
G01	Outdoor sports & Leisure activities, recreational		3	3			3				3			3			3	0.17	Unk
I01	Invasive non-native species	2	8	10	10	9	2	1		10			2	8		2	8	Unk	Unk
I02	Problematic native species	1	1	1	1	1		1			2		1	1		1	1	50	Unk
J01.01	Fire (burning down)		1	1	1		1				1			1			1	Unk	Unk
K04.03	Introduction of disease (microbial pathogens) [grey fungal attack]	1		1			1						1					0.15	na
L05	Collapse of terrain/ landslide	3	3	6			4	2		6			3	3		1	5	Unk	Unk
M01.03	Flooding and rising precipitation		5	5			5				5			5			5	Unk	Unk

3.4 *Future prospects* assessment

3.4.1 Site level assessment of *Future prospects*

Appendix 4 shows the *Future prospects* assessments of 40 *V. speciosa* populations surveyed during the RPMS. The effects of negative and positive impacting activities were weighed up against each other in the context of each site's *Population* assessment and *Habitat for the species* assessment. *Future prospects* were assessed over the next 12 years (two reporting periods).

In the previous reporting period, five populations had an Unfavourable-Inadequate Overall Conservation Assessment based on an Unfavourable-Inadequate *Future prospects* assessment at each of them (TS19, Co. Kerry; TS20, Co. Limerick; TS22, Co. Cork; TS25, Co. Cork; and TS26, Co. Waterford), with an Unfavourable-Inadequate *Habitat for the species* assessment for one population (TS25, Co. Cork). In the RPMS, seven populations had an Unfavourable-Inadequate Overall Conservation Assessment (Appendix 4), which included four of the populations previously assessed as Unfavourable-Inadequate. One population, TS19, Co. Kerry, is no longer considered to be in an Unfavourable conservation status as the population passed all targets and there were no obvious pressures recorded. Three additional populations had an overall Unfavourable-Inadequate conservation status. The reasons for the increase in the number of populations with an overall Unfavourable-Inadequate conservation status are detailed below:

- Two sporophyte colonies have become extinct within their populations since the last reporting period, (TS20.04.01, Co. Limerick and TS22.01.07, Co. Cork);
- As detailed in the Section 3.3, impacting activities were having a negative impact on *V. speciosa* at seven populations (TS01, Co. Tipperary; TS08, Co. Cork; TS12, Co. Kerry; TS20, Co. Limerick; TS22, Co. Cork; TS25, Co. Cork; and TS26, Co. Waterford). At three of these populations (TS22, TS25 and TS26) a positive impact on *V. speciosa* sporophytes due to essential canopy cover provided by invasive non-native/vigorous native species was also recorded. However, if one colony within a population has an Unfavourable-Inadequate conservation status, then this followed for the whole population. Therefore, seven populations had an Unfavourable-Inadequate conservation assessment for *Future prospects*, with the remaining 33 populations having a Favourable conservation assessment for *Future prospects*.

The presence of invasive non-native species in particular is a difficult impacting activity to quantify or to manage for, where populations of *V. speciosa* occur. The presence of such species provides shelter and canopy cover, and helps maintain sufficient relative humidity at locations where *V. speciosa* colonies occur. Therefore, the removal of such species in the immediate vicinity of *V. speciosa* colonies is not advised, as such a drastic measure may pose a greater threat to the *V. speciosa* colonies than would leaving the invasive species *in situ*. However, the control of their spread in locations where *V. speciosa* colonies occur is a conservation measure that would be expected to have a positive outcome for the future of these habitats. Any control plan implemented must be undertaken sensitively and with the requirements of *V. speciosa* in mind. The possible future effects from this threat is based on expert opinion and from surveys carried out where these invasive species occur. Appendix 4 shows the *Future prospects* assessments for the 40 *V. speciosa* populations monitored during the RPMS, with notes provided on the rationale for each.

3.4.2 National assessment of *Future prospects*

Following EU guidance (DG Environment, 2017), the following national assessment was made for the *Population* and *Habitat for the species* of *V. speciosa* (species code 6985).

Population

- Short-term (i.e., over the next 12 years) future trend for the populations is assessed as Stable. The current number of colonies and maximum area approximately equate to a Favourable population size. Loss of two colonies since the last reporting period was related to anthropogenic factors that were specific to the individual colony within each multiple colony population
- The current conservation status of the *Population* has been assessed as Favourable
- Future trend for *Population* is assessed as Favourable
- *Future prospects* for *Population* are therefore Favourable

Habitat for the species

- Short-term trend direction for *Habitat for the species* is Stable
- The current conservation status for *Habitat for the species* is Stable
- Future trend of *Habitat for the species* is assessed as Stable. However, the impact of the presence of invasive non-native species at a number of populations should be assessed in future surveys as, although they currently provide essential canopy cover and shade to *V. speciosa* sporophyte colonies, their presence in these locations could negatively impact the habitat, which in turn could impact on the *V. speciosa* colonies. This is currently not regarded as a national threat to *V. speciosa* populations or its habitats
- *Future prospects* of *Habitat for the species* are therefore Favourable

Although the overall *Future prospects* on a national level for both *Population* and *Habitat for the species* are Favourable, there was an overall Unfavourable-Inadequate assessment at seven populations that were considered local issues rather than on a national level (Appendix 4 and Table 23). Recommendations are given at the end of the report for a number of measures that, if implemented, could improve the *Future prospects* at these seven populations.

3.5 Overall conservation assessment

3.5.1 Overall conservation assessment at the site level

The assessments of the individual parameters at each site were combined according to the evaluation matrices in Table 2 and Table 13 to obtain the overall conservation assessment for each of the forty monitored *V. speciosa* populations. This resulted in 33 populations receiving a Favourable assessment across the three parameters and seven an Unfavourable-Inadequate assessment (Table 23). It should be noted that for the populations that received an Unfavourable-Inadequate assessment, this was, in most cases, the result of an impacting activity on a single colony within a population. Although seven populations had an overall Unfavourable-Inadequate assessment, these are considered to be local issues and are not currently regarded as a threat at the national level. Table 23 shows the results of the overall conservation assessment when all three parameters were assessed for the *V. speciosa* population survey.

