# An Comisun Pleanála Case reference: SU05E.324433

# Meenbog Substitute Consent Submission

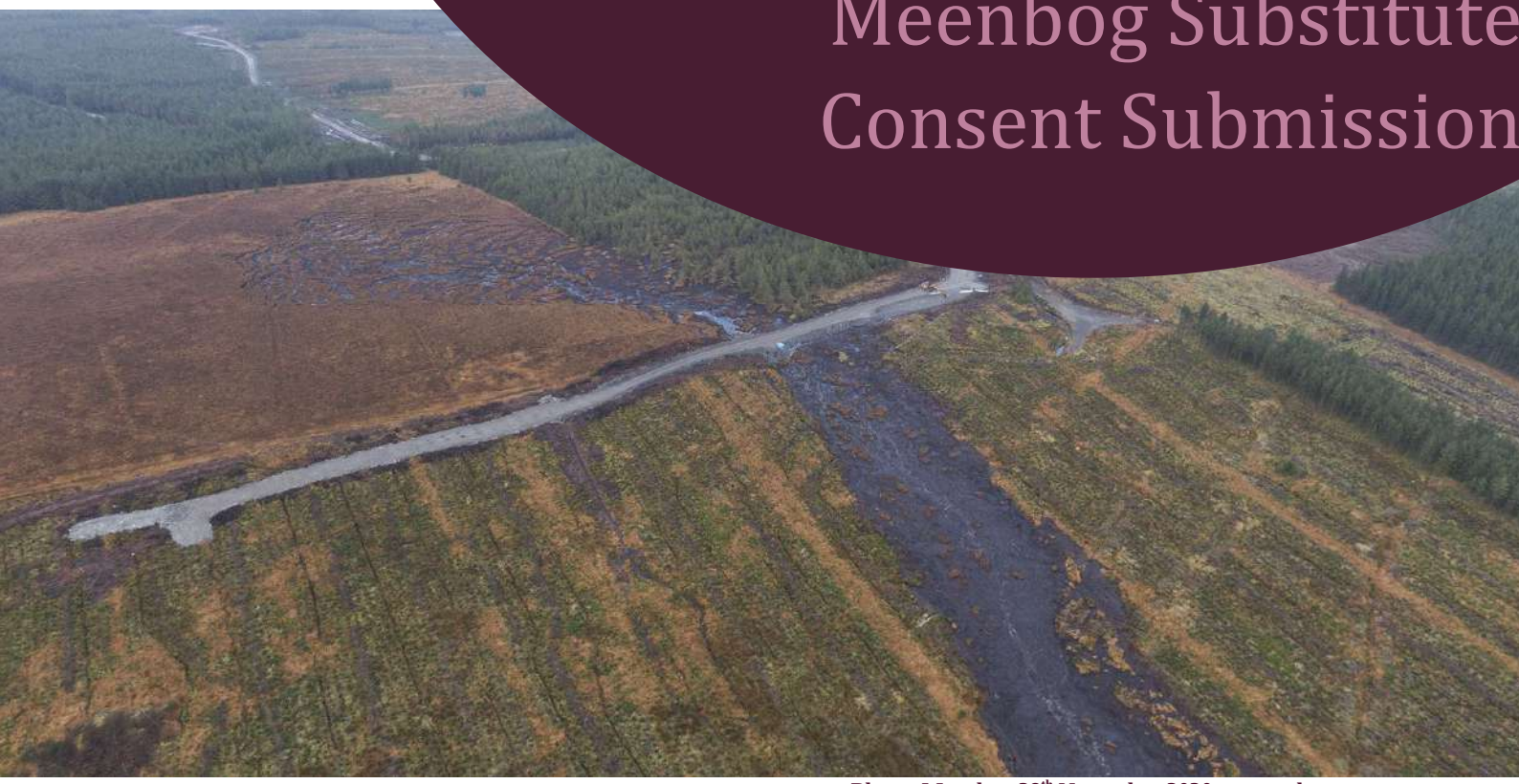


**Photo- Meenbog 28th November 2020 - ground zero.**

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# Submission

## Introduction

A.1 Wild Ireland Defence CLG ("WID") welcomes the opportunity to make this submission. WID is an independent environmental non-governmental organisation concerned with the protection of Ireland's environment, biodiversity and natural heritage, and with ensuring the proper application of national and European environmental law in public decision-making.

A.2 Planning & Environmental consultant, Sabrina Joyce-Kemper, has prepared this submission on behalf of Wild Irish Defence CLG as instructed by them. Ms. Joyce-Kemper has an Advanced Diploma in Planning and Environmental Law and a Diploma in Legal Studies from the Honorable Society of Kings Inn.

A3. Ms Joyce-Kemper has undertaken a review of the application including the remedial Environmental Impact Assessment Report (rEIAR), remedial Natura Impact Statement (rNIS), Planning Statement and supporting technical documentation, Water Framework Directive assessment report, together with the relevant provisions of European Union and Irish planning and environmental legislation. The relevant issues raised and conclusions expressed within Sections 1 onwards represent her independent assessment of the application documentation. Having considered that assessment in full, and having reviewed the sections prepared by Ms. Joyce-Kemper, Wild Ireland Defence CLG confirm it agree's with and endorses the contents of Sections 2 onwards, and respectfully adopts them as forming part of this submission to An Coimisiún Pleanála.

## 1. Substitute Consent: Exceptional circumstances.

1.1 Substitute consent is an exceptional remedial jurisdiction, not an alternative route to planning permission. The starting point is that substitute consent is not equivalent to an ordinary application for planning permission or retention permission. It is an exceptional mechanism devised to address the consequences of development having been carried out without the prior environmental assessment required by European Union law.

Section 177K(1A)(a) of the Planning and Development Act 2000, as amended, is mandatory:

"The Board shall not grant substitute consent … unless it is satisfied that exceptional circumstances exist that would justify the grant of such consent."

1.2 The matters which must inform that determination include whether regularisation would circumvent the purposes of the EIA or Habitats Directives; whether the applicant had or could reasonably have believed the development was authorised; whether retrospective environmental assessment and public participation have been impaired; the actual or likely significant environmental effects; the extent to which those effects can be remediated; and the applicant's history of compliance with planning permissions and unauthorised development.

1.3 Those factors cannot be treated as a checklist capable of converting an intrinsically exceptional jurisdiction into a routine mechanism for regularising development after construction. Holland J. addressed precisely this issue in Donegal County Council v Planree Ltd & Mid-Cork Electrical Ltd [2024] IEHC 193. He observed that satisfaction of the exceptionality requirement "is no easy achievement" and cannot be standard, typical or routine. He further held that the weight which

can be attributed to the statutory considerations is “heavily circumscribed” by the EU-law requirements of exceptionality and deterrence.

1.4 The Court of Appeal subsequently confirmed the underlying principle. Development requiring EIA or AA is required to undergo that assessment before development consent is granted. The Court described it as axiomatic that development requiring environmental assessment should not be carried out before development consent and explained that retrospective consent may therefore be granted only in exceptional circumstances. The present application must be approached from that restrictive starting point.

**1.5 The deterrent purpose of EU law is the core principal:** The exceptional-circumstances requirement exists for a particular reason. A developer must not obtain an advantage by carrying out development first and asking the competent authority to assess and regularise it afterwards.

In An Taisce v An Bord Pleanála; Sweetman v An Bord Pleanála [2020] IESC 39, the Supreme Court held that a system of retrospective regularisation is compatible with EU law only where it does not facilitate or encourage circumvention of the requirements of the EIA Directive and operates only in exceptional circumstances. The Court emphasised that national law cannot create an incentive to disregard the requirement for prior EIA.

1.6 That principle reflects the CJEU jurisprudence beginning with Commission v Ireland, Case C-215/06, concerning Ireland's retrospective regularisation regime, and subsequently developed in Comune di Corridonia, Joined Cases C-196/16 and C-197/16. The latter confirms that retrospective environmental assessment is an exceptional corrective mechanism; it cannot become the functional equivalent of obtaining the assessment which should have preceded development.

1.7 Holland J. expressed the same deterrent principle in this very case. Citing the Supreme Court and Ardagh Glass, he recorded that easy regularisation would encourage developers to disregard Article 2(1) of the EIA Directive and that it must be made plain that a developer gains no advantage through pre-emptive development. He further adopted the proposition that a strict approach is required precisely to discourage circumvention of EIA requirements.

1.8 That principle has particular force at Meenbog because this is not merely a historical failure by a public authority to perform an environmental assessment of development which the developer reasonably believed to be authorised. The courts have determined that material departures were made from an existing permission whose conditions and particulars were themselves the product of EIA and AA.

1.9 As a matter of fact this case falls on the wrong side of the distinction identified by the Court of Appeal. The Court of Appeal drew an important distinction between two materially different situations. Substitute consent may sometimes be necessary where a developer has complied with its legal obligations and with the decisions of the planning authority but, because of an error in the original consenting process, an EIA or AA which should have been undertaken was not undertaken. In such circumstances the underlying failure may principally be that of the competent authority.

1.10 The Court contrasted that situation with development carried out without permission or in breach of the terms of a permission, where the default lies with the developer. Meenbog belongs firmly in the latter category. The original wind farm had been subjected to both EIA and AA. The permission required the development to be constructed in accordance with the plans and

particulars assessed by An Bord Pleanála and required implementation of the environmental mitigation identified through those assessment processes.

1.11 Nevertheless, numerous departures occurred during construction. Planree ultimately accepted that the departures were material and constituted unauthorised development. The Board itself concluded that the deviations required EIA screening and AA because significant environmental effects could not be excluded and because it could not determine whether adverse effects upon European sites required, or were capable of, remediation. Holland J. considered that those conclusions made it impossible to continue characterising the departures as minor or immaterial.

1.12 This is therefore not an instance of a developer innocently discovering that an administrative defect existed in an otherwise compliant consent. It is a case in which development materially different from the environmentally assessed project was physically carried out.

1.13 In light of the distinction the applicant's asserted belief must be examined with particular rigour. Section 177K requires consideration of whether an applicant "had or could reasonably have had a belief that the development was not unauthorised." That is not satisfied merely because the developer or its consultants subsequently asserted that deviations were believed to be minor.

1.14 Holland J. accepted that large construction projects may require minor adaptations to respond to site conditions. He drew, however, an emphatic legal boundary. Such flexibility applies only to minor and non-material deviations. Developers remain bound to comply materially with planning permission and cannot justify material departures on the ground that flexibility is normal engineering practice. He stated that allowing otherwise would enable developers effectively to ignore planning permissions in material respects and would be destructive of planning law.

1.15 The same judgment records the developer's evidence that deviations were considered normal and were undertaken following engineering and environmental consideration. That evidence does not itself establish the statutory defence of reasonable belief. It instead raises the question which section 177K requires the Commission to determine: what steps were actually taken, before each material departure was executed, to establish that it remained within the permission and within the project previously subjected to EIA and AA?

1.16 Holland J. expressly observed that a prudent developer would record active inquiry into whether a departure was authorised. The absence of such a record may contribute to a finding that an asserted mistake as to materiality was not reasonable. The applicant should therefore be required to identify, for every material deviation:

- the date upon which the departure was decided upon;
- the person who authorised it;
- the planning and environmental advice obtained before construction;
- the assessment undertaken as to whether it remained within the permission;
- and any contemporaneous record demonstrating a reasonably held belief that the works remained authorised.

A retrospective assertion (bare assertion) that the departures were believed to be immaterial cannot substitute for contemporaneous evidence, substitute consent as an exception relief must be underpinned by evidence and granted on an evidential basis.

1.17 It must be a core proposition to this particular substitute consent application that the environmental consequences of the unauthorised development have already materialised. Exceptionality must also be assessed in the factual circumstances which now exist, not in the circumstances which existed when permission was originally granted. Would a development subject to AA and EIA have been granted if the application stated that there was a metrial risk of a floating road accrossa bog causing a serious peat slippage event? Under the legal test for both AA and EIA (and Water Framework Directive) the application would have been refused. In light of such a position how could the same development be granted retrospective consent? The simple answer is that it cannot.

1.18 The Meenbog case is particularly serious because the environmental risk is no longer theoretical. A major peat failure occurred during construction. The independent GSI/NPWS investigation records that the Meenbog bog-flow occurred on 12 November 2020 during the unauthorised construction of a floating wind-farm access road across blanket bog.

1.19 The courts have also recognised that the physical receiving environment has changed. Holland J. found that the applicant's reliance upon the original EIA and AA failed to address the fact that, because of the material deviations and peat slides, the receiving environment was no longer the environment understood when those assessments were undertaken. The Court of Appeal expressly agreed with that analysis. This fact bears directly upon the statutory exceptional-circumstances factors concerning actual environmental effects, impairment of retrospective assessment, remediation, circumvention of the Directives and developer conduct.

1.20 The Commission is therefore not considering an abstract regularisation of harmless technical deviations. It is considering whether an exceptional EU-law remedy should be afforded after materially unauthorised development occurred in an environmentally sensitive upland blanket-bog environment and after one of the risks inherent in disturbing that environment actually occurred.

1.21 It must be acknowledged that The European Commission has specifically warned Ireland against making substitute consent an easier route for developers who have broken the law and that there is also an important European context to the statutory provisions now relied upon by the applicant. At the Irish Package Meeting of 25–26 November 2021, the European Commission specifically raised concerns regarding proposed amendments to Ireland's substitute-consent regime. Although accepting that simplification of procedure and full public participation could be appropriate, the Commission expressed concern about amendments which would make substitute consent easier.

1.22 Most significantly, the Commission stated that “the whole point of the substitute consent process is that it is supposed to be an unattractive option for developers.” It expressed concern that allowing substitute-consent applications to be combined with applications for future development could reward developers who had broken the law, and questioned an additional residual ground capable of broadening the circumstances in which substitute consent might be granted. The Commission expressly linked those concerns to Ireland's continuing obligation to comply with the original Derrybrien judgment in Case C-215/06.

1.23 Those concerns must be considered in the present case and indeed when assessing the efficacy of the legislation as a remedy to the original Infringement action. The 2022 legislation subsequently removed the preliminary leave stage, moved the exceptional-circumstances assessment to the substantive application, and expressly facilitated simultaneous applications for future development.

1.24 The Commission's observations do not, by themselves, constitute a judicial determination that the amended legislation is incompatible with EU law. They do, however, demonstrate that the very features intended to make the domestic procedure easier or more flexible were already the subject of explicit concern by the institution responsible for enforcing the EIA Directive.

1.25 Accordingly, insofar as any provision of Part XA is capable of more than one interpretation, it must be interpreted consistently with the EU-law requirement that retrospective regularisation remain genuinely exceptional and must not reward or encourage the circumvention of prior environmental assessment. A broad interpretation which transformed substitute consent into a practicable alternative for a developer which materially departed from an EIA/AA-based permission would recreate the very incompatibility identified by the Supreme Court in McQuaid and the CJEU in Commission v Ireland.

1.26 The previous grant of leave does not establish entitlement to substitute consent. It is also important that the Commission does not treat the Board's earlier decision granting Planree leave to apply as establishing that exceptional circumstances presently exist. **T**he earlier application sought leave in respect of 25 deviations. The High Court recorded that the Inspector recommended that leave be granted because significant environmental effects could not be excluded and because he was unable to determine whether effects upon European sites required or could be remediated. Those conclusions established the necessity for environmental assessment; they did not determine that retrospective regularisation should ultimately be permitted.

1.27 Indeed, following the Supreme Court decision in McQuaid, the domestic legislation was specifically amended so that the exceptional-circumstances issue must be considered at the substantive stage with public participation and without the substantive decision being bound by the earlier determination at leave stage. The present submission therefore requests that the Commission make a fresh and rigorous determination of exceptionality by reference to the complete factual history now established, including the High Court and Court of Appeal judgments.

1.28 The applicant bears the burden of demonstrating circumstances sufficiently exceptional to justify departure from the fundamental EU-law rule that environmental assessment and development consent must precede development. The circumstances disclosed here point in the opposite direction. The original project had already undergone EIA and AA. The developer thereafter materially departed from that assessed permission to such an extent that the court deemed the whole development unauthorised in a cumulative manner. The departures were sufficiently serious to require further EIA screening and AA. The courts have determined that material compliance with the permission was absent and that the altered receiving environment can no longer simply be equated with that examined in the original assessments. A serious peat failure occurred during the construction process. The independent GSI/NPWS investigation associates that failure directly with unauthorised construction. The competent planning authority considered the breaches sufficiently serious to institute enforcement proceedings, and the High Court and Court of Appeal restrained further development.

1.29 To characterise those circumstances as the “exceptional circumstances” which justify retrospective consent would invert the statutory and European test. They are not exceptional circumstances excusing the absence of prior assessment; they are the circumstances demonstrating why prior assessment and material compliance with an environmentally assessed permission are indispensable.

1.30 A grant of substitute consent in such circumstances would risk sending precisely the signal which EU law requires the regime to prevent: that a developer may materially depart from an EIA- and AA-based permission, alter the receiving environment, allow the environmental risk to crystallise, and nevertheless seek to preserve the development through retrospective regularisation. The Commission should therefore find that the exceptional-circumstances requirement in section 177K has not been satisfied and refuse substitute consent.

1.31 If, contrary to this submission, the domestic provisions were interpreted as permitting substitute consent in circumstances of this nature merely because retrospective EIA and AA can now be attempted, a serious question would arise as to whether that interpretation itself is compatible with Articles 2 and 8a of the EIA Directive, Article 6(3) of the Habitats Directive, the principle of sincere cooperation under Article 4(3) TEU, and the binding jurisprudence of the CJEU requiring retrospective regularisation to remain exceptional and non-circumventive.