Table 23 Results of the overall conservation assessment when all three parameters were assessed for the 40 *Vandenboschia speciosa* populations monitored in the RPMS. F = Favourable; U-I = Unfavourable-Inadequate. None were assessed as Unfavourable-Bad. Gen. = generations.

Pop. Code	County	Gen.	Population	Habitat for the species	Future Prospects	Overall Status
TS01	Tipperary/ Limerick	S&G&J	F	U-I	U-I	U-I
TS02	Mayo	G	F	F	F	F
TS03	Wicklow	G	F	F	F	F
TS04	Wicklow	G	F	F	F	F
TS05	Kerry	S	F	F	F	F
TS06	Kerry	S&G	F	F	F	F
TS07	Carlow	S&G&J	F	F	F	F
TS08	Cork	S&G	F	U-I	U-I	U-I
TS09	Kerry	S&G	F	F	F	F
TS10	Kerry	S&G	F	F	F	F
TS11	Kerry	S&G	F	F	F	F
TS12	Kerry	S&G&J	F	U-I	U-I	U-I
TS14	Kerry	S&G&J	F	F	F	F
TS15	Kerry	S&G&J	F	F	F	F
TS16	Limerick	S&G	F	F	F	F
TS17	Sligo	S&G	F	F	F	F
TS18	Kerry	S&G	F	F	F	F
TS19	Kerry	S&G	F	F	F	F
TS20	Limerick	S&G	U-I	U-I	U-I	U-I
TS21	Donegal	S&G	F	F	F	F
TS22	Cork	S&G&J	U-I	F	U-I	U-I
TS23	Donegal	S&G&J	F	F	F	F
TS24	Kerry	S&G&J	F	F	F	F
TS25	Cork	S&G	F	U-I	U-I	U-I
TS26	Waterford	S&G&J	U-I	F	U-I	U-I
TS27	Waterford	S&G	F	F	F	F
TS28	Kilkenny	G	F	F	F	F
TS29	Wexford	G	F	F	F	F
TS30	Cork	S&G	F	F	F	F
TS31	Kerry	G	F	F	F	F
TS34	Galway	G	F	F	F	F
TS35	Kerry	S&G&J	F	F	F	F
TS37	Mayo	G	F	F	F	F
TS50	Kerry	S&G	F	F	F	F
TS51	Kerry	G	F	F	F	F
TS52	Kerry	S&G&J	F	F	F	F
TS55	Kerry	S	F	F	F	F
TS57	Tipperary	G	F	F	F	F
TS60	Cork	S&G&J	F	F	F	F
TS61	Kerry	S	F	F	F	F

3.5.2 Overall National Conservation Status assessment

The assessments of the individual parameters were combined according to the evaluation matrices in Table 2 and Table 13 to obtain the overall National Conservation Status Assessment for *V. speciosa* populations.

Following the guidelines for *Population* assessment at a national level (DG Environment, 2017), based on the results presented here and taking into account localised issues at seven populations and conservation measures in place for the species, the overall National Conservation Status Assessment result for *V. speciosa* populations is Favourable and the trend is stable. The following data detailed in this report were used to arrive at this result:

- Loss of two colonies was due to factors not expected to impact other colonies within these multiple-colony populations;
- Significant loss of colony area and frond numbers due to loss of canopy cover or bank slippage show signs of recovery with visible new sporophyte fronds emerging from the colonies (TS01.02.01, Co. Tipperary and TS26.01.14, Co. Waterford). Canopy cover is expected to recover. Bank slippage, although a concern at two populations (TS22, Co. Cork and TS26, Co. Waterford), is not regarded as a national issue;
- The presence of invasive non-native species is a difficult impacting activity to quantify or to manage for populations where *V. speciosa* occurs as, although they may negatively impact the habitat, they have a positive impact on the sporophyte colonies due to the shade and canopy cover that they provide. Impacts from non-native invasive species at certain locations are considered likely to impact the quality of the habitat in the future; however, no evidence of negative impacts on the species or habitat since the last reporting period have been identified.

Table 24 summarises the result of the National Conservation Status Assessment (NPWS, 2019) for the Irish populations of *V. speciosa*.

Table 24 Summary of the National Conservation Status assessment of *Vandenboschia speciosa* populations, based on the results of the RPMS and NPWS (2019).

Parameter	Conservation status	Trend	*Future prospects*
Range	Favourable	Stable	Good
Population	Favourable	Stable	Good
Habitat for the species	Favourable	Stable	Good
Overall National Conservation Status Assessment	**Favourable**	Stable	

3.6 *V. speciosa* populations inside and outside of the SAC network

V. speciosa is listed on Annex II and IV of the EU Habitats Directive. For species listed in Annex II of this Directive, member states are required to designate Special Areas of Conservation (SACs).

Populations of *V. speciosa* that are listed as qualifying features in SACs are protected under the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011) which regulates any plans or projects that may negatively impact on the species. Protection is afforded to qualifying features of SACs and consent is required to undertake certain activities that may negatively impact them. Damaging activities that may impact the conservation status of *V. speciosa* populations are regulated under the European Communities (Environmental Liability) Regulations 2008 (S.I. No. 547 of 2008). In addition, protection is afforded by the Flora (Protection) Order, 2015 (S.I. No. 356 of 2015).

With regard to the 40 *V. speciosa* populations monitored during the RPMS, 33 of these occurred within 19 SACs, in 16 of which the species is listed as a qualifying interest; these 16 SACs include 30 *V. speciosa* populations, comprising 153 monitored colonies.

Of the seven populations outside an SAC, two contain both generations: TS30, Co. Cork, which was only recently discovered (in 2012), and TS52, Co. Kerry, which is included within a proposed Natural Heritage Area (pNHA). All of the remaining five populations located outside an SAC are gametophytes-only and three of them are included within a pNHA.

Table 25 lists the populations surveyed for the RPMS, together with their status in relation to the SAC network. Not all of these SACs list *V. speciosa* as a qualifying interest.

Table 25 *Vandenboschia speciosa* populations surveyed in the RPMS in relation to the SAC network. QI=qualifying interest.

Pop. code	County	Generation at Population	SAC code	QI
TS01	Co. Tipperary/Limerick	S&G&J	930	Yes
TS02	Co. Mayo	G	2298	No
TS03	Co. Wicklow	G	0 [pNHA 1767]	No
TS04	Co. Wicklow	G	0 [pNHA 718]	No
TS05	Co. Kerry	S	375	Yes
TS06	Co. Kerry	S&G	375	Yes
TS07	Co. Carlow	S&G	2162	Yes
TS08	Co. Cork	S&G	1043	Yes
TS09	Co. Kerry	S&G	365	Yes
TS10	Co. Kerry	S&G	365	Yes
TS11	Co. Kerry	S&G	365	Yes
TS12	Co. Kerry	S&G	365	Yes
TS14	Co. Kerry	S&G	2185	Yes
TS15	Co. Kerry	S&G	375	Yes
TS16	Co. Limerick	S&G	2037	Yes
TS17	Co. Sligo	S&G	1669	Yes
TS18	Co. Kerry	S&G	375	Yes
TS19	Co. Kerry	S&G	365	Yes
TS20	Co. Limerick	S&G	1432	Yes
TS21	Co. Donegal	S&G	163	Yes
TS22	Co. Cork	S&G	1070	Yes
TS23	Co. Donegal	S&G	2047	Yes
TS24	Co. Kerry	S&G	365	Yes
TS25	Co. Cork	S&G	1547	Yes
TS26	Co. Waterford	S&G	2324	Yes
TS27	Co. Waterford	S&G	2170	Yes
TS28	Co. Kilkenny	G	2162	Yes
TS29	Co. Wexford	G	0	No
TS30	Co. Cork	S&G	0	No
TS31	Co. Kerry	G	365	Yes
TS34	Co. Galway	G	330	No
TS35	Co. Kerry	S&G	1342	Yes
TS37	Co. Mayo	G	0	No
TS50	Co. Kerry	S&G	365	Yes
TS51	Co. Kerry	G	365	Yes
TS52	Co. Kerry	S&G	0 [pNHA 1352]	No
TS55	Co. Kerry	S&G	365	Yes
TS57	Co. Tipperary	G	0 [pNHA 1133]	No
TS60	Co. Cork	S&G	90	No
TS61	Co. Kerry	S&G	365	Yes

4 Discussion

4.1 Conservation assessment of *V. speciosa* populations

4.1.1 Overall National Conservation Status of *V. speciosa*

Based on the results of this survey, the overall National Conservation Status of *V. speciosa* is assessed as Favourable. Although two colonies were lost since the last reporting period, the remaining colonies within these multiple-colony populations are not under threat. Impacts leading to the losses were considered a local issue, and not a threat on a national level. As there was no other evidence of decline in colony numbers since the Directive came into force, the conservation status remains Favourable.

There has been no change in the overall conservation status and conservation trend since the last reporting period. There has been an increase in population size and in range size, but these are due to improved knowledge and targeted surveys, revealing a fuller picture of the population size and distribution of the species, rather than actual increases in these.

4.1.2 *Population*

The current known population of the species in the Republic of Ireland numbers 86 populations, comprising 290 colonies in 120 sub-populations. During the RPMS, 40 *V. speciosa* populations, comprising 198 colonies, were surveyed.

Since the last reporting period (2007-2012), 24 additional populations have been recorded, comprising 37 newly-recorded colonies. The majority (16) of the 24 new populations recorded since the previous survey are gametophytes-only (67%). One of the new populations comprises gametophytes with juvenile sporophytes that may be recently emerged (TS71, Co. Kerry), while the remaining seven newly-recorded populations are of sporophytes-only. The gametophyte generation has been observed more frequently in recent times as botanists and ecologists are becoming more aware of this cryptic generation and its identification.

Of these 24 additional populations, 15 occur within new 10 km x 10 km Irish National Grid squares, thus increasing the range of the species from 7,000 km² in 2012 to 10,100 km² in 2018. These 15 populations in the new range comprise 20 colonies, of which 14 are gametophytes-only and six are sporophytes-only. One new record for gametophytes at population TS56, Co. Wicklow, is in a location where the sporophyte was historically recorded but considered to be extinct.

Of the 40 populations monitored during the current reporting period, 38% are S&G, with 30% S&G&J, 7% S populations and 25% G populations.

Sporophyte colonies lost since the last reporting period at populations TS20, Co. Limerick and TS22, Co. Cork, both occurred in populations with multiple colonies of both generations, as outlined in Section 4.1.1. As there is no other evidence of a decline in population size since the Directive came into force, population is assessed as Favourable.

Since the last reporting period there has been an increase in recording of *V. speciosa* juvenile sporophytes emerging from gametophytes, which may be the result of sexual reproduction or apogamy. During the RPMS, juvenile sporophytes were recorded at 30% of the 40 monitored populations. This is a 140% increase in the number of populations where juvenile sporophytes have been recorded since the last reporting period. The recording of additional juvenile sporophytes is, in part, the result of targeted surveying, improved knowledge and more accurate data.

Fertile colonies were recorded at 37% of the populations monitored, which was lower than the figure of 57% for the populations monitored during the previous reporting period (Ní Dhúill, 2014). The lower percentage of fertility is not, however, considered problematic and most likely reflects natural fertile frond turnover. Populations that supported fertile sporophytes and juvenile sporophytes emerging from gametophytes were considered to be good indicators of colony health as these provided an indication that historic or recent sexual reproduction may have occurred.

4.1.3 *Habitat for the species*

Impacts from non-native invasive species at certain locations are considered likely to impact the quality of the habitat in the future; however, no evidence of negative impacts on the species or habitat since the last reporting period have been identified, with the exception of the impact on one colony (TS26.01.19), which was attributed to bank slippage due, most likely, to movement of the invasive *P. laurocerasus* down the bank. This resulted in a significant reduction in area of occupancy and frond numbers at that colony. This was the only colony within this multiple-colony population considered to be negatively impacted by *P. laurocerasus*.

The habitat of *V. speciosa* is largely in good condition, and most suitable areas identified at known populations still support *V. speciosa*. Habitat was assessed as Favourable.

Most populations are within the SAC network (33 of the 40 monitored populations and overall 59 of the 86 known populations) and the Flora (Protection) Order, 2015 protects all populations. There is no reason to believe that any significant threats will present themselves in the future.