**2. Remedial Environmental Impact Assessment – Inadequate reconstruction and assessment of the environmental effects of the unauthorised development.**

2.1 The main question for the Commission is whether a lawful remedial EIA can actually be carried out on the information supplied. The purpose of the present exercise is not to determine whether the partially constructed wind farm appears environmentally acceptable in its present condition. Nor is it sufficient to determine whether environmental conditions have recovered since construction ceased. The task is retrospective. The Commission must be capable of identifying and assessing the significant environmental effects caused by the development which was carried out without the environmental assessment applicable to the development as actually constructed.

2.2 Such an exercise assumes particular importance at Meenbog. Construction commenced in November 2019 and more than 90% of the construction activity associated with the wind-farm infrastructure occurred between November 2019 and November 2020. The development constructed during that period included approximately 13.7 km of upgraded roads, 5.3 km of new roads, groundworks for 18 turbines, 16 fully or partially completed turbine foundations, peat-storage areas, borrow pits, forestry felling, drainage works and other infrastructure.

2.3 The rEIAR itself acknowledges that its purpose is to assess all works carried out since November 2019, including foundations and hardstands for 18 turbines, access roads, borrow pits, peat and spoil management, forestry felling and drainage infrastructure. Accordingly, the environmental question is not simply whether those works are stable today. It is what happened to the environment between the pre-development condition and the environment which now exists, including effects which occurred during construction and remain, effects which subsequently disappeared, effects which were remediated and effects which cannot now reliably be reconstructed, remediated and may still require compensatory measures. That is the essential evidential difficulty which the rEIAR does not adequately confront.

2.4 The baseline problem is material, the rEIAR expressly states that:

"The baseline against which the Existing Development is assessed is the pre-construction condition established in the 2017 EIAR."

That is, in principle, the correct temporal baseline. The difficulty lies in whether the 2017 material actually contains sufficient information to reconstruct that baseline for the development which was subsequently constructed, rather than merely for the project which was originally

proposed.

2.5 The 2017 EIAR was prepared prospectively to assess a particular proposed development, at particular locations, using particular construction methods, mitigation measures and assumptions. What subsequently occurred was materially different. The High Court and Court of Appeal proceedings have already established that material deviations occurred. Some of those deviations themselves required EIA screening and AA.

2.6 A baseline adequate to assess the originally proposed project does not automatically constitute an adequate baseline against which every subsequently constructed, materially different element can retrospectively be assessed.Indeed, the rEIAR illustrates the problem. Its Land, Soils and Geology chapter relies upon investigations undertaken at four fundamentally different stages: investigations for the 2017 EIAR; investigations during construction; investigations following the November 2020 peat slide; and investigations undertaken specifically for the present rEIAR. Those datasets are not temporally interchangeable and all form part of the construction timeline.

2.7 Information obtained after excavation, drainage, road construction, peat movement or slope failure may be highly valuable for understanding the site as it now exists. It cannot necessarily establish the physical, hydrological, ecological or geotechnical condition which existed before those interventions occurred. The Commission must therefore distinguish rigorously between:

(a) genuine pre-construction baseline evidence;

(b) information obtained during construction;

(c) information obtained following the peat failure;

(d) information obtained following remediation; and

(e) information collected in 2024–2026 from the substantially altered environment.

Unless the material differences are maintained, there is an obvious danger of reconstructing the environmental baseline backwards from the environment which the unauthorised development itself helped create.

2.8 Later surveys cannot retrospectively observe environmental effects which have already occurred. The biodiversity chapter provides a particularly clear example. The rEIAR states that the ecological baseline was established in the 2017 EIAR and subsequently “updated” through field surveys between 2021 and 2026. But those later surveys occurred after construction had already substantially altered the site. The document itself records that commercial conifer plantation declined from approximately 91% before construction to 81% by 2025; that the development replaced areas with built surfaces, bare ground and recolonising habitat associated with roads, foundations and peat-management areas; and that approximately 2.2 hectares of blanket bog were directly affected by the peat slide.

2.9 A survey conducted in 2024 or 2025 can provide useful evidence of the present ecological condition. It cannot retrospectively observe habitat, species utilisation, hydrological conditions or ecological functions which existed in 2019 and were subsequently removed or altered. This issue is particularly obvious in relation to bats. The rEIAR relies upon 2024 surveys to characterise bat

habitat suitability and activity and reports that no bat roosts were identified. Yet those surveys occurred approximately four years after substantial forestry clearance, road construction and site disturbance. The absence of a receptor from an altered environment in 2024 cannot, without appropriate historical evidence, establish its absence from the pre-development environment in 2019. The absence of bats in 2024 where a 2017 surveys identified evdence of populations would in itself identfy a serious substantial negative impact, that decimated bat populations. That is precisely why a retrospective assessment must identify candidly those effects which can be reconstructed and those which cannot.

2.10 The rEIAR's repeated assertion that there were “no limitations” requires particular scrutiny. For example the Land, Soils and Geology chapter states:

“No limitations or difficulties were encountered in the preparation of this chapter of the rEIAR.”

It immediately qualifies that statement by explaining that the retrospective assessment has been undertaken “based on the availability of the information relating to the construction of the Existing Development.”

2.11 The Hydrology chapter similarly states that the retrospective assessment was undertaken on the basis of available construction information and relies heavily upon the 2017 baseline and construction-phase monitoring. The same formulation appears elsewhere. The Noise chapter, for example, states that no limitations were encountered while simultaneously acknowledging that its retrospective assessment depends upon the information available concerning construction.

2.12 There is an important difference between having sufficient information to prepare a professional opinion and having complete contemporaneous information capable of establishing retrospectively all likely significant environmental effects. The rEIAR should therefore have identified, at minimum:

- what environmental parameters were actually measured before construction;

- what receptors were surveyed before construction at the locations where the material deviations subsequently occurred;

- what monitoring existed during the period of unauthorised construction;

- which effects can be established from contemporaneous measurements;

- which are reconstructed from later evidence;

- which depend upon assumptions or proxies; and

-which historical environmental conditions can no longer reliably be determined.

Without that exercise, the repeated conclusion that there were “no limitations” risks obscuring rather than identifying the inherent evidential limitations of retrospective environmental assessment.

2.13 The hydrological baseline contains an express and material assumption. Chapter 9 expressly acknowledges that no baseline Q-status data exist for the Shruhanagarve Stream. Instead,the rEIAR assumes that its pre-November 2020 condition was equivalent to other watercourses and

therefore assumes that it had Moderate Q-status. It similarly describes the pre-slide Mourne Beg status as assumed to be Good. There was evidence in 2020 that it was at poor/ bad status immediately after the slide[1]. The unqualified (theoretical) assumed baseline is then used to support the conclusion that water quality has "returned to baseline / pre-construction levels".

2.14 That reasoning is potentially circular:

**no measured baseline → baseline inferred from other watercourses → later monitoring compared with inferred baseline → recovery to baseline asserted.**

The Commission cannot treat an assumed baseline as equivalent to a measured baseline without examining the uncertainty created by that assumption, which essentially is a foundation of reasonable scientific doubt. This is especially important because the Shruhanagarve was the direct pathway by which the peat failure transmitted environmental effects downstream.

2.15 The rEIAR records effects considerably more serious than its present-day conclusions suggest. The underlying evidence concerning the November 2020 event is quite frankly striking. The 2021 aquatic investigation found peat siltation extending more than 14 km downstream, with siltation frequently severe, reducing salmonid and macroinvertebrate habitat quality. There was a significant restriction in salmonid spawning distribution, and juvenile brown trout numbers were noticeably reduced, an effect considered likely to have resulted from significant mortality associated with the peat-slide event.

2.16 More significantly still, the contemporaneously closer 2021 aquatic assessment concluded:

"the Meenbog November 2020 Peat Slide caused and continues to cause considerable impacts to the quality of aquatic habitats within the Shruhangarve and Mourne Beg River."

It predicted that impacts would "last long-term", because peat remaining within the system would continue to be re suspended and flushed downstream (to where?).

2.17 The 2026 rEIAR reaches a markedly more benign conclusion. It characterises the significant effects as temporary and states that no significant ongoing or residual effects remain. A mere assertion without evidence is in itself problematic but more importantly it does not retrospectively erase the earlier significant negative effect, that has changed the trajectory of population density, health and survival of species and habitats irrevocably.

Nor does subsequent recovery transform an effect which actually occurred into a non-significant environmental consequence for EIA purposes. The Commission must therefore assess the actual historical effect, including its magnitude at its worst point and its duration, rather than allowing the eventual recovery of the receptor to dominate the characterisation of the original impact. The Commission must consider if factually recovery can only ever mean revertion to original baseline with ongoing (cumulative) loss of what could have been potentially better habitats, more diverse species, higher populations of species at this point in time if the incident had not originally occurred, before the diverging 'timelines'.

2.18 Remediation cannot be allowed to overwrite the environmental effects which required remediation. The rEIAR also repeatedly relies upon remedial works undertaken after the peat

[1] https://irishriverproject.com/wp-content/uploads/2022/04/EPA_Red_Dot_Plus_2020_update_03022021.pdf

slide. Those works included barrage walls, peat removal, channel restoration, bank stabilisation and planting. These works in and of themsleves cause impacts to be assessed. The hydrology assessment acknowledges that the original channel morphology, depth and sinuosity of parts of the Shruhanagarve were lost and that the subsequent remediation involved redesigning the stream channel.

2.19 That is significant and undeniable evidence of environmental impact. A newly designed stable channel is not evidence that the original channel was unaffected. It is evidence that an environmental receptor was materially altered and subsequently reconstructed. Indeed, the rEIAR itself states that approximately 1,070 metres of stream morphology were affected. The remedial EIA must therefore maintain the analytical sequence:

**original environment → unauthorised development → environmental effect → peat failure → further environmental effect → emergency/remedial intervention → present environment.**

2.20 It cannot lawfully compare the present, partially remediated environment with an imperfectly reconstructed baseline and then infer from subsequent recovery that the intervening effects were environmentally insignificant. The proper question is what the competent authority would have been required to conclude had the actual risk now known to have materialised been identified at the outset. If, before construction, the assessment had disclosed a credible risk of significant pollution and ecological damage extending for many kilometers downstream, together with serious peat instability and effects on protected ecological receptors, could the project lawfully have been authorised on the basis of the evidence then available?

2.21 That question is especially important under the Habitats regime. If adverse effects on the integrity of a European site could not have been excluded beyond reasonable scientific doubt, ordinary consent under Article 6(3) could not have been granted. The project could only have proceeded, if at all, through the exceptional Article 6(4) derogation requiring the absence of feasible alternatives, imperative reasons of overriding public interest and the provision of adequate compensatory measures. The applicant would therefore have had to demonstrate not merely that the project was desirable, but that the stringent legal conditions for IROPI were satisfied.

2.22 The same issue arises in relation to alternatives. If the environmental risk actually realised in November 2020 had been properly understood before development commenced, the competent authority would have been required to consider whether a different layout, construction methodology, road alignment, turbine arrangement or even a materially different project could have avoided that risk. The present application cannot now rely on the fact that most of the infrastructure has already been constructed to eliminate those alternatives from consideration. That would allow the unauthorised development itself to narrow the environmental options which EU law required to be examined before construction.

2.23 Accordingly, if the project could not have satisfied the Article 6(3) test of no reasonable scientific doubt at the original consenting stage, and if the conditions necessary to invoke Article 6(4) could not have been demonstrated, the position is stronger rather than weaker today. The risk is no longer hypothetical. A significant adverse environmental event has actually occurred. A retrospective assessment cannot therefore apply a lower standard merely because remediation and the passage of time have reduced some of the visible consequences. The occurrence of the very harm which prior assessment was intended to prevent is powerful evidence that the original uncertainty was environmentally material, not insignificant.

2.24 There is a questionable separation of the peat slide and remediation from the development which caused or contributed to them. Chapter 9 states that the November 2020 peat slide is assessed separately from the other construction activities because of its "distinct nature and scale". More importantly, it states that the remediation works undertaken afterwards "do not form part of the Existing Development" and are instead assessed cumulatively. Such compartmentalisation requires close and strict scrutiny. The rEIAR itself accepts that construction was a contributory cause of the peat failure. The 2021 investigation identified, among the contributing factors, a localised area of weak peat which failed under construction of a 20 metre floating road. The remedial works were then necessitated by that failure.

2.25 For EIA purposes, the Commission must assess the project's overall environmental impact, including interactions between environmental effects. The CJEU has expressly held that a full EIA requires consideration not merely of effects individually but also of their interaction and consequently the project's overall environmental impact. It would therefore be artificial to treat:

- construction of the road,

- the destabilisation of peat,

- the peat failure,

- the downstream transport of peat,

- damage to the river,

- emergency works, and subsequent restoration

as environmentally independent events merely because they can be placed into different assessment headings. They form a causal environmental sequence.

2.26 The assessment also contains an apparent inconsistency concerning mitigation. The rEIAR repeatedly relies upon the proposition that the Existing Development was constructed in accordance with the mitigation and monitoring contained in the 2019 CEMP. Chapter 17 goes so far as to state:

"The Existing Development was constructed in accordance with the best practise measures and mitigation and monitoring as set out in the 2019 CEMP and as such, the residual effect(s) associated with the construction of the Existing Development are not significant."

The Land, Soils and Geology chapter similarly states that "All works were completed in accordance with the 2019 CEMP".

That proposition cannot simply be accepted as an answer to the environmental consequences of the material deviations.

2.27 The central fact giving rise to substitute consent is that development materially departed from the environmentally assessed and permitted project. The Commission must therefore determine, for each material deviation, whether the mitigation relied upon in the original EIA actually applied to the development as constructed, whether it was physically implemented at the relevant location,

and whether it remained effective in circumstances materially different from those assessed. The occurrence of a major peat failure while construction was proceeding is itself a powerful reason why compliance with mitigation should be demonstrated by contemporaneous evidence rather than asserted retrospectively.

2.28 The rEIAR's treatment of peat disturbance risks understating absolute environmental damage. There is another particularly questionable piece of reasoning. Chapter 17 records approximately 86,240 m³ of peat disturbed by the peat slide but then observes that this represents “only 26%” of the total peat disturbed by the Existing Development. It consequently describes the volume moved by the peat slide as minor in the context of the wider peat resource and concludes that the interacting residual effect is not significant.Such a comparison requires careful examination. The fact that an even greater volume of peat was disturbed by the development as a whole does not logically diminish the environmental significance of the peat disturbed by the catastrophic failure. On the contrary, the denominator itself represents environmental disturbance attributable to the development.

2.29 The proper EIA question is the significance of the environmental effect having regard to the sensitivity of the receptor, magnitude, geographical extent, duration, reversibility and interactions -not whether a damaging event constituted a relatively small percentage of an even larger quantity of development-related disturbance.

2.30 The sensitivity assigned to peat also requires strict scrutiny. The Land, Soils and Geology chapter classifies the site's peat and soils as being of “low importance” because the peat deposits are not designated and because forestry had degraded the soils before construction. That approach potentially conflates absence of statutory designation with environmental value and sensitivity. Such an approach is particularly problematic where the same rEIAR identifies upland blanket bog and wet heath on the site as habitat types protected under EU law and acknowledges that the peat slide directly affected approximately 2.2 hectares of blanket bog.

2.31 The rEIAR cannot use the passage of time as mitigation. A recurrent theme throughout the document is essentially:

**significant effect occurred → remediation occurred → several years passed → receptor recovered → no significant residual effect.**

2.32 For example, the biodiversity assessment expressly concludes that “Following the implementation of the remediation works and with the passage of time” no significant residual aquatic effects remain. But the passage of time is not mitigation. It may demonstrate recovery or establish the actual duration of an effect. That information is relevant and valuable. It does not however alter the fact that the effect occurred. This matters especially in a remedial EIA. If subsequent natural recovery were permitted to reduce retrospectively the significance attributed to an environmental effect, the longer an unauthorised development remained in place before assessment, the easier its environmental consequences could become to regularise. That would sit uneasily with the deterrent and exceptional character of retrospective regularisation identified in Section 1 of this submission.

2.33 The Commission must undertake the EIA itself and cannot simply adopt the rEIAR's conclusions. Ultimately, the rEIAR is environmental information supplied by the developer. It is not itself the Environmental Impact Assessment. The Commission must critically examine that information, the observations of statutory bodies and the public, the original EIAR, the evidence generated

during construction, the post-slide investigations and the subsequent monitoring and must itself reach reasoned conclusions concerning the significant effects of the development. If it does not have the expertise to independentally verify or interrogate the REIARs conclusions or reports then it is obliged to obtain such independent expertise at the expense of the developer.

2.34 That point is particularly important here because the rEIAR expressly presents itself, together with the prospective EIAR, as providing the information enabling the Commission to undertake EIA. The Supreme Court has emphasised the exceptional character required of substitute consent and the EU-law requirements governing retrospective regularisation. The CJEU jurisprudence likewise requires a full environmental assessment, addressing individual effects, their interactions and the project's overall environmental impact.

2.35 Here, (at the risk of repetition) the Commission should therefore satisfy itself that it can reconstruct, with sufficient reliability:

- the environmental condition immediately before development commenced;
- the development actually constructed rather than merely that originally permitted;
- the environmental effects occurring during each material deviation;
- the cumulative and interacting effects of those deviations;
- the conditions immediately preceding the November 2020 failure;
- the causes and environmental consequences of that failure;
- the effects of the emergency and remedial works themselves;
- the duration and reversibility of the resulting environmental damage; and
- the environment which exists today.

2.36 Where reliable historical information does not exist, that absence cannot be filled merely by present-day surveys or by assumptions based upon neighbouring receptors. The evidential lacuna must itself be acknowledged and considered in determining whether a lawful remedial EIA can be performed.

2.37 In conclusion, the rEIAR does not provide a sufficiently reliable basis for remedial EIA. The principal deficiency in the rEIAR is therefore not simply that individual environmental effects may have been underestimated. The document repeatedly moves between three different environments: the environment described in 2017, the environment during and immediately following construction and the peat failure in 2019–2021, and the altered and partly remediated environment surveyed in 2024–2026. As previously stated those environments cannot be treated interchangeably.

2.38 The later surveys provide increasingly good information about recovery. They do not necessarily provide increasingly good information about what was lost or damaged before those surveys occurred. That problem is demonstrated most starkly by the Shruhanagarve. There is no measured pre-slide biological Q-status baseline; its condition is assumed from other watercourses. Yet that assumed baseline is subsequently relied upon to conclude that the watercourse has returned to its pre-construction condition. At the same time, the rEIAR acknowledges that approximately 1,070 metres of its original channel morphology was lost and reconstructed, while the earlier aquatic investigation found severe siltation extending more than 14 km downstream and predicted long-term effects.

2.39 Similarly, post-construction ecological surveys cannot retrospectively observe habitats or species utilisation removed before those surveys commenced; present stability cannot establish the degree

of instability existing during construction; successful remediation cannot erase the environmental damage which made remediation necessary; and natural recovery cannot retrospectively convert a significant environmental effect into an insignificant one.

2.40 The rEIAR nevertheless repeatedly asserts that no limitations were encountered and places substantial weight upon the quantity of information subsequently collected. Quantity of later information is not a substitute for missing contemporaneous baseline or impact information. Accordingly, before undertaking EIA the Commission must identify expressly which conclusions in the rEIAR are supported by contemporaneous pre-construction and construction evidence, which are retrospective reconstructions, which depend upon assumptions or proxy evidence, and which environmental effects can no longer reliably be reconstructed.

2.41 If those evidential deficiencies prevent the Commission from establishing the nature, magnitude, duration, cumulative effects and interactions of the environmental effects which actually occurred, the deficiency is not capable of being cured by the fact that the environment has subsequently recovered. The Commission would not have before it the information necessary to conduct the full remedial Environmental Impact Assessment required by EU law and could not lawfully rely upon the rEIAR as an adequate basis for granting substitute consent.

2.42 Given the scale and materiality of the departures from the development originally assessed, the Commission is requested to require the applicant to undertake a systematic comparison between the original EIAR and the rEIAR. It should not fall upon observers, or ultimately upon the Commission, to search across thousands of pages to identify where the original assessment predicted one environmental outcome and the subsequent evidence demonstrates another. For each relevant environmental factor, the applicant should identify the original baseline, the effects originally predicted, the mitigation relied upon, what was actually constructed, what environmental effects actually occurred, and whether the rEIAR now reaches a different conclusion. Any difference should be expressly identified and scientifically explained.

2.43 The applicant should similarly identify every material limitation, assumption or evidential lacuna affecting that comparison. In particular, it should distinguish genuine pre-construction baseline information from information obtained during construction, following the peat slide, following remediation, or from surveys undertaken years later. Where the original baseline does not contain sufficient information for the location or form of development actually constructed, or where an historic environmental condition has been reconstructed by assumption, extrapolation or proxy evidence, this should be expressly identified together with the resulting degree of uncertainty. Later evidence of environmental recovery cannot retrospectively supply environmental information which was never collected before or during the unauthorised works.

2.44 There is at least one clear example demonstrating why that exercise is necessary. The applicant's earlier aquatic evidence following the November 2020 peat slide predicted that impacts would “last long-term”, whereas the 2026 rEIAR now characterises the significant effects as temporary and relies upon subsequent recovery and the absence of significant residual effects. The rEIAR nevertheless accepts that the peat slide caused significant effects upon aquatic habitats and species for approximately 14 kilometres and contributed to existing pressures upon the catchment. That change in assessment may or may not have a valid scientific explanation, but the applicant should be required to identify the explanation, the evidence which caused the earlier conclusion to be revised, and whether the later characterisation describes the significance of the effect when it actually occurred, rather than merely the residual condition several years later.

2.45 The same reconciliation is required for cumulative and interacting effects. The applicant should identify where the original EIAR predictions, the material deviations, the unauthorised construction, forestry and peat disturbance, the peat slide, downstream pollution, emergency works, remediation and the remaining prospective development have been assessed together across the periods in which their effects actually interacted. The fact that an effect subsequently ceased or a receptor recovered does not establish that cumulative effects did not occur during the period when environmental pressures coincided. Nor should remediation necessitated by environmental damage be treated simply as a separate positive environmental effect without first accounting fully for the damage which made that remediation necessary.

2.46 Accordingly, before completing its EIA, the Commission should either require the applicant to provide this reconciliation or itself expressly undertake and record that exercise. In the absence of such an exercise, it is impossible to determine with confidence whether apparent differences between the original predictions, contemporaneous post-event findings and present rEIAR conclusions represent genuine environmental recovery (allbeit permantly inhibting the natural growth and stagnating habitats and populations) with an ongoing revised scientific understanding, different assessment methodologies, incomplete historic information, or unresolved contradictions. The applicant bears the responsibility for demonstrating that the rEIAR and its underlying evidence are sufficiently complete, consistent and robust to permit a lawful retrospective assessment of the full direct, indirect, cumulative and interacting effects of the development actually carried out.

**3. Appropriate Assessment .**

3.1 The Appropriate Assessment regime is legally distinct from Environmental Impact Assessment and imposes a materially more stringent evidential test. The applicant itself correctly states that a lawful Appropriate Assessment must identify, in light of the best scientific knowledge, all aspects of the project which may affect the conservation objectives of a European site; must contain complete, precise and definitive findings and conclusions without lacunae or gaps; and can exclude adverse effects on site integrity only where no reasonable scientific doubt remains. The applicant further acknowledges that where adverse effects cannot be excluded, the process must proceed to consideration of alternatives and, where applicable, Article 6(4) IROPI.

3.2 That test is of particular importance here because this is no longer a prospective assessment of theoretical environmental risks. The rNIS accepts that the November 2020 peat slide produced negative effects upon the River Finn SAC and River Foyle and Tributaries SAC and that effects upon qualifying habitats and species extended approximately 14 km through the Shruhanagarve and Mourne Beg Rivers. It further expressly acknowledges that the peat slide "did contribute to the existing pressures on the catchment" arising from surrounding land uses including forestry and agriculture. The River Foyle and Tributaries SAC assessment itself identifies complete source-pathway-receptor chains from the development through water pollution to Atlantic salmon, protected watercourse habitat and otter.

3.3 The Commission should therefore require the applicant to demonstrate, rather than merely assert, how those proven effects can be reconciled with the ultimate conclusion that the peat-slide effects were temporary, short-term and "did not undermine the integrity of these European Sites". In particular, the applicant should identify the evidence capable of establishing retrospectively, beyond reasonable scientific doubt, the condition of each affected qualifying interest immediately before the event, the magnitude and geographical extent of the effect upon it, its duration, its interaction with pre-existing pressures, and whether any conservation-objective attribute or target was adversely affected during the period of impact. The absence of a significant residual effect in

2026 is not, without more, proof that site integrity was not adversely affected when the event occurred.

3.4 There is also a significant issue concerning the division of the assessment between the rNIS and NIS. The applicant defines the "Subject Development" as the Existing and Prospective Developments combined, yet the rNIS purports to provide the information necessary for an Article 6(3) assessment of the Existing Development while the NIS separately purports to provide the information necessary for an Article 6(3) assessment of the Prospective Development. The NIS goes further and expressly states that the effects of the November 2020 peat slide are considered in the rNIS "not this NIS." The Commission should therefore demonstrate precisely where it has undertaken a single integrated assessment of the implications of the whole Subject Development, including the proven effects of its construction history, rather than deriving an Article 6(3) conclusion by combining separate assessments of retrospectively and prospectively defined portions of the same project.

3.5 That concern becomes more material in the cumulative assessment. The NIS reasons that because the peat-slide effects are no longer ongoing or residual, the Existing Development "cannot contribute to any effect in cumulation with the Prospective Development". The rNIS similarly acknowledges that the peat slide contributed to existing catchment pressures but then relies upon the effects being temporary and no longer residual to exclude continuing cumulative effects. That reasoning requires rigorous examination against Article 6(3). An effect does not cease to have occurred in combination with another pressure merely because it subsequently ended. The relevant question includes whether the project adversely affected site integrity, alone or in combination, during the period when those pressures coincided.

3.6 The attached drone photographs Figs 3.1 to 3.10), taken shortly after the peat slide, demonstrate the physical scale and extent of the peat displacement. The peat which was displaced cannot simply be reinstated to its former position or condition. It is therefore difficult to reconcile the conclusion that the effects on the peat environment are no longer ongoing with the physical reality demonstrated by the photographs. The event fragmented and physically disrupted the bog, altered its structure and continuity, and potentially affected its hydrological and ecological functioning. Subsequent stabilisation or revegetation should not therefore be equated with restoration of the pre-development peatland. The relevant question is whether the bog has actually been restored to its former structure, integrity and function, and, if not, what continuing and irreversible effects arise from that fragmentation and disturbance and the interplay with the surrounding feathered such as waterbodies.

3.7 Accordingly, the Commission should require the applicant to provide a consolidated AA reconciliation demonstrating, for each screened-in European site and each affected qualifying interest, the original conservation-objective baseline, the effects originally predicted, what actually occurred, the contemporaneous evidence of effect, the duration and geographical extent of that effect, the pre-existing pressures with which it interacted, the remediation undertaken, the evidence of subsequent recovery and the scientific basis upon which adverse effects on site integrity are nevertheless excluded beyond reasonable scientific doubt. Where that evidence cannot now be reconstructed completely, precisely and definitively, the resulting lacuna cannot be cured by relying upon subsequent recovery. It is precisely such unresolved scientific uncertainty that Article 6(3) does not permit the competent authority to disregard.

**3.8 Hen Harrier and the Biodiversity Management and Enhancement Lands.** The NIS identifies the Biodiversity Management and Enhancement Plan ("BMEP") lands as areas to be managed

specifically for Hen Harrier habitat and peatland habitat enhancement. The prospective development itself expressly includes "biodiversity enhancement measures", including peatland restoration and Hen Harrier habitat areas, as a component of the development for which permission is sought.

3.9 At the same time, however, the NIS excludes likely significant effects upon SPAs at screening stage and consequently states that the extensive bird surveys undertaken for the project "are not relevant to this NIS". The NIS explains that SPA connectivity was assessed using Scottish Natural Heritage guidance concerning dispersal and foraging ranges and that sites for which a pathway was identified were brought forward for further assessment.

3.10 That creates an issue requiring clarification. If no likely significant effect upon any SPA or its Special Conservation Interests exists, the applicant should explain the ecological and planning purpose for which substantial lands are incorporated within the application specifically for the provision or enhancement of Hen Harrier habitat.

3.11 The Commission should in particular establish whether those lands are genuinely additional biodiversity enhancement unrelated to any predicted effect of the wind farm, or whether their provision responds, wholly or partly, to predicted displacement, disturbance, habitat loss, deterioration of foraging habitat, collision risk or other effects upon Hen Harrier arising from the construction or operation of the Subject Development.

3.12 Measures which genuinely avoid or reduce an identified adverse effect may, where properly assessed, form part of the Article 6(3) assessment. Measures whose purpose is instead to compensate for ecological loss after that loss occurs stand on a fundamentally different footing. Article 6 of the Habitats Directive distinguishes preventative measures from compensatory measures, the latter belonging to the Article 6(4) derogation regime. The Court of Justice has repeatedly emphasised that this distinction cannot be avoided merely by describing replacement or enhancement habitat as mitigation. See, in particular, Briels, Case C-521/12.

3.13 The matter is particularly relevant because the NIS has screened out SPA effects entirely. If the Hen Harrier habitat measures are required because the operational wind farm would otherwise diminish the quantity, quality or availability of habitat used by Hen Harrier associated with a protected SPA, that underlying effect must first be identified and assessed under Article 6(3). It cannot lawfully disappear from the screening exercise merely because alternative or enhanced habitat is proposed elsewhere.

3.14 Conversely, if the BMEP Hen Harrier measures have no relationship whatsoever to an effect upon an SPA population or functionally linked habitat, the applicant should state that expressly and identify the independent ecological basis upon which those measures form part of the proposed development. The Commission should therefore require the applicant to identify:

- the Hen Harrier population for whose benefit the BMEP lands are proposed;
- whether that population is associated with any SPA;
- whether Hen Harrier recorded using the development site are considered part of, or ecologically connected with, an SPA population;
- the existing and proposed habitat value of the BMEP lands;
- the predicted effect of the turbines and associated infrastructure upon Hen Harrier habitat use, displacement and collision risk;
- the specific reason why Hen Harrier habitat enhancement forms part of the Subject Development; and

- whether the BMEP measures are avoidance, mitigation, restoration, enhancement or compensation for an identified project effect.

3.15 Until those matters are established, the Commission cannot safely assume both that the Hen Harrier enhancement lands are necessary components of the development and that the extensive bird evidence underpinning them is irrelevant to Appropriate Assessment because effects upon all SPAs have already been excluded at screening. In the following paragraphs WID expressly identifies the presence of Hen Harriers at the development which appears to be part of their normal habitat.

**3.16 Hen Harrier: External Scientific Evidence and the Importance of the Meenbog Site.** Wild Ireland Defence wishes to draw the Commission's particular attention to three external scientific and conservation documents submitted with this observation. These documents are not documents prepared by or on behalf of the developer. They provide important independent context against which the applicant's assessment of effects upon Hen Harrier Circus cyaneus, an Annex I species under Directive 2009/147/EC, should be examined.

3.17 The first, and most directly relevant, is Ruddock, M., Wilson-Parr, R., Lusby, J., Connolly, F., Bailey, J. & O'Toole, L. (2024), The 2022 National Survey of breeding Hen Harrier in Ireland, Irish Wildlife Manuals No. 147, National Parks and Wildlife Service ("IWM 147" appendix 3.1). This is the fifth national survey of breeding Hen Harrier and was undertaken by the Golden Eagle Trust, Irish Raptor Study Group and BirdWatch Ireland on behalf of NPWS. Its purpose included establishing the abundance and distribution of breeding Hen Harrier and documenting pressures and threats affecting the species.

3.18 IWM 147 contains evidence of exceptional relevance to the present application because Meenbog is expressly identified by name. In its assessment of regional population change, the report records that the Blue Stack Mountains, Pettigo Plateau and south Donegal population, having increased substantially up to 2015, subsequently declined by 42% between 2015 and 2022. The authors then state:

"several known pairs have been reported by surveyors in 2022 to have been likely displaced by recent wind energy developments, including e.g. due to works at Meenbog (Co. Donegal) where extensive environmental damage was caused due to peat slippage."

3.19 This is highly material independent evidence. The Commission is therefore not dealing simply with a site upon which Hen Harrier might theoretically occur. The national survey commissioned by the State's nature-conservation authority identifies Meenbog itself in the context of the likely displacement of known Hen Harrier pairs, against the background of a 42% decline in the relevant regional population.

3.20 The national conservation position makes that site-specific evidence still more significant. IWM 147 concludes that the Irish breeding population has declined by more than 50% over approximately 25 years and now meets the population-decline criterion for Red-listing. It calls for increased and urgent conservation management. The report further recommends that conservation status be assessed using the best available data and that monitoring and protection extend both within and outside the SPA network, specifically so that better information is available for decision-making concerning sectors including renewable energy.

3.21 The second external document is the National Parks and Wildlife Service (2021), Hen Harrier

Conservation and the Wind Energy Sector in Ireland – Supporting Document to the Hen Harrier Threat Response Plan (appendix 3.2). This is particularly relevant because it identifies South Donegal 1 as a non-designated Hen Harrier breeding population area. Table 7 records that this area supported 11 pairs, extended to approximately 24,337 ha, and already contained 21 turbines. The significance of this evidence is that important Hen Harrier populations are not confined to the six SPAs designated for breeding Hen Harrier. The Commission must therefore consider the ecological importance of the Meenbog population in its actual regional context (per birds directive as an ex situ site or a site that should have been designated an SPA per the EU criteria) rather than treating the absence of a Hen Harrier SPA designation at the development site as equivalent to an absence of conservation importance.

3.22 That NPWS document identifies the principal interactions between wind-energy development and Hen Harrier as loss of or displacement from breeding foraging and nesting habitat; direct disturbance of nesting and roosting birds; loss of or displacement from winter foraging and roosting habitat; and collision mortality. It records that operating turbines can exert displacement pressure upon nesting and foraging Hen Harrier and identifies a recommended 500–750 m minimum setback in relation to disturbance of nesting attempts.

3.23 Of particular importance to the proposed biodiversity/habitat enhancement measures, the same NPWS document expressly cautions that the effectiveness of Hen Harrier habitat-offsetting measures requires further research. It states that focused research is required to establish whether such works are effective in supporting Hen Harrier. It also recommends avoidance of turbine installation on open heath/bog habitat and avoidance of disturbance to breeding and roosting birds.

3.24 Most importantly for the legal characterisation of the measures now proposed at Meenbog, the NPWS document itself distinguishes habitat offsetting from mitigation for the purposes of Article 6(3), stating that creation of habitat to offset effects “has been determined not to be mitigation (in the meaning of a Habitats Directive Article 6(3) assessment)”, but rather a measure falling to be assessed under Article 6(4). That external NPWS guidance is directly relevant to the Commission's examination of whether measures described as habitat enhancement can properly be relied upon to remove or reduce an identified adverse effect at the Article 6(3) assessment stage.

3.25 The third external document is the Hen Harrier Project, European Innovation Partnership Final Report 2017–2023 (appendix 3.3). Unlike IWM 147, this report does not appear from WIDs review to identify Meenbog specifically, and Wild Ireland Defence does not suggest otherwise. Its relevance is contextual and scientific rather than site-specific. It records the conservation-management experience gained through the Hen Harrier Project and the practical measures required to maintain and restore habitat for the species. It should therefore be read alongside the two NPWS publications and the applicant's proposed Biodiversity Management and Enhancement Plan, rather than presented as independent evidence of a Hen Harrier record at Meenbog.