4.1.4 Impacts/Activities and *Future prospects*

There were no high impacting pressures or threats identified at any of the 40 individual populations monitored during the RPMS. As detailed in Section 3.3, impacting activities were recorded at 24 populations out of the 40 visited, with 11 different impacting activities recorded at these locations. Of these 24 populations, impacts were having a medium intensity impact at seven populations, with the remaining impacts considered to be low intensity (see Table 22 for details). At two of these populations (TS22, Co. Cork and TS26, Co. Waterford) invasive non-native species were considered to be having a positive impact on *V. speciosa* colonies by providing essential canopy cover and shade.

The presence of exotic invasive species poses a threat at some sites where populations and colonies exist (TS01, Co. Tipperary; TS12, Co. Kerry; TS17, Co. Sligo; TS20, Co. Limerick; TS22, Co. Cork; TS24, Co. Kerry; TS26, Co. Waterford; TS27, Co. Waterford; TS37, Co. Mayo and TS60, Co. Cork); however, this is considered to be a localised issue at present. The impact of invasive non-native species is difficult to assess at locations where they occur, as they can have a positive impact on *V. speciosa* sporophytes, but a negative impact on the habitat, as discussed in Section 3.6.2.

A number of threats are being addressed through national legislation. Some of the rarest and most threatened plants in Ireland, including *V. speciosa*, are protected under the Flora (Protection) Order, 2015 (S.I. No. 356/2015). It is an offence to cut, uproot or damage plants listed under this Order. The Habitats Directive (which specifically protects *V. speciosa* in Annex IIb) was transposed into Irish law in the European Communities (Natural Habitats) Regulations (S.I. 94 of 1997).

Considering the impacts, pressures and threats to *V. speciosa* in Ireland today and the measures in place to assist its protection, there is no reason to expect that this species will not continue to survive and thrive. The overall Conservation Status for *V. speciosa* is Favourable and the overall Conservation Trend is Favourable.

4.2 Challenges during the survey

A small number of challenges were presented by this survey. One issue was the definition of a colony which had previously been the same for both generations, as outlined in Section 1.6.1.1. A colony was defined as a discrete, i.e. unconnected, "patch" or "plant" (Ratcliffe *et al*., 1993; Rumsey, 1997). However, it became apparent during this current survey that this definition would need to be revised for the gametophyte generation as, more often than not, gametophyte patches are not discrete. The most suitable definition for a gametophyte colony was considered to be the niche in which the gametophytes occur, i.e. a particular boulder or crevice, or cave, or section of cliff wall. These may contain numerous patches of gametophytes.

Following on from this challenge was that of calculating or estimating the area of occupancy of the gametophyte generation. This is straightforward for the sporophyte generation as it typically occurs in discrete patches that can usually be measured and an area of occupancy assigned. However, this is not the case for the gametophyte generation which rarely occurs as a discrete patch (see Section 1.6.1.3 on reviewing methodologies for the *Population* assessment, which explains fully the challenges of monitoring the gametophyte generation). This makes estimating an area of occupancy quite challenging. Comparisons of estimated areas of occupancy for the gametophyte generation can be difficult as such estimates can be very subjective. Differences in area of occupancy for the gametophyte generation between monitoring periods could falsely indicate a decline in area of occupancy of a colony. Therefore, expert opinion should be used when determining whether a gametophyte colony passes or fails on the target for area of occupancy. The maximum area would not be expected to be reduced unless there was some pressure impacting on it, e.g. a landside, bank slippage or other such event.

In the larger populations where sporophytes and gametophytes co-occur (TS20, Co. Limerick; TS22, Co. Cork; TS24, Co. Kerry and TS26, Co. Waterford,) gametophytes are often more widespread within populations than the sporophytes and often occur in deep crevices that are difficult to access. These populations occurred in ravines that provide an ideal continuous habitat for *V. speciosa*. For these larger populations, it was not possible to measure every single gametophyte colony and, as such, gametophytes in the immediate vicinity of a sporophyte colony were measured; however, it is highly likely that these gametophyte colonies extended much further beneath bryophyte mats and along deep crevices. The ravines were searched for gametophytes at the edges of the area of suitable habitat to get the extent of this generation in the population. It is highly likely that the gametophyte area of occupancy at these populations is under-estimated. This is also likely to be the case on a national level as this generation is more widespread than the sporophyte generation.

Reporting on sporophyte colony areas and frond numbers was difficult for inaccessible colonies. To overcome this challenge, estimates for area were made on a visual inspection, which can be difficult when a colony is high up on a gorge and parts of it are obscured by vegetation. Frond numbers were based on estimates from a colony of similar density and, for this reason, these estimates are very subjective.

A Rope-access Specialist was required to gain access to one sporophyte population (TS05, Co. Kerry) that occurred on the side of a waterfall. At another colony within population TS09, Co. Kerry, rope access was required; however, this was not known until the colony was located. In this case, the colony was monitored visually from the side of the waterfall where it occurred.

Adverse weather conditions prevented a complete search for *V. speciosa* at population TS47, Co. Kerry, which is reported to be located in the vicinity of a large waterfall. Adverse weather conditions also prevented access to two colonies at TS15, Co. Kerry. This was due to extremely high water levels making access unsafe. Three other colonies within population TS15 were, however, successfully monitored.

5 Recommendations

5.1 Management of invasive non-native species and vigorous native species

The presence of invasive non-native species is a difficult impacting activity to quantify or to manage for, where populations of *V. speciosa* occur. As outlined in Section 3.4.1, such invasive species may have a positive impact, such as providing important shelter and canopy cover. Removal of such species in the immediate vicinity of *V. speciosa* colonies is not advised, as such a drastic measure may pose a greater threat to the *V. speciosa* colonies than would leaving the invasive species *in situ*. As stated in Section 3.4.1., control of invasive species is a conservation measure that would be expected to have a positive outcome for the future of these habitats. Any control plan implemented must be undertaken sensitively and with the requirements of *V. speciosa* in mind.

Conservation measure CI03 (management, control or eradication of other invasive alien species) is recommended with the aim of implementing a programme to control the spread of invasive species in locations where *V. speciosa* sporophyte colonies occur. The presence of invasive non-native species at ten *V. speciosa* populations is a cause for concern for the habitat where these colonies occur.

5.2 Monitoring juvenile sporophytes emerging from gametophytes

The reported rare occurrence of sporophytic recruitment in conjunction with the persistence of both generations of *V. speciosa*, often occurring independently, has led to the conclusion that there has been a breakdown in the link in the life cycle between the sporophyte and gametophyte generations of *V. speciosa* (Sheffield, 1994).

However, as mentioned in Section 4.1.2, there has been an increase in recording of *V. speciosa* juvenile sporophytes emerging from gametophytes since the last reporting period, which may be the result of sexual reproduction or apogamy. It may be that environmental factors, perhaps linked to climate change, are triggering the growth of juvenile sporophytes at these populations. Climatic control of juvenile sporophyte production and survival has been suggested (Rumsey & Sheffield, 1996) and it was further noted that climate change, which may result in warmer, wetter climates, may provide more favourable conditions for *V. speciosa* to complete its life-cycle (Krukowski & Świerkosz, 2004). This is very positive in terms of population growth, as the establishment of emerging sporophyte colonies suggest that the life-cycle is being completed via sexual reproduction, albeit on a limited basis. The completion of the life-cycle of *V. speciosa* is important in terms of genetic diversity of this species, with the additional ability of both generations to perpetuate vegetatively being important for continued survival at its current locations.

There is very little known in terms of survival rates of these juveniles or how long they take to develop to maturity and under what conditions. Monitoring of juvenile sporophytes is essential for helping to understand this part of the life-cycle of *V. speciosa*.

Although not all juvenile sporophytes would be expected to survive to reach maturity, the successful establishment and continued growth of any of these juvenile sporophytes will be a positive outcome. Monitoring of juvenile sporophyte could be carried out as part of the six-yearly reporting cycle for this species.

5.3 Refinements to *Habitat for the species* assessment methodology

It is recommended that the presence of invasive non-native species, such as *R. ponticum, P. laurocerasus*, *R. japonica* and *A. ovalifolia (*and perhaps *E. brunnescens*), within a population, in the vicinity of any sporophyte colonies or providing shade to any colonies, be used as an indicator for the *Habitat for the species* parameter rather than simply those invasives that occur within one metre of a sporophyte colony, as two of the major problematic invasive species (*R. ponticum* and *P. laurocerasus*) would not occur within a *V. speciosa* sporophyte colony. The positive impacts would be balanced against any negative impacts arising from the presence of these species in locations where they occur with the sporophyte generation. The target would be "*no obvious impact on the colony*". If the invasive species is providing essential canopy cover, then this would result in a pass for that indicator. However, if a negative impact is observed, such as bank slippage in the vicinity of the sporophyte colony, this would result in a fail for this indicator. This refinement is recommended for populations that contain sporophytes in either woodland or open upland habitats. This will aid in the assessment and understanding of the impact that invasive species have on *V. speciosa* colonies.

For gametophytes-only populations, the indicators for assessing *Habitat for the species* were shade (Shade Index) and relative humidity using a thermohygrometer. It is proposed to use only the indicator '*substrate moisture*' rather than '*humidity/substrate moisture*' as, although the recording of relative humidity is useful, the locations where gametophytes-only colonies occur typically have moist substrate. This generation is known to occur in less humid conditions than the sporophyte generation; however, relative humidity was always > 80% and typically > 90% for both generations. This amendment will streamline surveys and reduce the amount of equipment required.

For the *Population* assessment (Table 6), it is recommended that the sporophyte and gametophyte areas be reported separately for the next reporting period rather than as a combined figure as is currently the case. This will make comparisons between generations and between years clearer and make it easier to highlight changes that may be affecting one generation and not the other.

5.4 Other recommendations

5.4.1 Timing of surveys

Previously it was recommended that monitoring of both generations of *V. speciosa* be carried out between June and October (Ní Dhúill *et al*., 2015). The rationale for this was that encroachment of non-native species or vigorous native species would be more likely to be observed during the growing season. It was also considered that, as this is the period that spores are reported to mature (Page, 1997), monitoring during this time would increase the likelihood of observing mature fertile fronds.

For woodland populations where sporophytes occur, it was considered that this timing allowed for observation of changes in canopy cover and encroachment by the vigorous native species *R. fruticosus* agg., or by any invasive non-native species that may negatively impact a colony/population. However, species such as *R. fruticosus* agg., *P. laurocerasus* and *R. ponticum* would be present at any time of the year.

Revised recommendation: for the gametophyte generation, it is recommended that monitoring could be carried out at any time of the year, depending on weather conditions. The timing for surveys of *V. speciosa* populations that support sporophytes could be extended from March to November, when canopy cover would still be intact. Monitoring populations earlier in the year makes access easier, especially in open upland habitats where *Pteridium aquilinum* (Bracken) and *Molinia caerulea* (Purple Moor-grass) form dense swathes across the mountain slopes, often covering boulders and holes. Visibility of the terrain will make access safer and quicker in such locations. In terms of observing fertile

fronds, a monitoring period from March to November is also suitable, as these fronds are long-lived and would be expected to be observed at any time of the year. The shorter day-length for surveys should be kept in mind if surveying later in the year.

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Appendix 1 – Site survey card

Vandenboschia speciosa Site Survey Card (population may include 1 or more colonies)

Site Code:	Discovery Map:
Population Name:	Aerial Photo no. /year:
County:	Vice-county:
Land tenure: (SAC, NHA, private, unknown)	SAC No:
Habitat type:	Population generation:
Grid reference: (may be more GPS readings depending on colony numbers)	Type of survey:

Surveyed by:	Date surveyed:	Time spent on site:
Fossitt Hab.:	Annex I Hab.:	Seasonal flooding:

No. colonies:	Weather conditions:
Approx. extent of habitat (m^2):	Extent of population (m^2):
Photos taken:	

Site description or changes since baseline:

Impact code/description e.g. A09. Intensive grazing or overgrazing by livestock. [Was A04.01. Intensive grazing]	Location Inside/outside area of occupancy	Influence (+/-/0)	Intensity (H/M/L)	% Area affected

Other remarks, including comments on condition/management:

SITE SKETCH (if necessary)

Indicate North

Appendix 2 – Monitoring sheet

Vandenboschia speciosa Monitoring Sheet (one per colony)

Surveyor(s):	Date:

Population code	Population name/number	Colony name/number	Generation

SECTION A – Monitoring of sporophyte direct attributes	
Sporophyte present (Y/N):	Grid reference (if possible):
Colony Area (m²): (Measured as a rectangle, one measurement across the maximum dimension of the colony and another perpendicular to this)	Area of occupancy (%): (Extent of the area of the colony within the rectangle occupied by *V. speciosa*).