3.26 The external evidence should then be considered alongside what the developer itself now accepts in Chapter 7, Ornithology of the EIAR. The applicant records confirmed Hen Harrier nests within the Wind Farm Site in 2020, 2021, 2024 and 2025, at four locations between approximately 200 m and 660 m from the nearest proposed turbine locations, and considers these likely to represent the same pair returning to its breeding territory. The applicant consequently classifies the breeding Hen Harrier population using the site as being of National Importance.

3.27 The applicant further records Hen Harrier using the Wind Farm Site for both hunting and breeding (ex situ site at present), accepts that direct habitat loss cannot be excluded, accepts that disturbance/displacement cannot be excluded and accepts that collision risk cannot be excluded.

3.28 There is therefore an important convergence between the independent and developer-generated evidence. NPWS's 2022 National Survey independently identifies Meenbog as a location where known Hen Harrier pairs were reported as likely to have been displaced by wind-energy works. The developer's subsequent surveys then demonstrate continued and repeated breeding within the Wind Farm Site in 2020, 2021, 2024 and 2025 and classify that breeding population as nationally important.

3.29 That chronology demonstrates that the ecological significance of Meenbog for Hen Harrier is neither speculative nor dependent exclusively upon the developer's survey evidence. The State's national Hen Harrier survey independently identified Meenbog in the context of displacement of known pairs; the State's specific review of Hen Harrier and wind energy identifies South Donegal as an important non-designated breeding area and recognises displacement, disturbance and habitat loss as mechanisms by which wind development can affect the species; and the developer's own subsequent surveys establish repeated breeding within the development site itself.

3.30 Accordingly, Wild Ireland Defence submits that the Commission should expressly address this external evidence in its assessment and should not determine the Hen Harrier issue solely by reference to the conclusions presented in the applicant's EIAR/NIS. In particular, the Commission should satisfy itself, on the basis of the best available scientific evidence, whether the development would contribute to further loss, fragmentation or displacement of breeding and foraging habitat within a regional population which IWM 147 records as having already declined by 42% between 2015 and 2022, and in respect of which that same national survey specifically identifies works at Meenbog as a reported cause of likely displacement of known pairs.

**Figs 3.1 – 3.11 depicting the aftermath of the peat slide.**























**4. Water Framework Directive- Demonstrated deterioration and the November 2020 peat slide.**

4.1 The Water Framework Directive assessment raises a particularly important issue because this is not a case in which deterioration is merely hypothetical. The developer's rEIAR Appendix 9-3, Water Framework Directive Compliance Assessment Report expressly records that the Mourne Beg River (Derrygoonan) surface water body deteriorated from Moderate to Poor status in the latest WFD cycle and states that this deterioration is a "likely consequence of the November 2020 Peatslide".

4.2 The assessment elsewhere records that the November 2020 peat slide entered the Shruhanagarve Stream and resulted in liquefied peat travelling downstream, causing significant negative effects upon both the River Finn SAC and River Foyle and Tributaries SAC. The assessment therefore establishes both a direct hydrological pathway and an actual significant pollution event.

4.3 The difficulty is the manner in which the WFD assessment subsequently treats that deterioration. It relies principally upon monitoring showing that suspended solids subsequently reduced, biological Q-ratings recovered and conditions returned towards their pre-slide baseline. On that basis, the effects of the peat slide are characterised as "temporary" or "short-term".

4.4 That approach requires particularly careful examination against Article 4(1) WFD. In Case C-461/13, Weser, the Court of Justice established that the prohibition on deterioration is binding at individual project level and that deterioration occurs where the status of at least one relevant quality element falls by one class, even where that does not result in a change in the overall classification of the water body.

4.5 More importantly in the circumstances of Meenbog, the subsequent judgment in Case C-525/20, Association France Nature Environnement establishes that temporary or short-term effects cannot simply be disregarded because they do not have lasting consequences. Such effects may be excluded only where, by their nature, they are obviously minor and incapable of producing deterioration for the purposes of Article 4.

4.6 That principle appears directly engaged here. The developer's own evidence does not describe the 2020 event as minor: it describes significant negative effects, records elevated suspended solids downstream, and acknowledges an actual deterioration of the Mourne Beg River (Derrygoonan) from Moderate to Poor which it considers likely attributable to the peat slide. Subsequent

ecological recovery is plainly relevant evidence, but it does not retrospectively establish that legally relevant deterioration never occurred.

4.7 There is also an apparent internal inconsistency which the Commission should resolve. The rWFD assessment acknowledges that the Mourne Beg River (Derrygoonan) deteriorated to Poor status and attributes that deterioration to the peat slide, yet subsequently concludes that the Existing Development "did not result in any effect on WFD status of any SWB or GWB." Those propositions are difficult to reconcile without a considerably more detailed quality-element assessment.

4.8 This assumes additional importance because several receiving water bodies are already environmentally vulnerable. The assessment identifies Mourne Beg_010 as remaining at Poor status, Mourne Beg River (Derrygoonan) as Poor, Mourne Beg (Lisnacloone) as Moderate, and Derg River (Millbrook) as Poor, with most relevant Foyle catchment water bodies identified as being at risk of failing their WFD objectives.

4.9 For the prospective development, the applicant relies heavily upon mitigation to conclude that there will be no deterioration and no cumulative or in-combination effect. That conclusion includes reliance upon the proposed mitigation of other wind farms within the same hydrological study area. Given that mitigation associated with the Existing Development did not prevent the 2020 peat slide and consequent significant downstream effects, the Commission should independently satisfy itself that the proposed measures provide the necessary evidential basis for the conclusion of WFD compliance rather than simply adopting the applicant's predicted post-mitigation outcome.

4.10 Accordingly, WID submits that the Commission must undertake its own Article 4 assessment addressing the actual deterioration which has already occurred, the individual WFD quality elements affected, the significance of the deterioration from Moderate to Poor, the legal consequences of temporary deterioration under Association France Nature Environnement, and the cumulative implications of completing the development within water bodies already failing, or at risk of failing, their WFD objectives. The fact that water quality subsequently recovered cannot, without further analysis, substitute for that assessment.

**5.1 Failure to undertake proper transboundary consultation.** The development is plainly capable of giving rise to transboundary environmental effects. The Wind Farm Site lies within the Foyle international river basin district; the Mourne Beg River flows from the vicinity of the site into Northern Ireland and onward through the River Derg system. The applicant's own WFD material acknowledges that approximately 3% of the Foyle river basin district lies within Northern Ireland and that the Mourne Beg crosses the border shortly downstream of the Wind Farm Site.

5.2 Notwithstanding that obvious transboundary context, the consultation material identified by WID appears to show requests for consultation being issued to the Loughs Agency and the Department for Infrastructure Northern Ireland, but no equivalent consultation request to the Department of Agriculture, Environment and Rural Affairs (DAERA) has been identified.

5.3 That omission requires explanation. DAERA is the Northern Ireland Department responsible for environmental advice in the planning process. Its Planning Response Team is the single point of contact for planning consultations and provides an integrated response across DAERA's environmental responsibilities. DAERA expressly identifies wind farms as a class of development requiring consultation where natural-heritage effects may arise, and its published

guidance states that applications accompanied by an Environmental Statement fall within statutory EIA consultation arrangements in Northern Ireland.

5.4 The issue is important because neither consultation with the Loughs Agency nor with the Department for Infrastructure necessarily substitutes for consultation with the Northern Ireland authority responsible for natural environment, biodiversity, water quality, fisheries and related environmental interests. DAERA's published material and information on Irish Local authority sites boarding Northern Ireland, expressly records that DAREA's remit includes designated sites, priority habitats and species, and developments capable of affecting the natural environment.

5.5 The obligation is not confined to consultation between government bodies. Article 7 of the EIA Directive and the Espoo Convention require a transboundary procedure which enables the affected State and the public in the affected territory to participate before the development decision is taken. Article 4 of the Espoo Convention requires the EIA documentation to be provided to the affected Party and arrangements to be made for its distribution both to relevant authorities and to the public in areas likely to be affected, with an opportunity to submit comments before the final decision.

5.6 That requirement assumes particular significance here because transboundary effects are no longer merely theoretical. The November 2020 peat slide entered the Shruhanagarve Stream and caused liquefied peat and sediment to travel downstream through a catchment which crosses into Northern Ireland. The applicant's own remedial WFD assessment records significant negative downstream effects and expressly recognises hydrological connectivity to the River Foyle and Tributaries SAC.

5.7 WID therefore requests that the Commission identify precisely what transboundary procedure has been undertaken in respect of the present substitute-consent and prospective-consent applications. In particular, the Commission should identify whether DAERA was formally notified; what environmental documentation was furnished to it; whether DAERA elected to participate; whether the Northern Ireland public was notified and afforded an equivalent opportunity to inspect the rEIAR, EIAR, rNIS and NIS and submit observations; and how any resulting observations have been taken into account.

5.8 If no such consultation has occurred, consultation with individual Northern Ireland bodies cannot simply be treated as equivalent to the transboundary procedure required by EU and international environmental law. The Commission must be satisfied that the affected jurisdiction and its public have been afforded meaningful participation before any decision is made.

**6. Peat Stability, bog integrity and irreversible environmental effects.**

6.1 The peat issue cannot be reduced to the question of whether the remaining construction works can now be engineered so as to avoid a second catastrophic failure. The November 2020 event has already fundamentally altered the receiving peatland environment. The relevant assessment must therefore address not only future geotechnical stability, but the permanent physical, hydrological, ecological and carbon consequences of the failure and of the wider fragmentation caused by the development already constructed.

6.2 The most important external evidence is the GSI/NPWS report, Assessment of Main Contributing Factors Leading to Three Major Peatland Failures in Leitrim, Kerry and Donegal (appendix 6.1)

- Main Factors Considered to Have Contributed to Three Major Peat Failures in 2020. This report was prepared independently by Fehily Timoney on behalf of Geological Survey Ireland and NPWS. It records that the Meenbog failure occurred during the unauthorised construction of the floating wind-farm access road across blanket bog, involved an estimated 86,240 m³ of failed peat, produced an upper scar approximately 260 m long and up to 120 m wide, and affected an estimated 2.4 hectares in the upper scar alone.

6.3 The external GSI/NPWS investigation is also considerably more definitive as to causation than any suggestion that the event was simply attributable to unusual weather. It identifies the key triggering activity as construction of the floating access road close to a convex break in slope and directly downslope of deep blanket bog containing peat of very low shear strength. It identifies additional conditioning factors including forestry drainage, deep peat, previous forestry use and hydrological modification. Materially, it records that there was no clear significant peak rainfall event immediately before the failure and concludes that the same weather affected similar nearby sites without causing failure, pointing to construction activity together with site-specific drainage factors as the predominant cause.

6.4 That finding is particularly significant because the national landslide susceptibility mapping had classified the failure location as having low susceptibility. The separate external GSI/NPWS Task 4 report records that Meenbog, Shass Mountain and Mount Eagle all failed in areas mapped as Low or Moderately Low susceptibility and concludes that peat-specific assessment needs to take account of additional factors including peatland condition, breaks in slope, roads, infrastructure, forestry, artificial drainage and historic failures. The Commission should therefore be cautious about relying upon conventional slope-based stability classifications as establishing an acceptably low future risk at this site.

6.5 The applicant's own current material demonstrates why that caution is necessary. The 2026 Peat Stability Assessment contains locations where information remains unavailable and parameters are expressly assumed on the basis of general onsite experience. Some locations are assigned pre-mitigation hazard likelihoods of “Possible” or “Very Possible”; for example, the floating road to T07 receives a total hazard rating of 70, corresponding to “Very Possible” prior to mitigation. Similar worksheets for turbine areas record assumed peat properties, unknown seepage conditions, low factors of safety and the fact that a slide has already occurred on or adjacent to the site.

6.6 The CEMP itself provides further evidence that the residual geotechnical uncertainty is real. It states that the November 2020 failure involved an “unforeseen body of very weak peat” and consequently requires confirmatory re-testing immediately before works recommence in each area, monitoring for ground movement, proof testing and restrictions during or after heavy rainfall. It expressly recognises that heavy intense rainfall can, in extreme circumstances, trigger large-scale peat failure. The CEMP further records a fundamental “lesson learned” from the failure: no further construction of floating roads on the Wind Farm Site is to be carried out.

6.7 Those controls may reduce the risk of another failure. They do not establish that the peatland has been restored or that the effects of the first failure are no longer ongoing. That clarification is essential. The question the Commision must ask itself is not merely whether the site can now be made safe enough to finish construction, but what environmental functions have already been lost through excavation, drainage, compression, road construction, foundations, peat storage, the catastrophic displacement event and subsequent remediation.

6.8 The independent scientific paper by Alan P. Dykes, Landslide investigations during pandemic restrictions: initial assessment of recent peat landslides in Ireland (appendix 6.2) is particularly relevant in this respect. It identifies peat failures as environmentally damaging because highly humified peat is a strong pollutant to aquatic life, but also because failures result in "fragmentation, exposure, oxidation and associated release of carbon dioxide" from what the paper describes as one of the Earth's most effective carbon-storing materials. The same paper concludes that the Meenbog bogflow appears to have resulted from removal of toe support by an earlier peat flow which was itself probably caused by construction of an access road.

6.9 Accordingly, the assessment should address peat not merely as "soil" or geotechnical material but as a functioning carbon store, hydrological system and peatland ecosystem. Once an intact or semi-intact peat mass is fractured by roads, drainage channels, deep excavations and failure scars, its environmental function cannot necessarily be restored by revegetating exposed surfaces or stabilising individual scars. Fragmentation alters water movement and exposes peat to drying and oxidation; drainage and cracking provide pathways into deeper, more decomposed peat; and the external GSI/NPWS investigation expressly identifies those processes as relevant conditioning factors at Meenbog.

6.10 The Commission should therefore require the applicant to quantify, so far as scientifically possible, the full carbon and peatland-function consequences of the Existing Development and peat failure: the volume and area of peat permanently excavated, compressed, displaced or exposed; the extent of changed drainage; the area of bog fragmented by roads and foundations; the quantity of peat no longer functioning under its original hydrological regime; the consequential oxidation and carbon emissions; and whether the remaining peatland continues to operate as an integrated hydrological unit. It should also distinguish clearly between stabilisation, revegetation, rehabilitation and true restoration to pre-development ecological and hydrological function.

6.11 That distinction is particularly important in light of the photographic evidence submitted with this observation. The post-failure drone imagery demonstrates the physical scale of the rupture and displacement. The peat cannot simply be returned to its original stratigraphy, structure and hydrological relationship with the surrounding bog. The Commission should therefore require a clear statement as to which areas can genuinely be restored and which cannot, rather than accepting "reinstatement" or "rehabilitation" terminology as synonymous with restoration.

6.12 The current assessment also needs to explain how it has incorporated the external GSI/NPWS findings into the 2026 stability analysis. The independent report identifies not only the road construction as the principal trigger but also deep weak peat, forestry drains, previous land-use damage and modified hydrology as interacting conditioning factors. Those are landscape-scale characteristics. The Commission should therefore be satisfied that the prospective assessment has not treated future stability simply as a series of isolated turbine, road or hardstand calculations without adequately accounting for the altered integrity of the peatland system as a whole.

6.13 Finally, the fact that substantial additional mitigation is now proposed cannot erase the significance of what has already occurred. Many of those measures exist because the original assessment and construction controls did not prevent failure. The prohibition on further floating roads, confirmatory pre-construction testing, permit-to-work procedures, independent geotechnical oversight, rainfall restrictions and ground-movement monitoring are evidence of lessons learned from a realised hazard; they are not evidence that the original environmental risk was insignificant.

6.14 For those reasons, the Commission should not confine the peat assessment to whether another catastrophic slide is now unlikely after mitigation. It must determine whether the unauthorised development has already caused irreversible fragmentation, permanent loss of peatland structure and function, continuing hydrological alteration and carbon consequences, and whether those effects have been fully identified and assessed. If they have not, the peat assessment cannot provide a reliable basis for concluding that the environmental effects of the development are capable of satisfactory remediation or that substitute consent should be granted.

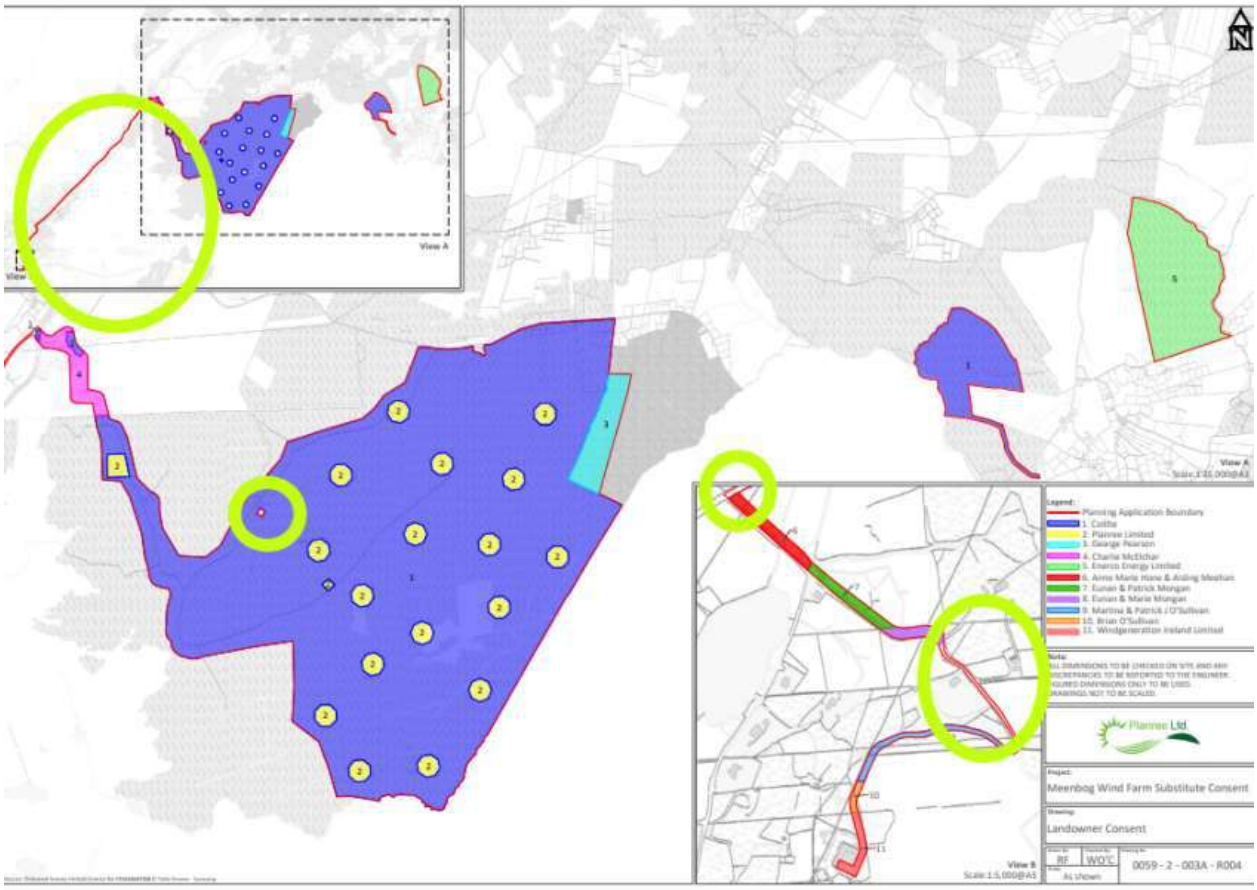



**Figure 7.1 –** unidentified ownership within development site circled in green.

**7. Landownership, landowner consent and unidentified lands within the application boundary**.

7.1 The documentation submitted concerning landownership and landowner consent appears incomplete and requires clarification before the application can properly be determined. Drawing No. 0059-2-003A-R004, "Landowner Consent", identifies the planning application boundary by a red line and provides a colour-coded legend identifying eleven stated landowners or parties whose lands are said to be relevant to the application. Those parties include Coillte, Planree Limited and a number of private landowners.See Figure 7.1 where the relevant obvious areas with no ownership identified, have been circled in lime green.

7.2 However, examination of the drawing indicates that not all lands enclosed by the red planning

application boundary are attributed to one of the identified landowners. This is particularly apparent along the southern/access-road portion of the application boundary shown in View B. There are areas enclosed within the red line which remain white/uncoloured and which therefore do not appear, on the face of the submitted landowner-consent drawing, to correspond with any of the eleven ownership categories identified in the legend.

7.3 This creates a material ambiguity. Either those lands are within the ownership or control of one of the identified parties but have inadvertently not been coloured on the drawing, or they comprise lands in some other ownership for which no corresponding owner is identified on the drawing. The application documentation should make clear which is the case.

7.4 This issue is not resolved merely by the existence of the bundle of letters of consent. Those letters relate to identified parties and identified lands. For example, the Coillte letter expressly limits its consent to the submission of the application insofar as the development concerns the Coillte property shown on the accompanying map, and describes that property as the lands shown in yellow and blue. Other letters similarly consent to Planree Limited including the signatories' "identified lands" in the application. The existence of such consents therefore does not, without further explanation, establish ownership of or consent in respect of the uncoloured areas.

7.5 This is particularly important because this is not simply a question of whether the applicant owns the land. Where an application includes lands belonging to persons other than the applicant, the statutory planning procedures concerning ownership, notification and consent exist to protect the procedural rights of persons whose property interests may be affected by the application. The Commission should therefore be satisfied that every parcel of land falling within the application boundary has been accounted for, whether by applicant ownership, landowner consent, an existing legal right or easement, or the appropriate statutory notification procedure.

7.6 There is a further distinction which should be maintained between ownership of land and the existence of lesser property rights. The submitted material itself demonstrates that some interests relevant to the development may take the form of easements rather than ownership. The Windgeneration Ireland documentation, for example, concerns easement rights associated with defined servient premises and an underground passage/run for utilities. Accordingly, identifying the registered or beneficial owner of the surface land alone may not necessarily identify every person possessing a legal interest capable of being affected by the development.

7.7 The Commission should therefore require the applicant to provide an unambiguous cadastral/landownership schedule and corresponding map accounting for the entirety of the red-line application area and identifying, parcel by parcel, the basis upon which the lands are included in the application. In particular, an explanation should be provided for every white or otherwise unallocated area appearing within the application boundary on Drawing No. 0059-2-003A-R004.

7.8 Where the identity of an owner or holder of an affected property interest was not known to the applicant, the applicant should also be required to identify what reasonable enquiries and measures were undertaken to establish that person's identity and interest. That should include, as appropriate, examination of Land Registry/Registry of Deeds information, title documentation, known easements and wayleaves, adjoining ownership information and other reasonably available sources. It should not simply be assumed from an inability to identify an owner that no relevant property right exists.

7.9 This is particularly important in the context of a substitute-consent application. The application

concerns development which has already been carried out, at least in part. Consequently, the issue is not merely whether consent exists for proposed future works. It must also be clear upon whose lands the development already undertaken was carried out and what legal or consensual basis existed for the use of those lands. If any element of the existing development was constructed upon land for which the owner or relevant rights-holder has not been identified, that fact requires express examination rather than being obscured by an incomplete ownership map.

7.10 Accordingly, the Commission is requested to require clarification identifying:

- the owner or relevant interest-holder for every area within the red planning application boundary, including each presently white/uncoloured area;
- the nature of the applicant's entitlement to include each such parcel within the application;
- the corresponding consent, easement, wayleave or other legal interest relied upon;
- where an owner or rights-holder has not been identified, the reasonable measures undertaken to identify and notify that person; and
- confirmation that all persons whose ownership or property rights may be affected by either the existing unauthorised development or the prospective development have been dealt with in accordance with the applicable statutory requirements.

Until that information is supplied, the submitted Landowner Consent drawing does not appear capable of demonstrating that the entirety of the application site has been accounted for in terms of ownership and affected property rights.

**8. Conclusion.**

8.1 This application arises from exceptional circumstances. The development was not merely constructed with minor deviations from its permission; the courts determined that the departures were sufficiently material that the development as constructed could not be treated as the development which had been authorised. Those unauthorised works were followed by a major peat failure which caused proven significant environmental effects extending well beyond the development site.

8.2 Substitute consent is an exceptional remedial procedure. It should not operate so that development which could not lawfully have proceeded had its true environmental risks and material departures been known in advance is placed in a more favourable position because those risks have now materialised, substantial works have already been completed, and some affected receptors have subsequently recovered. The passage of time and successful remediation cannot substitute for the environmental assessment and lawful consent which were required before the development occurred.

8.3 The deficiencies identified in this observation are not advanced as technical objections for their own sake. They concern whether the Commission has before it evidence sufficiently complete and robust to reconstruct the actual environmental consequences of the development: the appropriate pre-development baseline; the differences between what was assessed and what was constructed; the cumulative and interacting effects of the unauthorised works and peat failure; the acknowledged effects upon protected watercourses and species; the permanent fragmentation and alteration of the peatland; the adequacy of Appropriate Assessment; transboundary participation; and the unresolved position concerning certain lands within the application boundary.

8.4 Where the applicant's own evidence has changed over time, where subsequent recovery is relied

upon to characterise earlier significant effects as temporary, or where information is absent or uncertain, the evidential burden should remain upon the applicant. The Commission should require those matters to be reconciled and demonstrated rather than fill evidential gaps, infer favourable conclusions, or require observers to prove the contrary.

8.5 Most importantly, this is now an assessment informed by what actually happened. Risks which were previously prospective can be compared with actual outcomes. The peat failure, downstream pollution, ecological effects and subsequent remediation provide evidence against which the assumptions, predictions and mitigation underlying the environmental assessments can be tested. That evidence cannot be disregarded merely because conditions have subsequently stabilised or improved.

8.6 For the reasons set out above, WID submits that the statutory and environmental-law requirements necessary for the exceptional remedy of substitute consent have not been demonstrated. The Commission should therefore refuse substitute consent. If the evidential deficiencies identified above prevent the Commission from reaching the complete and legally certain conclusions required under EIA, Article 6(3) of the Habitats Directive and the Water Framework Directive, that uncertainty cannot properly be resolved in favour of regularising the development.

8.7 The consequence is not that environmental protection should cease. Necessary stabilisation, remediation, restoration and protection of affected watercourses, peatlands and habitats should continue irrespective of the planning outcome. Remediation of environmental damage and retrospective authorisation of the development which contributed to that damage are separate questions. The environmental necessity of the former does not establish a legal entitlement to the latter.

Yours Sincerely

Elizabeth Davidson

**On Behalf of**
**Wild Ireland Defence CLG**

Peter Sweetman

**On Behalf of**
**Wild Ireland Defence CLG**

I confirm that the facts, opinions, analyses, methodology, reasoning and conclusions contained in this report are entirely my own and are based solely upon my own knowledge, expertise, experience, review of the evidence and independent professional judgment. Generative artificial intelligence tools may have been used for editorial and administrative assistance, including document formatting, grammar, spelling, punctuation, style, headings, layout, proofreading and presentation. Any suggested drafting amendments were independently reviewed by me and accepted only where they accurately reflected my own intended wording. I have personally reviewed the entirety of this report and confirm that it accurately reflects my own opinions and evidence. I accept full responsibility for its contents. SJK.

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Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service

# ASSESSMENT OF MAIN CONTRIBUTING FACTORS LEADING TO THREE MAJOR PEATLAND FAILURES IN LEITRIM, KERRY AND DONEGAL

## POTENTIAL TO UPDATE NATIONAL LANDSLIDE SUSCEPTIBILITY MAP

Prepared by Fehily Timoney and Company on behalf of Geological Survey Ireland (Department of the Environment, Climate and Communications and National Parks and Wildlife Service (Department of Housing, Local Government and Heritage).

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# POTENTIAL TO UPDATE NATIONAL LANDSLIDE SUSCEPTIBILITY MAP

**REVISION CONTROL TABLE, CLIENT, KEYWORDS AND ABSTRACT**
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**Client:** GSI/NPWS

**Keywords:** Landslide**,** Peat failure, blanket bog, susceptibility, land use, human activity, Meenbog, Shass Mountain, Mount Eagle

**Abstract:** Task 4 of the project involves an assessment of the potential to update the National Landslide Susceptibility Map using data collated and analysed in this project. Review and assess whether areas of peatland within the study areas of this project, currently mapped as low to moderate susceptibility on the National Landslide Susceptibility Map, are likely to have a higher classification of susceptibility to landslides.

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# 1. Introduction

## 1.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science, and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has c.90 members of staff, including engineers, scientists, planners and technical support staff. We deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

FT have been involved in over 100 wind farm developments in both Ireland and the UK at various stages of development i.e. preliminary feasibility, planning, design, construction and operational stage and have established themselves as one of the leading engineering consultancies in peat stability assessment, geohazard mapping in peat land areas, investigation of peat failures and site assessment of peat.

## 1.2 Project Description

The Services for this project comprise the carrying out of a detailed scientific assessment, using available data and data provided, along with appropriate site visits, to determine the main contributing factors that led to a series of peatland failures located in Counties Donegal, Leitrim, and Kerry. The project seeks to characterise the environmental setting of the landslides, determine the main contributing factors to the failures and further determine any shared conditions that may identify susceptibility in 3 additional areas of interest to GSI and NPWS.

The results of this assessment will be used to assess the potential to update Geological Survey Ireland's National Landslide Susceptibility Map and to produce technical notes for documentation(s) related to peatland land use and peat stability in Ireland.

This Technical Note covers Task 4 of the Specification of Requirements, namely *"Assess the potential to update the National Landslide Susceptibility Map and associated database using data collated and analysed in this project. Review and assess whether areas of peatland within the study areas of this project, currently mapped as low to moderate susceptibility on the National Landslide Susceptibility Map, are likely to have a higher classification of susceptibility to landslides due to factors, not previously included in the analyses, for example those associated with peatland ecology, peatland degradation, hydrology, stratigraphy or geomorphology or historic or recent land use changes etc. and produce a short technical note based on this review."*

# 2. Landslide Susceptibility Map

## 2.1 Summary of Existing Mapping

The existing National Landslide Susceptibility map was developed between 2007 and 2016, with the purpose of assessing landslide susceptibility to assist in the identification of areas that are likely to experience landsliding and develop a model for susceptibility mapping on a national level.

The susceptibility map was developed using what was referred to as “Unique Condition Units” (UCU), which are made up of a series of attributes, in this case: slope (based on a 20m DEM), soil type and Topographic Flow Index (TFI). A total of nine slope bands, seven soil types and three TFI’s were used to develop the UCU. The UCU methodology assumes that where a landslide is observed in an area with a specific combination of attributes, then if that combination occurs elsewhere that location is also susceptible to landslides.

The UCU model was then weighted by applying a known inventory of landslide events (following a quality control check of events) to the combined parameters and values for the number of landslides per UCU was calculated. This basic count was then normalised by dividing the area of the relevant UCU to give values of incidence per area of a UCU i.e. number of landslides/$km^2$. These incidence values were then multiplied by 100 which give the number of landslides/100$km^2$ (GSI, 2016).

The susceptibility map refers to areas where landslides may occur and these areas are ranked, in accordance to slope stability and associated topographic factors, into categories that range from low to high.

It should be noted that the term “susceptibility” refers to the identification of areas which are predisposed to landslides (including peat failures), and this is measured by the number of incidences per square km, or density of landslides per UCU. This map should not be treated as a “Hazard” map which shows the potential to cause damage by frequency/probability or intensity or a “Risk” map which shows loss potential (GSI, 2016).

# 3. Relevance to Peat Failures on Shallow Slopes

## 3.1 Peat Failures

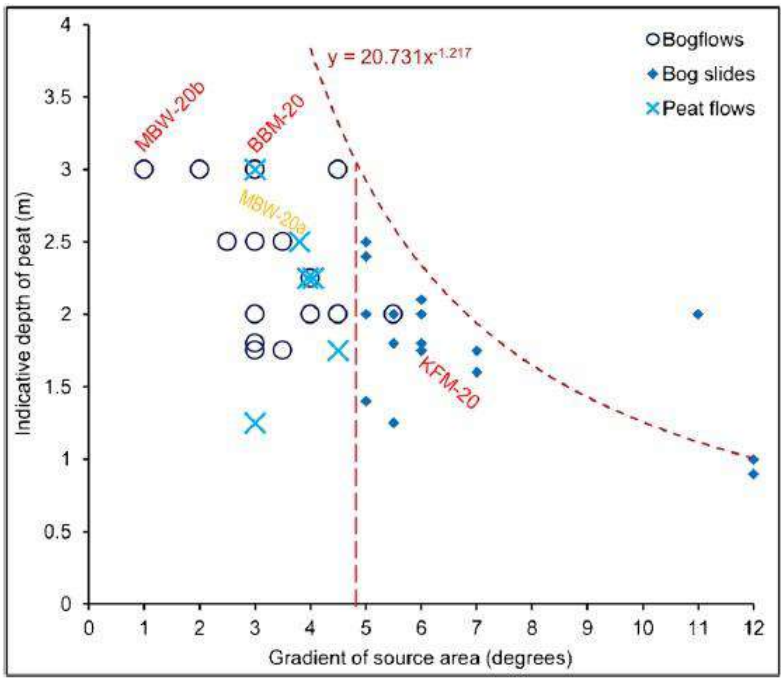
The GSI's landslide susceptibility mapping was designed for landslides in general, not specifically peat failures, and as such it does not consider the possibility of specific peat failure mechanisms or the possibility of peat failures on relatively shallow slopes. This is understandable, as the purpose of the susceptibility mapping was to provide a national assessment covering a wide variety of soil types and failure mechanisms.

While peat was included as one of the seven soil types in the existing mapping, the failure mechanisms within peat are often different to landslides which occur in other types of superficial deposits or in bedrock, and as such different attributes must be considered. A review of the landslide database indicates that around 55% of the records relate to peat failures (Long, 2022).

The existing mapping is based on identifying areas where landslides have occurred, and at the time this only included a relatively small number of peat failures on shallow slopes.

It can be seen in the figure below, reproduced from a paper by Dykes (2021), that a number of peat failures have been recorded in a shallow slope angle band between 3 and 7 degrees. Importantly this slope angle range is also the range where large scale (in terms of peat volume) peat landslides are typically encountered.

**Figure 3.1: Characteristics of Irish Peat Failures (Dykes, 2021)**



## 3.2 Potential Changes to Account for Peat Failures

### 3.2.1 Additional Caveat on Peat Stability

The simplest option in lieu of making significant changes to the existing landslide susceptibility mapping (through further research) may be to add an additional layer (or note) to the existing susceptibility mapping for areas that can be identified as having the following characteristics:

- Presence of an upland blanket bog or active raised bog setting
- Slopes of 3-10 degrees (as an example)

The additional layer/note would state that these areas are considered to be at higher risk from peat instability than indicated on the landslide susceptibility map, and that an appropriate peat stability assessment should be undertaken for any works proposed in these areas, irrespective of the current landslide susceptibility rating. The peat stability assessment should include the gathering of site-specific data on vegetation and ecosystem condition including effects of land uses (past and current); extent of the peatland and condition of the peat and drainage conditions (hydrology and hydrogeology) on the site and in its vicinity and sub-catchment area including upslope and downslope areas.

An alternative to the above would be to apply a filter layer to the existing susceptibility mapping, effectively "greying-out" all areas of upland blanket bog. A note would also be added to the legend stating "Areas of upland blanket bog should be considered at higher risk of peat failure. Any development in these areas should include an appropriate site-specific peat stability assessment undertaken by a multidisciplinary team of suitably qualified and experienced professionals including blanket bog ecologist and hydrologist".