Count or Estimate		Count	Estimates		
			Patch No. (25 x 25 cm)	Patch No. (25 x 25 cm)	Patch No. (25 x 25 cm)
Frond Numbers	Mature sterile fronds (> 50% green, fully expanded)				
	Fertile fronds (> 50% green, fully expanded)				
	Young expanding fronds (still unfurling, not fully expanded)				
	[1]Young fronds (previously juvenile from gametophytes). If not clear, then tick "Young expanding")				
	Juvenile fronds (emerging from gametophytes, typically a simple frond)				
	Croziers (beginning to unfurl)				
	Dying fronds (< 50% green)				
	Dead fronds (blade ± intact but frond all brown)				

[1]Differ from typical young expanding fronds as they will start developing pinnae pairs rather than unfurling with them. Only complete if frond form clearly grown from previously juvenile from gametophyte.

SECTION B – Monitoring of gametophyte direct attributes	
Gametophyte present (Y/N):	Grid reference (if possible):
Colony Area (m²):	Area of occupancy (%): (As above. May also be calculated based on areas of discrete patches within the maximum colony area)
No. of discrete gametophyte patches:	Distance to nearest sporophyte:

Area of discrete gametophyte patch	% occupied by *V. speciosa*	Patch location within colony (centre/periphery)	Patch description (e.g. Dense/Patchy/Sparse)
(1)		(1)	(1)
(2)		(2)	(2)
(3)		(3)	(3)

Describe overall gametophyte colony:
(e.g. Dense/Patchy/Sparse)

SECTION C – Monitoring of colony direct attributes	
Aspect:	Altitude:
Seasonal flooding at colony (y/n):	Rock type:

Relative humidity and substrate moisture at colony:	Visible water source (Y/N):
	[2]Water source:
	Substrate damp/wet to touch (at sporophyte colony):
	Relative humidity: Target RH ≥ 80% (at gametophyte colony)
[2]WATER SOURCE: 1 = Stream; 2 = River; 3 = Dripping Cave; 4 = Splash; 5 = Waterfall; 6 = Ground seepage; 7 = Rock seepage; 8 = Other.	
Shading of colony:	Adequate shading (Y/N): (if no, give reason)
	[3]Woodland shading: (Target [4]Shade Index ≥ 4)
	Open upland shading: (Target Shade Index ≥ 5)
[3]Note at woodland colonies, if shading provided by cave entrance, then score accordingly, e.g. 7 for a cave entrance). [4]SHADE INDEX: 1, Fully exposed to sunlight all day. 2, Sunlit for > half the day. 3, Significant sunlight, but for < half the day. 4, Moderate shade, e.g. light-medium deciduous canopy. 5, Permanently shaded from direct sunlight but otherwise open to sky. 6, Deep woodland shade (e.g. broadleaf, coniferous or in ravine). 7, Perpetual deep shade, e.g. cave entrance, beneath boulder, deep crevice.	
Canopy Cover at colony: (Woodland habitats only)	Adequate canopy cover (Y/N): (If N, give reason)
	Canopy cover ([5]Domin): (Target Domin score ≥ 8) (For colonies occurring in cave entrances/deep crevices in woodlands, score the canopy cover provided to the opening of the cave/crevice to where the colony occurs).
[5]DOMIN SCALE: + = < 1% with no measurable cover; 1 = < 1% 1 – 2 individuals, no measurable cover; 2 = < 1% with several individuals; 3 = 1–4%; 4 = 5–10%; 5 = 11–25%; 6 = 26–33%; 7 = 34–50%; 8 = 51–75%; 9 = 76–90%; 10 = 91–100%.	
[6]Encroachment of vigorous native or non-native invasive species (List species name(s) and give Domin score and area of colony affected (m^2))	Vigorous native species in colonies where sporophytes occur: (Target is Domin ≤ 4)
	Non-native invasive species in colonies where sporophytes occur: (Target is Domin ≤ 4)
	Encroachment of bryophyte species in colonies where gametophytes occur: (No target set)
[6]ENCROACHMENT: For sporophyte colonies < 1 m x 1 m, Domin score of ≤ 4 for such species that occur in a 1 m x 1 m quadrat centred on the colony is a pass. For sporophyte colonies ≥ 1 m x 1 m, Domin score of ≤ 4 for such species that occurs within the extent of the colony is a pass.	
Observation of vigorous native species or non-native invasive species in the vicinity of the colony:	
Other impacting activities:	Extent of damage: (No. of fronds damaged and/ or area of colony affected (m^2))
Recommendations for management of colony:	

Appendix 3 – Assigning area of occupancy and frond numbers for unmonitored colonies

This appendix sets out the rationale and methodology used for assigning area of occupancy and frond numbers for unmonitored colonies where there is no information on file.

In order to derive a national area of occupancy and overall number of fronds for *V. speciosa* for the National Conservation Status Assessment (NPWS, 2019), unmonitored colony records where there is no information on frond numbers or area were set a minimum value of 52 fronds and 0.22 m² area of occupancy for sporophyte colonies (Table 26) and 0.12 m² for gametophyte colonies (Table 27).

SPOROPHYTES

For calculating an area of occupancy and frond number for unmonitored sporophyte colonies where there are no details of these available, average figures for these were calculated from figures recorded at monitored colonies, in order to assign a figure that was representative of a typical colony containing sporophytes. The following caveats applied when selecting monitored colonies from which to derive these figures:

- Colonies where actual frond counts were carried out were selected (colonies with estimated frond numbers were excluded). This totalled 64 colonies for this calculation. This ensured that the particularly large colonies were not included, as they would not be representative of typical colony sizes (e.g. large colonies at populations TS22, Co. Cork; TS25, Co. Cork; TS26, Co. Waterford and TS52, Co. Kerry);
- The combined area of occupancy for these 64 colonies was used to calculate an average area of occupancy to assign to unmonitored colonies;
- Juvenile-only colonies were excluded.