### 3.2.2 Use of more detailed survey information

As the GSI susceptibility mapping was undertaken based on a 20m DEM, an option would be to look to update the mapping based on more detailed topographic information (such as LiDAR), which would allow for a refinement in the calculation of the TFI as well as providing a more detailed slope angle assessment, which may alter the landslide susceptibility classification of certain areas. However, this would not address the issue of identifying the potential for peat failures on relatively shallow slopes.

### 3.2.3 Updated Landslide Susceptibility Mapping

To be relevant specifically to peat failures, it is considered that additional factors would have to be included to create a specific assessment of the landslide susceptibility of peat deposits. This would involve the collation of a series of datasets, such as blanket bog and wet heath GIS data, peat depth data, forestry plantation GIS data, natural and artificial drainage systems, topographic data, catchment boundaries data and others. However, a difficulty with any such assessment is applying suitable weighting factors to datasets, as not all datasets have an equal impact on peat stability.

As an example,

- Slightly different slope bands to the original slope bands applied would need to be selected, providing more bands at lower slope angles (<15 degrees) with only a couple of bands above this, as peat

typically cannot accumulate on steep slopes in significant quantities. This would require more detailed topographic information (ideally LiDAR) than that used in the current susceptibility mapping.

- The slope characteristics, such as areas of concave/convex breaks in slope would have to be identified, as these areas are considered to be at higher risk of failure based on available data. LiDAR data would also facilitate this. In all these cases, the surface slope angle is assumed to reflect the slope angle of the base of the peat, unless evidence to suggest otherwise is available. However, mapping using airborne geophysics may, with appropriate ground truthing (by probing or use of Ground Penetrating Radar (GPR)), be able to provide an estimate of peat depth and therefore the slope of the base of peat.

- Additional factors, such as location of areas within the headwaters of watercourses would also need to be considered (possibly identifiable using LiDAR and also often identifiable on aerial imagery to an experienced peatland ecologist), as well as drainage patterns (natural/man-made). This may be possible through a revision to the existing TFI calculations. Rainfall levels may also be a part of this assessment, in order to assess the likely flow volumes. This would need to be extrapolated from the nearest rainfall station but taking in account higher rainfall levels at higher elevation etc.

- The condition (level of peat decomposition as per Von Post scale (1926)), thickness of a peat deposit and water level/hydrogeological conditions within the peat deposit should also be considered. The shear strength of peat is also important, although there are issues around the accuracy of field measurements of peat strength and this parameter can typically only be recorded following some form of site investigation (either through peat probing or using geophysical methods).

- The current and past human activities / land use of an area, and specifically any change in land use, (such as peat extraction or forestry, for example) would also need to be considered. Degradation of peatland areas is reported as a pre-conditioning factor in peat failures, and these areas would need to be identified and mapped, likely from high quality satellite imagery/aerial photography. This would require significant time and effort if applied to all upland peatlands across the country however there is already some habitat condition data available in NPWS* for c. 25 SACs many of which include areas of blanket bog and GIS turbary and drain data based on recent aerial image data (Bluesky) for 55 blanket bog SACs. Additionally, the National Land Cover and Habitat Map (NLCHM), provides a more detailed dataset of land types nationally and would likely be very useful for this though it will need some prior validation against existing peatland ground truth data. (*See Perrin et al., 2014 for an overview of NSUH data and NSUH site survey reports are published on www.npws.ie while GIS and associated survey and condition plot data is available on submission of Data Request Form on www.npws.ie).

Each additional factor would need to be given a ranking, such as on a simple 1-3 or 1-5 scale. Some factors may also have to be weighted, due to them being considered more important in terms of peat stability. Existing examples of this type of assessment typically sum the ratings for all the relevant attributes, and provide ranges indicating susceptibility, such as the low/moderately low/moderately high/high classification already in use. This would require the existing methodology to be significantly altered. As steeper slopes (>10 degrees) are typically already classified as moderately high/high susceptibility, it may be easier to isolate areas of peat or peatlands currently with low/moderately low susceptibility and use additional attributes to denote a revised or “Peat Specific” susceptibility classification for these areas.

To implement the above would be time consuming to undertake for large areas, especially given the coverage of Blanket Bog across the country (up to c.775,000 ha). However, the TE/EPA National Land Cover and Habitat Mapping would assist significantly with this and potentially also with the above mentioned NPWS NSUH and other peatland habitat distribution data.

It may be possible to exclude certain areas of peat from any such assessment where raised bogs are present, with the caveat that these areas can be susceptible to bog bursts/flows should water become impounded behind large banks of peat as occurred at Knocknageeha (1896).

Given the number of factors involved in peat stability (see Section 3.3) it is unlikely that it would be possible to fully update the current national landslide susceptibility map with any degree of certainty. However, it may well be possible to indicate areas which have potentially a higher susceptibility to failure.

It may be advised to select three or four of the more common peat landslide susceptibility factors and apply them to the existing landslide susceptibility classification. These factors would need to be quantifiable from existing datasets/survey data, and should for example include:

- peatland areas
- topography/slopes
- breaks in slope,
- land uses e.g. causing peatland degradation such as drains, roads, infrastructure, forestry, fire breaks, turbary, fire damage, erosion complexes,
- natural drainage
- artificial drainage
- evidence of historic failures

Each of these factors would need to be ranked in order of its likely role and importance in peat instability (say on a simple 1-3 or 1-5 scale), with the resulting sum of factors indicating the chosen area's revised landslide susceptibility.

## 3.3 Study Areas Susceptibility and Relevant Factors

A review of the existing landslide mapping within the areas of the three failures indicates that the current susceptibility rating, as indicated, in these areas is mainly linked to slope angle. Where the slope angle is steeper, the landslide susceptibility rating is indicated as higher.

The landslides at Meenbog, Shass Mountain and Mount Eagle occurred in areas indicated as Low or Moderately Low susceptibility on the current Landslide Susceptibility Map. These areas had slope angles of between 2 and 6 degrees, which are considered to be relatively shallow in general slope terms. It is noteworthy in this regard that the Landslides in Ireland publication (GSI 2006) advised that peat on any slope may be susceptible to failure if the peat deposit is greater than 0.5 m thickness (peat is also stated to be vulnerable if less than 0.5m thickness but on slopes steeper than 15 degrees). Furthermore, the above graph (from Dykes, 2021) also shows that peat landslides can occur on slopes as low as 1 degree. Peatlands where there is a depth of 0.5m or greater are more susceptible to failure even on very gentle gradients and it is therefore important that this is be taken into account in any proposed improvements to the current landslide susceptibility mapping.

The following is a non-exhaustive list of site factors that may influence peat stability, from published papers (See References and Bibliography):

- Peat depth
- Peat strength
- Ecosystem condition/condition of peat (vegetated, bare, degraded, drained, desiccated, degree of humification, presence of peat pipes, water level etc)
- Slope Angle, including the angle of the base of the peat layer

- Break in slope (convex/concave)
- Underlying geology (substrate conditions)
- Human activity on site
- Land use (current and past) and change in land use causing peatland degradation
- Presence/absence of drains, such as dense systems of forestry drains. Direction of drains is also important.
- Drainage feeding surface runoff into headwaters of streams (interface between man-made and natural drainage systems)
- Rainfall amounts and rainfall patterns

There are limitations on the type or resolution of data that can be remotely (i.e. without site investigations) gathered in terms of these factors:

- Peat depth/strength: peat depth can only be inferred from slope angle, requires site specific data requiring site visits and site investigation to confirm peat strength.
- Peat soils distribution: there is mapping data for peat soils published by Teagasc.
- Slope angle: this can be determined in general terms from the publicly available 20m DEM, but this mapping is too course to pick up subtle changes in slope. Site specific surveys, using LiDAR or similar would be required to identify subtle or small-scale features which would be important in terms of peat stability.
- Slope of base of peat layer: unless sufficient probing or GPR surveys are undertaken, this is assumed to be the same as the surface slope angle.
- Break in slope: convex/concave breaks in slope have previously been identified as one of the contributing factors in peat failures. These can be identified where sufficiently detailed survey information (such as LiDAR) is available and could likely be used in conjunction with GIS to identify such areas.
- The temporal variation in peat condition: can be determined in a general case from recent aerial photography, plus comparison of aerial photography over several years can show any changes over time. The presence of peat pipes can usually only be determined by site visits, and often require intrusive investigation. The presence of flushes and wetter areas of peat may be determined from aerial photography or from remote sensing (satellite imagery) and existing habitat GIS datasets (though incomplete).
- Change in land use: can possibly be determined from a comparison of historical and current Corine databases or land cover mapping and aerial photographs, or Coillte and Forest Service forest inventory GIS data, provided these are up to date.
- Land use (forestry): the direction of furrows and drains can have an adverse impact on stability. Drains parallel to slope can allow for rapid drainage of surface water (provided a suitable outfall is present), but oblique drains may trap water on the slope. If the area has been recently felled, but not replanted, a higher water table can be expected, and this may lead to a higher risk of instability in some circumstances. Direction of drains/furrows can often be determined from aerial photography in felled areas but can be more difficult to determine where forestry is still present. Historical aerial photographs can sometimes show these features. The Coillte and Forest Service forest inventory GIS data could also be considered.
- Land use (peat cuttings/turbary areas): these have been linked to certain peat failures, as they expose the more humified catotelm to the elements (rainfall). The machine cutting of peat has been directly linked to peat failures, as the blade of the machine slice the peat into thin sections and remove a significant proportion of the strength of the peat mass. Generally, peat cutting can be easily identified from aerial photography, but this may not indicate if the peat has been machine cut. GIS data on turbary areas is available for blanket bog SAC.

- Drains: if sufficiently large, these can be recorded from aerial photographs, otherwise they can only potentially be inferred from contours. Typically, drains are visible on LiDAR surveys. Otherwise, these require site inspections to confirm the extent of any drains present. Presence of drains may require an assessment of the relative impact of drains parallel to/or oblique to the slope. Oblique drains would typically hold water on a slope, potentially saturating the peat present, increasing the risk of failure. Drains parallel to the slope will typically aid the drainage of a slope, as long as an appropriate outfall is provided. However, increased drainage of a peat deposit can reduce the water table, leading to desiccation of the peat surface and an increase in erosion, increasing the risk of peat failure.
- Interface between natural and man-made drainage regimes: often visible from aerial photography, typically located directly upslope and downslope of forestry areas and also often associated with areas of peat cutting (turbary areas).

Each of the bullet points above would require the collation of a series of existing datasets, refinements of some existing datasets, and in some cases the creation of new datasets to allow these factors to be included in a landslide susceptibility assessment.

## 3.4 Revised Study Area Susceptibility

From a review of available data and site visits to the three study area failure sites, the following is noted:

- Meenbog: the failure occurred where an unauthorised floating road was being constructed along a break in slope, downslope of a large area of relatively deep, very soft peat (Active Blanket Bog). Peat strengths recorded using a hand shear vane in this area were all <10kPa, and often <5kPa, indicative of very soft (i.e. weak) peat.

- Shass Mountain: the failure occurred following heavy rain, in the blanket bog in the upper catchment of a stream. This area was fed by artificial drainage channels within the forestry on the upslope side of the failure. Deep peat (up to 4.5m) was present on shallow slopes (2-6 degrees). The failure point also occurred upslope of a convex break in slope.

- Mount Eagle: the failure occurred within an area of forestry and regressed upslope to an area of open blanket bog. Peat depths were between 2 and 2.5m with relatively shallow slopes of 3-5 degrees. No significant breaks in slope are present. Artificial drainage is present within the forestry plantation. A previous failure had occurred adjacent to the failure studied in this report.

In terms of susceptibility to peat failure at the sites of the 3 slides in this study, the following table uses four (depth, strength, slope, drainage (artificial and natural) of the contributing factors in peat failures previously identified and applies a relative risk to each factor using a simple 1-5 scale, where 1 is the lowest risk to susceptibility and 5 is the highest. The sum of these factors is then used to determine if a change in the susceptibility rating should be considered. The table below provides an example of this procedure.

**Table 3-1: Example of 'peat specific' risk assessment for shallow slopes for the three landslides sites**

| | Meenbog | Shass Mountain | Mount Eagle |
|---|---|---|---|
| **Peat Depth**<br><br>0-1m = 1 (unless on slope >15 degrees = 5)<br>1-3m = 3<br>>3m = 5 (unless slope angle < 2.5 degrees = 1) | 3 | 5 | 3 |
| **Peat Strength (as indicated by shear vane)**<br><br>0-10kPa = 5<br>10-20kPa = 3<br>>20kPa = 1 | 5 | 3 | 3 |
| **Slope Characteristics**<br><br>Convex = 5<br>Concave = 3<br>Planar = 1 | 5 | 1 | 1 |
| **Drainage (artificial)**<br><br>Presence of transverse/oblique drains = 5<br>Presence of drains parallel to slope = 3<br>No artificial drains = 0 | 3 | 5 | 5 |
| **Drainage (natural)**<br><br>Presence of Flushes/Headwaters of stream in immediate vicinity = 5<br>No flushes/headwaters present = 1 | 1 | 5 | 1 |
| **Total** | **17** | **19** | **13** |
| | | | |
| 0-9 – no change<br>10-14 – elevate by one Category (such as from "Low" to "Moderately Low")<br>15-20 – elevate by two Categories (such as from "Low" to "Moderately High"))<br>>20 – elevate to "High" susceptibility (irrespective of previous classification)<br><br>Notes: As an additional check, if any site records three values of 5 the susceptibility should increase to "High".<br>Peat strength may alternatively be replaced by Von Post classification, or moisture content if site specific results are available. | | | |

The above assessment would apply for the immediate failure area, plus any other areas within the landslide study sites with similar attributes. It should be noted that this assessment is only possible because of data gathered during site visits, such as peat depth, peat strength and spacing and orientation of drains. The above assessment is effectively treating the trigger for a failure as rainfall, as this is most common trigger factor noted in Irish peat failures.

- **Meenbog**: any change to the landslide susceptibility classification (increase from "Low" to "Moderately High") would be limited to areas with a convex break in slope with relatively deep peat (>2.5m) and low peat strengths (<10kPa). An assessment of the contours across this study area highlighted several areas of peatland with a convex break in slope. One of these areas recorded peat

depths in excess of 5m, and this area would be considered similar to the area of the failure and therefore susceptible.

- **Shass Mountain**: any change to the landslide susceptibility ("Low" increasing to "High" and "Moderately Low" increasing to "High") would likely be limited to areas downslope of forestry around open peatland, especially close to existing natural drainage channels/flushes. This combination of factors would appear to be limited to locations immediately to the east and west of the failure.
- **Mount Eagle**: the main contributing factor in this appears to have been the alteration of the natural drainage around the perimeter of the forestry plantation. The entire southern boundary of the forestry appears to have the same geotechnical characteristics and given the presence of a historic failure adjacent to the recent failure, this entire boundary would have to be given an increased landslide susceptibility classification (increase from "Moderately Low" to "High").

The above can be seen to potentially increase the landslide susceptibility assessment of the three areas to a point where a failure may have been expected following a suitable trigger event.

The Meenbog failure was triggered by activity associated with the construction of an unauthorised wind turbine access road across blanket bog. Such human impact can only be assessed on a site-specific basis.

In the case of Shass Mountain, a very heavy rainfall event is considered to be trigger for the peat failure. However as heavy rainfall does not always lead to a peat failure it is clear that there are other predisposing factors operating at Shass. These include forestry drainage upslope of slide; poorly functioning interceptor drain upslope of slide; natural drainage flush lines near slide location; possible presence of peat pipes. The condition of the bog may also be an important factor as it appeared to have a lower than expected *Sphagnum* cover for deep upland blanket bog so the surface peat may be drier and more compacted than it would be if it were in a more natural condition. This would result in a poorer capacity to absorb rainfall and greater amounts of surface water run-off which may overwhelm the natural drainage channels (or peat pipes if present) in the vicinity of the landslide location. Essentially the blanket bog ecosystem functioning has been impaired by forestry drainage and the effects of forestry trees (increased evaotranspiration as compared to a natural unforested bog) in its upper catchment just above the location of the landslide.

The Mount Eagle failure appears to have been mostly related to the drainage of the site contributing to increased volume of surface water runoff over time. Forestry drains may have reduced the strength of the fibrous acrotelm layer and contributed to collapse of the bog by ingress of the volumes of surface water.

As different triggers are associated with each failure, producing an assessment which can accurately reflect all of these failures is not considered feasible.

Within each of the three upland locations of the landslide sites there are areas with similar characteristics (and similar landslide susceptibility) to the failure areas. In the cases of Shass Mountain and Mount Eagle, several locations in these uplands are likely to have experienced the same rainfall/runoff as the areas that failed. However, the failures were localised, indicating that specific factor/s are present at the failure locations that are not replicated in nearby areas that incurred the same rainfall event.

As the Meenbog failure was triggered by construction activity, any areas with similar characteristics would be considered a high risk of a peat failure if similar construction activity was planned at that location but would not necessarily be considered to be at high risk of peat failure in the absence of that human activity trigger.