The areas of occupancy at the selected monitored colonies ranged from 0.002 m² to 1.9 m². Frond counts ranged from 1 to 364. Table 26 shows the calculations for deriving the figures to assign to unmonitored colonies with sporophytes where there are no details on area of occupancy or frond numbers.

Table 26 Figures used to derive area of occupancy (m²) and frond numbers for unmonitored colonies where there are no details available (based on average figures for 64 monitored sporophyte colonies). These figures contributed to the overall frond number and area of occupancy figures included in the National Conservation Status Assessment (NPWS, 2019) for all *Vandenboschia speciosa* colonies.

No. of selected colonies	Total combined area of occupancy	Average area of occupancy to be assigned	Total combined frond counts	Average frond number to be assigned
64	14	0.22	3,332	52

GAMETOPHYTES

For calculating an area of occupancy for unmonitored gametophytes-only colonies where there are no details, an average for that measurement was calculated based on monitored colonies in order to assign a figure that was representative of a typical gametophytes-only colony. The following caveats applied when selecting from monitored colonies to derive this figure:

- Gametophyte colonies with an area of occupancy of ≤ 0.8 m^2 were selected, as the inclusion of larger gametophyte colonies would not be reflective of a typical gametophyte colony. This totalled 78 colonies for this calculation;
- Colonies with juvenile sporophytes were excluded.

The areas of occupancy at the selected monitored gametophyte colonies ranged from 0.0006 m^2 to 0.8 m^2. Table 27 shows the calculations for deriving the figures to assign to unmonitored gametophyte colonies where there are no details on area of occupancy.

Table 27 Figures used to derive area of occupancy (m^2) for unmonitored gametophytes-only colonies where there are no details available (based on average figures for 78 monitored gametophyte colonies). These figures contributed to the overall area of occupancy figure included in the National Conservation Status Assessment (NPWS, 2019) for all *Vandenboschia speciosa* colonies.

No. of selected colonies	Total combined area of occupancy	Average area of occupancy to be assigned
78	9.4	0.12

Appendix 4 – *Future prospects* assessments for the 40 *Vandenboschia speciosa* populations

Future prospects (FP) assessments for the 40 *Vandenboschia speciosa* populations monitored in the RPMS between 2015 and 2018. F=Favourable; U-I=Unfavourable-Inadequate. None were assessed as Unfavourable-Bad. Gen. = generations.

Pop. Code	County	Gen.	FP for *Population*	FP for *Habitat for the species*	Overall FP	Rationale
TS01	Tipperary / Limerick	S&G& J	F	U-I	U-I	Loss of canopy cover significantly affected colony TS01.02.01. Although recovering, there is still a threat from this activity on the habitat where this colony occurs. Bank slippage occurred at TS01.02.05 (G-only colony).
TS02	Mayo	G	F	F	F	No impacting activities recorded at this location.
TS03	Wicklow	G	F	F	F	No impacting activities recorded at this location.
TS04	Wicklow	G	F	F	F	No impacting activities recorded at this location.
TS05	Kerry	S	F	F	F	No impacting activities recorded at this location. Flooding is a threat to S colony TS05.01.01 which occurs on the side of a waterfall and could potentially be dislodged in an extreme weather event.
TS06	Kerry	S&G	F	F	F	No impacting activities recording at this location. However, with the frequency of extremes in weather conditions, flooding may be a threat to S colony TS06.01.01 which occurs on the side of a waterfall under the canopy of a single Ash tree. This colony could be potentially dislodged in an extreme weather event. *Epilobium brunnescens* was recorded in this location.
TS07	Carlow	S&G& J	F	F	F	No impacting activities at this location. A large quantity of spoil was dumped within one metre of a large G colony (TS07.02.01). It is not currently considered a threat to this colony which occurs in a deep crevice, but should be monitored in the future.
TS08	Cork	S&G	F	U-I	U-I	Recent loss of canopy cover and bank slippage at this location affected only one colony (TS08.01.02). Recent tree fall at this colony has exposed a section of this large S colony (c. 5 m^2) to direct sunlight.
TS09	Kerry	S&G	F	F	F	Grazing within the area, but no evidence of impact on sporophyte colony TS09.01.01. *E. brunnescens* was recorded in this location.
TS10	Kerry	S&G	F	F	F	No impacting activities recording at this location. *E. brunnescens* was recorded in this location.

Pop. Code	County	Gen.	FP for *Population*	FP for *Habitat for the species*	Overall FP	Rationale
TS11	Kerry	S&G	F	F	F	No impacting activities at this location. However, frequency of extremes in weather conditions, flooding is a threat to S colony TS11.01.01 which occurs beneath a boulder in a stream and could potentially be dislodged in an extreme weather event.
TS12	Kerry	S&G&J	F	U-I	U-I	Loss of canopy cover, removal of *Rhododendron ponticum* and grey fungal attack at colony TS12.01.01, in addition to the presence of *R. ponticum* throughout this population and evidence of herbicide use in vicinity of colony TS12.02.01.
TS14	Kerry	S&G&J	F	F	F	Although canopy cover was lower than the target of Domin ≤ 4, at colony TS14.02.01, the overhanging vegetation provided adequate shade for this colony. The remaining colony in this population has adequate canopy cover.
TS15	Kerry	S&G&J	F	F	F	No impacting activities at this location.
TS16	Limerick	S&G	F	F	F	Although the threat of fire (burning down) was highlighted, the impact of this activity is considered low at present.
TS17	Sligo	S&G	F	F	F	Grazing within the area, but no evidence of impact on S&G colony TS17.01.01. *Acaena ovalifolia* was recorded in this population; however, the impact, if any, of this species on the *V. speciosa* population is unknown. This species is reported as a medium impact species in a report on Ireland's invasive and non-native species (O'Flynn *et al*., 2014).
TS18	Kerry	S&G	F	F	F	No impacting activities recorded at this location.
TS19	Kerry	S&G	F	F	F	No impacting activities recorded at this location. This population previously had an Unfavourable-Inadequate *Future prospects* assessment due to significant loss of fronds and area of occupancy due either to an unknown pressure or natural turnover of fertile fronds. In this reporting period, the colony appears to be recovering and there were no pressures or threats observed. Grazing occurs throughout this woodland but is considered a low impacting activity in relation to *V. speciosa*.
TS20	Limerick	S&G	U-I	U-I	U-I	Removal of canopy cover provided by *R. ponticum* caused the loss of colony TS20.04.01. Therefore, there is an Unfavourable-Inadequate *Population* assessment. The impact from this activity is not considered to be acting on the remaining colonies which are expected to continue to survive, as the impact was specific to the location of the now-extinct colony. *Habitat for the species* failed on the canopy cover target for colonies TS20.01.01 (S&G); TS20.01.02 (G); TS20.02.01 (S&G); TS20.02.02 (G); TS20.02.03 (G). All other colonies passed on this target.

Pop. Code	County	Gen.	FP for *Population*	FP for *Habitat for the species*	Overall FP	Rationale
TS21	Donegal	S&G	F	F	F	No impacting activities at this location.
TS22	Cork	S&G&J	U-I	U-I	U-I	Loss of colony TS22.01.07 was due to bank slippage. Danger of loss of this colony was flagged in the previous reporting period due to trampling. Such activity may have impacted the stability of this part of the bank. Bank stability should be monitored in the future at this location. Also the presence of *R. ponticum* and *Prunus laurocerasus* should be monitored, as although not impacting the species, they could have future impacts on the habitat where they occur. The remaining colonies within this population are expected to continue to survive. Bank slippage was also observed at colony TS22.01.02 impacting the area of occupancy of gametophytes.
TS23	Donegal	S&G&J	F	F	F	No impacting activities at this location.
TS24	Kerry	S&G&J	F	F	F	*R. ponticum* and *P. laurocerasus* occur throughout this population, providing essential shade to many colonies. Although these species may negatively impact the habitat where the colonies occur, there was no evidence to suggest that the extent or quality of the habitat for the species has changed significantly in the recent past.
TS25	Cork	S&G	F	U-I	U-I	Encroachment of *Rubus fruticosus* agg. is impacting colonies TS25.01.01 and TS25.01.02. Although it is providing essential shading to colony TS25.01.01, it is now encroaching on the adjacent colony TS25.01.01. Encroachment by this species has engulfed colony TS25.01.02 making it extremely difficult to see how it is impacting the colony beneath.
TS26	Waterford	S&G&J	U-I	F	U-I	The effect of bank slippage in sections of this population is a cause for concern. In some cases, the bank slippage appears to be due to natural causes (S&G colony TS26.01.04 and S&G&J colony TS26.01.14). In another case (S&G&J colony TS26.01.19) it is likely that the movement of *P. laurocerasus* is causing instability at sections of these steep banks. *Reynoutria japonica* occurs in the vicinity of S&G colonies TS26.01.01 and TS26.01.03 but is not regarded as a threat to *V. speciosa*.
TS27	Waterford	S&G	F	F	F	Although there was bank collapse at the access point to G colony TS 27.02.01, there is no reason to suspect that the G colony, which occurs in a deep crevice, was impacted. Bank slippage is not currently a concern for the remaining S and G colonies on the opposite side of the river *R. japonica* occurs in the vicinity of S&G colony TS27.01.01, but is not regarded as a threat to *V. speciosa*.
TS28	Kilkenny	G	F	F	F	No impacting activities recorded at this location.

Pop. Code	County	Gen.	FP for *Population*	FP for *Habitat for the species*	Overall FP	Rationale
TS29	Wexford	G	F	F	F	Evidence of herbicide spraying along the track within a few metres of the gametophyte colonies TS29.01.01 and TS 29.01.02 which both occur at ground level and should be monitored for any impacts from this activity. At present, there does not appear to be any current impact from this activity.
TS30	Cork	S&G	F	F	F	No impacting activities recorded at this location.
TS31	Kerry	G	F	F	F	*R. ponticum* was cleared in the past, but many seedlings re-emerging at colonies TS31.01.01-03. Not considered a current threat to the G colonies, but its presence is likely to become problematic and negatively impact this woodland habitat.
TS34	Galway	G	F	F	F	No impacting activities recorded at this location.
TS35	Kerry	S&G&J	F	F	F	With increasing frequency of extremes in weather conditions, flooding is a threat to S colony TS35.02.01 which occurs beneath a boulder in a stream and could potentially be dislodged in an extreme weather event. It is not currently impacting this colony.
TS37	Mayo	G	F	F	F	Dense *R. ponticum* stands and many seedlings occurring in the vicinity of the G colony and on the mountain slope. Not considered a current threat to the G colony, but its presence is likely to become problematic and negatively impact this open upland habitat.
TS50	Kerry	S&G	F	F	F	No impacting activities recording at this location. *E. brunnescens* was recorded in this location.
TS51	Kerry	G	F	F	F	No impacting activities recording at this location. *E. brunnescens* was recorded in this location.
TS52	Kerry	S&G&J	F	F	F	No impacting activities recording at this location. This population occurs in a private garden that was historically planted with exotic species. These are not regarded as a threat to the S colonies.
TS55	Kerry	S	F	F	F	No impacting activities recording at this location. *E. brunnescens* was recorded in this location. Also, with increasing frequency of extremes in weather conditions, flooding is a threat to S colonies TS55.01.01 and TS55.01.02 which occur beneath a boulder on a waterfall and could potentially be dislodged in an extreme weather event.
TS57	Tipperary	G	F	F	F	Illegal dumping was recorded on the upper slopes of the gorge; however, not in the vicinity of the G colony that occurs at the bottom of the slope.
TS60	Cork	S&G&J	F	F	F	No impacting activities recording at this location. This population is invaded with *R. ponticum* and *Luma apiculate* (Chilean Myrtle), however their presence is not impacting the colonies in this location.

Pop. Code	County	Gen.	FP for *Population*	FP for *Habitat for the species*	Overall FP	Rationale
						Such species are likely to become problematic for the habitat in the future and should be monitored. Work that has been implemented to control the spread of these species should continue.
TS61	Kerry	S	F	F	F	No impacting activities recorded at this location.