Therefore, the specific site factors are important to identify and these include;

- the presence of drains in the peatland (all 3 sites)
- the presence of forestry and forestry drains (all 3 sites)

- possible presence of peat pipes
- an increase in the size of a local drainage catchment because of the artificial drainage systems upslope of the slide location (Shass and Meenbog)
- drying or compaction of the peat and impaired peatland ecosystem functioning (reduced *Sphagnum* cover and poor absorption capacity) due to interception by the drains and reduction of normal surface runoff supply to the bog in the vicinity of the peat failure (Shass)
- increased surface water run-off from forestry drains running downslope towards the failure site
- poorly functioning forestry collector drain leading to build up in water pressure above the slide location (Shass)
- natural drainage lines (flushes) near the slide location site (Shass)
- excavated firebreak and erosion and increased surface water runoff above the peat failure location (Mount Eagle)
- previous peat failure near location of current study failure (Mount Eagle)
- cracking of the peat beneath mature plantation forestry allowing water ingress to weaker catotelm layer and precipitating peat failures (Shass and Meenbog)
- subpeat geological factors

# 4. Summary

This technical note was produced in order to review and assess whether areas of peatland within the study areas of this project, currently mapped as low to moderate susceptibility on the National Landslide Susceptibility Map, are likely to have a higher classification of susceptibility to landslides due to factors not previously included in the analyses.

The most straightforward option may be to add an additional layer (or note) to the existing susceptibility mapping for areas that can be identified as having the following characteristics:

- Presence of an upland blanket bog or active raised bog setting
- Slopes of 3-10 degrees (as an example)

The additional layer/note would inform that these areas may be at higher risk from peat instability, and that an appropriate peat stability assessment should be undertaken for any works proposed in these areas, irrespective of the current landslide susceptibility rating. The peat stability assessment should include the gathering of site-specific data on the condition and extent of peat and drainage (hydrology and hydrogeology) on the site.

An alternative to the above would be to apply a filter layer to the existing susceptibility mapping, effectively "greying-out" all areas of upland blanket bog. A note would be added to the legend stating "Areas of upland blanket bog should be considered at higher risk of peat failure. Any development in these areas should include an appropriate site-specific peat stability assessment undertaken by multidisciplinary teams of suitably qualified and experienced scientific and technical professionals".

As the susceptibility mapping was undertaken using a 20m DEM, another option would be to look to update the mapping based on more detailed topographic data such as LiDAR, which would allow for a refinement in the calculation of the TFI, which may alter the landslide susceptibility classification of certain areas. It may also allow for the identification of concave and convex breaks in slope, which are a known conditioning factor in peat failures.

In order to be relevant specifically to peat failures, it is considered that additional factors would have to be included to create a specific assessment of the landslide susceptibility of peat deposits. This would involve the collation of a series of datasets, such as blanket bog/wet heath areas, forestry plantations, drainage systems, topographic data, catchment data, peatland condition data and others. However, any such assessment would require the application of suitable weighting factors to datasets, as not all datasets have an equal impact on peat stability.

As an example,

- The slope characteristics, such as areas of concave/convex breaks in slope would have to be identified, as these areas are considered to be at higher risk of failure. In all of these cases, the surface slope angle is assumed to reflect the slope angle of the base of the peat, unless evidence to suggest otherwise is available.
- Slightly different slope bands to the originals would need to be selected, providing more bands at lower slope angles (<15 degrees) with only a couple of bands above this, as peat typically does not accumulate in significant quantities on steep slopes. Such steeper slopes are already classified as 'High' susceptibility.

- Additional factors, such as areas within the headwaters of watercourses would also have to be considered, as well as drainage patterns, (natural/man-made) such as flushes. Rainfall levels and patterns would also be a part of this assessment.
- The condition (level of decomposition), thickness of a peat deposit and water level/hydrogeological conditions within the peat deposit should also be considered. The shear strength of peat is also important, although there are issues around the accuracy of field measurements of this parameter.
- The land use of an area, and specifically any change in land use (such as peat extraction or forestry, for example), would also have to be considered. Degradation of peat areas can also be a conditioning factor in peat failures, and these areas would also have to be identified, likely from high quality satellite imagery/aerial photography and other available data. This would require significant time and effort if applied to all upland peatlands across the country. The National Land Cover and Habitat Map (NLCHM), provides a more detailed dataset of land types nationally and would likely be very useful for this though it will need some prior validation against existing peatland ground truth data.

Each of the bullet points above would require the collation of a series of existing datasets (such as locations of blanket bog/wet heath, forestry plantations, drainage systems and habitats), refinements of some existing datasets, and possibly the creation of new datasets to allow these factors to be included in a landslide susceptibility assessment.

An example of a "peat specific" qualitative risk assessment is provided for the three failures, based on peat depth, peat strength, slope shape and the presence of artificial drains. It shows that this type of assessment would increase the landslide susceptibility classification of the three sites, to "Moderately High" for the area around the Meenbog failure, "Moderately Low" and "Moderately High" for Shass Mountain and "Moderately High" for Mount Eagle.

The above can be seen to not significantly increase the landslide susceptibility assessment of the three areas to a point where a failure may have been expected. This highlights the difficulties in attempting to identify specific areas of high risk.

The Meenbog failure was triggered by activity associated with the construction of an unauthorised wind turbine access road across blanket bog. The risk associated with work related to a development such as a windfarm must be carefully assessed on a site-specific basis as part of the EIAR process and a precautionary approach is clearly needed.

In the case of Shass Mountain, rainfall is considered to be the trigger for the peat failure however heavy rainfall does not always lead to a peat failure therefore it is clear that there are predisposing factors operating at Shass and these relate to land uses at this site that have significantly altered the ecosystem functioning of the blanket bog at this site. The land use change (forestry) has been shown to alter the hydrological environment and properties of the peat.

The Mount Eagle failure appears to have been mostly related to the drainage of the site along with the volume of surface water runoff from an excavated firebreak over time. The blanket bog at this site is also highly compromised in terms of normal ecosystem functioning by forestry drainage and a previous landslide also occurred close to the site of the current study landslide site which may have destabilised the latter.

As different triggers are associated with each failure, producing an assessment which can accurately reflect all of these failures is not considered feasible.

Creighton (2006) reports that the Irish Landslides Working Group recommends that a large body of research be completed with regard to landslide susceptibility assessment in Ireland. The National Landslide Susceptibility map was published in 2016. The growing pressure for development in more marginal land

areas, and the potential impacts of climate change, make such work an important imperative in the context of the sustainable development of the Irish landscape, and also on health and safety grounds. In the 2006 publication, a need for multidisciplinary studies on landslide phenomena involving geologists, geomorphologists, engineers, peatland ecologists, climatologists, planners and those with GIS expertise was identified. The collaborators would include university researchers, local authorities, government departments and agencies, and consulting geologists and engineers. With progress in these specific themes, more informed approaches can be undertaken on the methodology of landslide susceptibility mapping.

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# Landslide investigations during pandemic restrictions: initial assessment of recent peat landslides in Ireland

**Abstract** Landslides involving peat are relatively common in Ireland, upland areas of Great Britain and subantarctic islands. Bogflows and bog slides are less common types of peat failure and almost unknown outside Ireland. Unusually, three of these occurred in 2020 including one bogflow at a windfarm that gained much adverse media attention, and a small but damaging peat slide was also reported. The aim of this paper is to determine the extent to which the new bog slide and bogflows are consistent with previous examples in terms of their contexts, characteristics and possible causes, particularly relating to commercial forestry operations. Aerial video footage of all three landslides obtained by local people using drones, and ground-based footage of one of them in progress, allowed a detailed examination of their characteristics and contexts to be made despite the global travel and activity restrictions caused by the coronavirus pandemic. The windfarm bogflow appears to have resulted from removal of toe support by an earlier peat flow that was itself probably caused by construction of an access road; the other two landslides were most likely triggered by rainfall. All three are consistent with previous examples of their respective types in their general characteristics and appear to be associated with well-known causal factors including hydrological, topographic and/or forestry influences. Forestry operations probably contributed to the occurrence of two of the landslides and restricted the expansion of two of them.

**Keywords** Upland blanket peat · Bogflow · Bog slide · Peat landslide · Ireland

## Introduction

Landslides involving peat have become well known as geomorphological and geotechnical phenomena since a series of damaging events in 2003 in western Ireland and northern Scotland (Lindsay and Bragg 2005; Long and Jennings 2006; Dykes and Warburton 2007a, 2008). Previously sporadic reports of specific individual events started to be collated and re-assessed around that time to start to identify common causal factors and, thus, potential risk factors (Warburton et al. 2004; Dykes and Kirk 2006; Dykes 2008a; Boylan et al. 2008). As part of this rapid expansion of new knowledge of the topic, Dykes and Warburton (2007b) presented a formal classification scheme intended to reduce further confusion arising from inconsistent use of descriptive names in the literature. Some types of failure (bog slides, peat slides, peaty-debris slides and at least some peat flows) involve shearing and sliding on a discrete failure surface but the precise mechanism of failure in bog bursts and bogflows is as yet unknown. The distinction between bogflows (with bog bursts) and bog slides is therefore made according to field evidence of failure morphology and the presence or absence of an observable failure surface.

Although relatively common in many parts of the British Isles and on several subantarctic islands with climates similarly favourable for the formation of blanket peat (Lindsay et al. 1988), few failures of peat deposits are known from elsewhere in the world (Dykes and Selkirk-Bell 2010). Many peat failures occur in more remote locations where they may pose relatively little hazard to local communities and associated infrastructures, but they are often locally environmentally damaging because the more highly humified (decomposed) peat is a strong pollutant to aquatic life where runout sediment enters streams and lakes (e.g. McCahon et al. 1987; Wilson et al. 1996). In some past cases, the runout affected watercourses, agricultural land and even treated water supplies to whole towns many kilometres downstream (Dykes and Jennings 2011). Furthermore, they result in the fragmentation, exposure, oxidation and associated release of carbon dioxide from sometimes very large quantities of what is one of the Earth's most effective carbon-storing materials.

Following several years with only a handful of significant peat failures, four events thought to comprise five landslides occurred in 2020 (Fig. 1) and were initially reported by Petley (2020 and subsequent posts):

1. In the evening of Sunday 28 June 2020, a large bogflow occurred on Boleybrack Mountain near Lough Allen, Co. Leitrim, Republic of Ireland. This landslide (Ref. 'BBM-20' in this paper) is notable for being the first of its type to occur for several years, and the largest of its type since the Glendun bogflow of 1963 (Colhoun et al. 1965).
2. On 25 August, a small landslide of around 2000–3000 $m^3$, provisionally identified as a peat slide, was triggered by heavy rainfall from Storm Francis on the northern spur of Slieveanorra, Co. Antrim, Northern Ireland, at 55°05′28″N, 6°13′59″W (Ordnance Survey Ireland grid coordinate D 129 286). It blocked the same road as on previous occasions (e.g. Tomlinson and Gardiner 1982) but in this case the disruption was short-lived.
3. On 13 November, a bogflow occurred at Meenbog in Co Donegal, Republic of Ireland (Ref. 'MBW-20b' in this paper). This landslide is particularly interesting because of its relationship to construction of a new windfarm and a preceding failure ('MBW-20a').
4. Sometime shortly before the Meenbog event, a significant landslide—provisionally classified as a bog slide—occurred on the forested northern slope of Knockanefune Mountain in Co




**Fig. 1** Locations of the five peat landslide events of 2020 in Ireland (two at 'MBW-20'). Source: Google Earth (Image Landsat/Copernicus; Data SIO/NOAA/U.S. Navy/NGA/GEBCO; ©2021 Google)

Kerry, Republic of Ireland (Ref. 'KFM-20'). Here, the forestry context demands specific consideration.

This Technical Note examines the degree to which the recent bogflows (BBM-20, MBW-20b) and bog slide (KFM-20) have characteristics and causal factors consistent with previous such landslides for which details are known, and assesses the possible role of commercial forestry as a contributory causal factor in each case. The peat slide (No. 2, above) is not included in this study because peat slides and peaty-debris slides are more common and generally much smaller. The purpose of the study is to enhance knowledge and awareness of risk factors for which future provisions may need to be made by landowners and relevant authorities, given the scale of any potential direct environmental and indeed economic impacts of such events.

## Materials and methods

All of the recent landslides reported in this paper occurred during the global coronavirus pandemic when travel and other restrictions prevailed. This work was made possible by the existence and availability of aerial video footage of the three large landslides obtained by local people using drones, but also some unique ground-based footage of one of them in progress. Because of the inadvisability and effective impossibility of travelling to undertake fieldwork, all details and characteristics of these failures have been derived from three sources: (a) Google Earth (hereafter referred to as 'GE'); (b) Ordnance Survey of Ireland ('OSI') 1:50,000 scale 'Discovery Series' topographic maps; and (c) the third-party video footage made available on-line on YouTube or Twitter (for which permission to use here was readily granted). Characteristics of all reported bogflows ($n = 17$) and bog slides ($n = 20$) since 1895 were obtained from published accounts, in many cases supplemented by more recent field examinations (e.g. Dykes 2009). These records allow some assumptions to be made about the new landslides, including displacement of the full thickness of peat across large parts of the source areas following failure somewhere within typically the lowest 0.5 m. Source area gradients of the 2020 landslides were derived from the 1:50,000 maps. As such, this study demonstrates the present feasibility of one possible 'future' mode of landslide research—i.e. undertaken entirely from the office—expounded by Brunsden (1993).

## Details of the recent landslides

### BBM-20: Boleybrack Mountain bogflow

#### Site characteristics and trigger conditions

The source area of this bogflow is roughly centred on 54°12′30″N, 8°04′40″W (OSI grid coordinate G 948 285), 6 km northeast of Drumkeeran. The bogflow initially became known as the Dawn of Hope landslide (e.g. Petley 2020) but in this paper it is identified

as 'BBM-20' (i.e. 'Boleybrack Mountain 2020'). A video showing the entire extent of affected land can be viewed on YouTube (https://www.youtube.com/watch?v=ttJsyGSBPcc – Flynn 2020). The source area is located on the south-facing side of a very broad and gently sloping spur at the southeastern end of Boleybrack Mountain (Fig. 2a), at around 270 m above sea level. The underlying geology is the Gowlaun Shale Formation of Carboniferous (Namurian) age, comprising silty sideritic shale (GSI 2021). Much of Boleybrack Mountain is a designated Special Area of Conservation with active blanket bog being one of the five habitats that led to this status (NPWS 2013). Commercial forestry has encroached upon the southern tip of the Boleybrack upland in recent years. The 2004 edition of the topographic map shows no forest within 500 m of the failure site (OSI 2004), but at the time of the failure there was young plantation forest immediately north, west and south of the bogflow's source area (Flynn 2020). The trigger for the failure was most likely localised very heavy—though perhaps not 'extreme'—rainfall on 28 June 2020, with 44.4 mm recorded at Finner Camp, Co. Donegal (33 km to the NNW) (Met Éireann 2020a) and Newport, Co. Mayo, experiencing its wettest June day in its 60-year record on the same day with 53.4 mm (Met Éireann 2020b). This followed an unusually warm and dry second quarter of the year.

## Characteristics of the landslide

Dykes and Warburton (2007b) defined a 'bogflow' as 'Failure of a *blanket bog* (i.e. bog peat) involving the break-out and evacuation of semi-liquid highly humified basal peat from a clearly defined source area' (p.79, their italics). The morphology of a bogflow is very distinctive: BBM-20 is an excellent example of the type (Fig. 2). The defining characteristic is that most of the source area perimeter comprises large (e.g. up to 15–20 m long, up to 3–5 m wide and typically > 1 m thick) intact blocks or 'rafts' of peat that have been displaced downwards into the source area by vertical subsidence, back-tilted rotation and/or occasionally forward toppling, often with a crescentic pattern (Figs. 2b, c). In this case, the toe of the source area appears to coincide with the head of the tributary stream course adjacent to a narrow strip of forest (Fig. 2d). Upstream of this point, the 1:50,000 map (OSI Sheet 26) shows a steepest average gradient (over ~ 350 m distance) of no more than 3.3°, but the gradient into the tributary valley varies between around 3 and 6° suggesting a convex change of slope that is significant at such low gradients.

The thickness of the peat is not known but measurements at other failure sites (e.g. Dykes and Jennings 2011; Dykes 2019) suggest that the base of the peat is likely to be up to around 3 m deep, and possibly more, across much of the affected area at BBM-20. Based on the video of Flynn (2020) and the (pre-failure) GE view of the site, the source area is around 450 m long and up to 250 m wide, with a minimum volume of 200,000 $m^3$ if the peat is slightly less than 3 m deep throughout. The properties of the catotelm (i.e. lower, permanently saturated anaerobic layer below 0.5–1.0 m depth) of Irish blanket peat are summarised in Table 1. Based on these, this bogflow released many thousands of tonnes of solids,

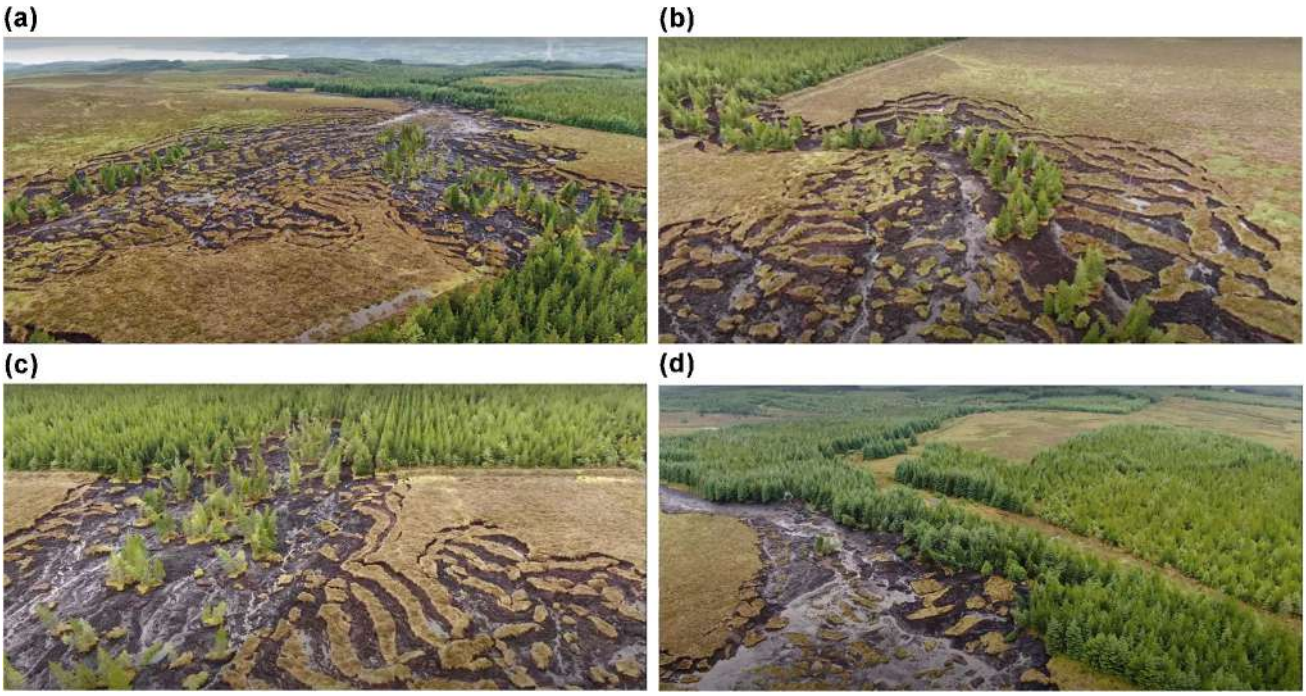



**Fig. 2** **a** The source area of the Boleybrack Mountain bogflow, looking approximately towards SSW. The 'main' head is at the extreme right within the forest. Source: 2 m 39 s in Flynn (2020). **b** Train of trees heading south from the secondary head of the bogflow, with adjacent peat subsiding inwards towards an apparent subsurface drainage line. Source: 1 m 03 s in Flynn (2020). **c** The main head of the bogflow with much greater evacuation of peat and associated transport of rafts of upper peat. In **b** and **c,** note how the transported trees remain upright as the peat rafts effectively float on top of the flow of semi-liquid lower peat. Source: 1 m 20 s in Flynn (2020). **d** The toe of the source area looking downstream. Note the left margin has been eroded, with some rafts pushed up against it, whilst on the right some trees have been pushed over by the moving mass of peat. Source: 3 m 05 s in Flynn (2020)

mostly comprising colloidal fragments of highly humified (decomposed) amorphous remains of plant matter, which were carried by the runout flow and contaminated watercourses and farmland up to 7 km downstream. However, much of the displaced peat, including many large rafts, remained within the source area.

There are several features that indicate what probably happened here, partly in line with Petley's (2020) preliminary observations:

1. Upslope of the convex break of slope (near the bottom of Fig. 2d), all parts of the source area margins show tension cracking of the upper peat as it was dragged inwards and downslope by the lower peat, whereas downslope of this point both sides have been impacted by moving peat (the flow and intact floating rafts) from upslope. This suggests that the failure originated at, or upslope of, the convex break, with everything further upslope developing by retrogression. This is a common scenario as observed at 8 out of 15 previous bogflows, where very deep and very soft and wet peat on low-angle topographic benches on the substrate exerts stress onto slightly thinner, drier and firmer peat on the adjacent steeper slope. The other 7 of the 15 occurred at the edges of escarpments where the same configuration is more pronounced.
2. There is a main source area which extends directly from the toe to the forest plantation, within which almost all of the surface peat has been carried away by the flow. The 'main' head extends back into the forest for a short distance. Figure 2c shows the trees—and therefore the pre-forestry drainage plough lines—to lead directly towards the location of the bogflow. This would have preferentially directed the rainwater into the deep peat on the slope outside the forest, especially if the peat contained well-developed pipe networks as observed elsewhere (Holden and Burt 2003; Warburton et al. 2004; Dykes et al. 2008), contributing to the lateral loading throughout the lower peat against the break of slope at the toe. Conversely, further headward retrogression was probably prevented by root reinforcement of the acrotelm peat by the trees.
3. There is an extensive area of upslope retrogression to the east of the main source area where the lower peat has failed but was mostly unable to fully mobilise and flow down the slope. However, a train of trees leading away from the 'secondary' head of the bogflow (Fig. 2b) shows significant displacement of rafts of upper peat floated on a narrow channel of flowing lower peat. This suggests that there may be a topographic drainage channel along the mineral substrate surface, within which the peat may always have been extremely wet and possibly already semi-liquid in consistency. The large rainwater inputs from the forestry drains can be expected to have exerted very high and possibly artesian water pressures around this channel (as observed elsewhere: Dykes and Warburton 2008), promoting the very localised flow and its own lateral retrogressive margins.

**Table 1** Values of peat properties, measured in the laboratory, of undisturbed samples obtained from near the base of the (lower catotelm) peat in the source area margin at each landslide

| Property of peat | Units | Range | No. of bogflows | No. of bog slides | Reference(s) [a] |
|---|---|---|---|---|---|
| Water content (field-wet) | % (mass fraction) | 450–990 | 5 | 3 | A, B, C, D |
| Water content (saturated) | % (mass fraction) | 450–1160 | 5 | 3 | A, B, C, D |
| Liquid limit | % (mass fraction) | ~700–800 | 2 | 1 | A |
| Volumetric water content (saturated) | Ratio | 0.88–0.97 | 3 | 2 | A, B |
| Bulk density (saturated) | kg $m^{-3}$ | 1010–1120 | 5 | 3 | A, B, C, D |
| Bulk density (dry) | kg $m^{-3}$ | 100–200 | 5 | 3 | A, B, C, D |
| Ash content | % | 1.0–5.5 | 5 | 3 | A, B, C, D |
| Humification | von Post scale | 8–10 | 3 | 2 | A, B |
| Saturated hydraulic conductivity (vertical) | m $s^{-1}$ | $<10^{-11}$–$10^{-5}$ | 2 | 3 | A, C |
| Saturated hydraulic conductivity (horizontal) | m $s^{-1}$ | $10^{-11}$–$10^{-6}$ | 3 | 2 | B, C, D |
| Undrained shear strength (triaxial) | kPa | 1.6–2.4 | 3 | 0 | D |
| Undrained shear strength (direct simple shear) | kPa | 5.0–6.0 | 0 | 0 | E [b] |
| Tensile strength | kPa | < 3 (< 4) | 3 | 0 | D, E [b] |

[a] A = Yang and Dykes (2006), B = Dykes (2008c), C = Dykes et al. (2008), D = Foteu Madio and Dykes (2018), E = Dykes (2019)

[b] Data from a peat slide in Co. Antrim

### MBW-20b: Meenbog Windfarm bogflow

#### Site characteristics and trigger conditions

The source area of this bogflow (Fig. 5) is at 54°43′06″N, 7°52′30″W (Ordnance Survey Ireland grid coordinate H 081 856), approximately 8 km southwest of Ballybofey and 5 km east of the Barnesmore Gap, Co. Donegal, 700 m west of the international border with the UK (Northern Ireland). Two videos of this site can be viewed on YouTube: one is an aerial drone footage from the distal runout to the source area (https://www.youtube.com/watch?v=xbQe55YnW5g: Derg Media 2020), while the second (https://www.youtube.com/watch?v=rf6S9Uz2Zrw: Donegal Daily TV 2020) shows the flow passing the truncated road at the exit from the source area, which must be only a short time after the initial failure. The source area is located at around 265 m altitude on a small spur of Carrickaduff Hill that descends roughly northeastwards towards Meenbog. The underlying geology comprises Precambrian metamorphosed sandstones (GSI 2021).

The location of the failure site is within a large area of commercial forestry, but the main source area developed within a rectangular parcel of unplanted ground roughly 380 m N-S × 280 m E-W. It is not known why this plot was never planted. The regular geometry suggests a land ownership issue but it may be that the peat was known to be too soft and weak and/or too deep to support any forestry operations. The Meenbog Windfarm project led to felling of trees within many similar parcels of land along with construction or upgrading of a dense network of access roads/tracks, including 'floating roads', to facilitate construction of the turbines. AGEC (2017, p. 12) noted that the pre-existing floating roads varied in type but commonly comprised 'tree brash/trunks laid directly onto the peat surface and/or … geogrid overlain by up to 500 mm of coarse granular fill'. Note that there are no turbines within 300 m of the landslide source area, nor within 200 m of the runout path, and therefore, that turbine base construction works are not relevant to the peat failure.

Site investigations by AGEC (2017, p. 12) found peat depths along the proposed new access roads to be 'typically less than 3.0 m with localised depths of up to 4.5 m recorded'. The very low gradient of the unplanted plot and its position at the foot of a much steeper slope could be expected to give rise to a very deep and very wet accumulation of peat. Peat more than 3.0 m deep was recorded around a road within 60 m NW of the unplanted plot, and in the area of the eventual failure, a road identified as a 'new access track', along the eastern edge of the same plot, crosses peat 2.5–3.0 m deep (AGEC 2017). The general susceptibility of the blanket peat to failure, as throughout Ireland, is highlighted by the occurrence of the large Barnesmore bogflow in November 1963 (Colhoun et al. 1965) on the same tract of upland just 3.5 km further northwest.

The rainfall recorded at Finner Camp, the nearest meteorological station to MBW-20, shows no evidence for a rainfall trigger any time between 1 and 13 (date of bogflow) November. However, the lower end of the source area, where the displaced peat effectively channelised into a runout track, is located where the 'new access road' crosses the eastern boundary of the unplanted plot. The drone video (Derg Media 2020) clearly shows that tree brash/trunks had been placed along the first 60–70 m along the plot boundary and that the gravel fill was being advanced towards the corner of the plot (bottom left corner of Fig. 3a). Therefore it appears likely that the failure is associated with construction of this new access road, as discussed below.

#### Characteristics of the landslide

The morphology of the source area of MBW-20b—upslope of the new access road—is another excellent example of a bogflow with the same general characteristics as described for BBM-20 (Fig. 3). The inward tearing of rafts of peat from the lateral margins, including from the adjacent forested plot (Fig. 3b), indicated that the failure began downslope of these zones—i.e. at or near the new access road. Note the limited expansion into the forested area compared with the open plot. The 1:50,000 map (OSI Sheet 11) suggests a gradient of little more than 1° across the open plot and around 3.8° downslope from the road. The peat depth throughout the source area can reasonably be assumed to be at the upper end of the measured 2.5–3.5 m range (see above). Based on the video of Derg Media (2020), the source area upslope from the road is around 240 m long and up to 120 m wide. A mean peat depth of slightly less than 3 m gives the failure a volume of 65,000 $m^3$. The catotelm peat can be reasonably expected to have properties consistent with Table 2. Therefore, this bogflow also released several thousand tonnes of polluting solids in addition to runout from the initial peat flow.

There are several pieces of visible evidence in the Donegal Daily (2020) video that strongly suggest the bogflow to have been indirectly caused by the access road construction, by means of a preceding failure. Firstly (0:26–0:34 in the video: Fig. 4a), the furthest part of the advancing gravel fill for the new access road can be seen to have subsided into an area of collapsed peat, with some small patches of gravel visible several metres downslope from the road at 0:34. Secondly, the peat ahead of, and downslope from, this collapsed end of the road is entirely disrupted, broken into chaotic blocks. This is typical of 'peat flows' (Dykes and Warburton 2007b) triggered by head-loading, as observed at other known examples (e.g. Slieve Bearnagh – Dykes 2008b; Ballincollig Hill – Dykes and Jennings 2011). Thirdly, this zone of chaotic blocks is stationary, i.e. an initial head-loaded failure has ceased, but trees from the edge of the bogflow source area, less than 100 m further upslope, are just starting to float past this point standing on intact rafts of peat. This is a strong indication that an initial peat flow at the convex break of slope (Fig. 4b) removed lateral support for, and thus allowed the release of, very wet and weak lower catotelm peat from the unplanted plot; i.e. the bogflow constitutes a separate second failure.

It is not clear whether the initial failure ('peat flow MBW-20a') involved the full width of the gap in the new access road (around 60 m) or, as the two videos seem to suggest, just the ~ 30 m nearest the collapsed gravel section (Fig. 4b). It is also not clear how far downslope the initial failure of peat extended, although there appears to be significant loss of peat from an erosion track around 40 m wide extending to the drainage line 290 m further downslope. If the peat here is 2.5 m deep, then—including the peat flow head near the road—at least 30,000 $m^3$ of peat may have been displaced within this zone, probably sending at least several hundred tonnes of polluting solids downstream.

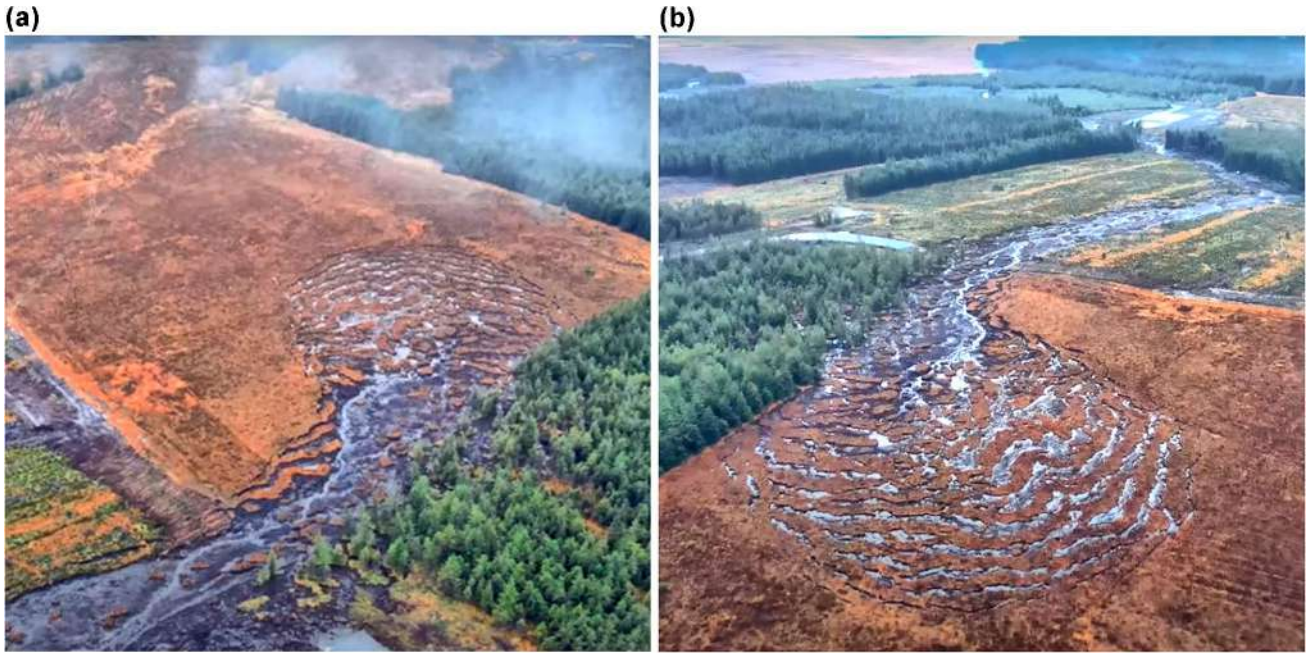



**Fig. 3** The source area of the Meenbog Windfarm bogflow. a View towards the SW showing the steeply rising slope at the far end of the unplanted plot (top left). Source: 0 m 47 s in Derg Media (2020). b View towards the NE showing the site of the initial peat flow (beyond the new access road) and the runout extending into a natural drainage line. Source: 1 m 10 s in Derg Media (2020)

**Table 2** Frequency of known incidence of common features of failure sites

| Failure site characteristics [a] | Bogflows (out of 17) [b] | Bog slides (out of 20) [b] |
|---|---|---|
| Edge of escarpment | 7 | *None* |
| Concave break of slope | *None* | 6[c] |
| Convex slope/convex break of slope | 8 plus **BBM-20, MBW-20b** | 6 plus **KFM-20** [d] |
| Stream channel at toe of failed slope | **BBM-20** – *but not like the bog slides* | 4 |
| One or more drainage or boundary ditches | 8 | 5 |
| Forestry plough lines and/or ditches | 2 plus **BBM-20** (*possibly* **MBW-20b**) | 2 plus **KFM-20** |

[a]Two failures were associated with peat cutting (both manual and by tractor-mounted Difco ('sausage') machine, and two other failures may or may not have been affected by manual peat cutting

[b]Totals include the three 2020 landslides

[c]All bog slides with concave breaks of slope have length:width ratios ≤ 2.4 (except BCF-88) and volumes ≤ 27,000 $m^3$

[d]All bog slides on convex slopes have length:width ratios ≥ 6.4 and volumes ≥ 45,000 $m^3$ (+ SBO-73 with 19,000 $m^3$)

**KFM-20: Knockanefune Mountain**

Site characteristics and trigger conditions

The source area of this bog slide is at 52°13′30″N, 9°18′12″W (Ordnance Survey Ireland grid coordinate R 110 090), 11 km east of Castleisland, Co. Kerry. It is located on the north-facing slope of the roughly east–west mountain ridge immediately southwest from Knockanefune Mountain, 2 km southeast from Mount Eagle, at around 430 m above sea level. Two videos of this site can be viewed on Twitter: one is an aerial drone footage of the mid-lower source area (https://mobile.twitter.com/savekerry/status/1328059773825257475?lang=en-GB: Save Kerry 2020a), while the second (https://twitter.com/savekerry/status/1328342795795492866?lang=en: Save Kerry 2020b) shows some views within the source area from the ground. The underlying geology is the Feale Sandstone Formation of Carboniferous (Namurian) age, comprising alternating sandstone with shale/siltstone (GSI 2021). The location is within a private forest plantation, which is shown on the 2006 edition of the topographic map (OSI 2006). The new bog slide formed alongside a near-identical failure dating from sometime between 27 March 2012 and 29 March 2019 (dates of GE images). Both landslides are visible on the latest (22 April 2021) GE image of this location (Fig. 5). The exact date of this bog slide is not known but it was shortly

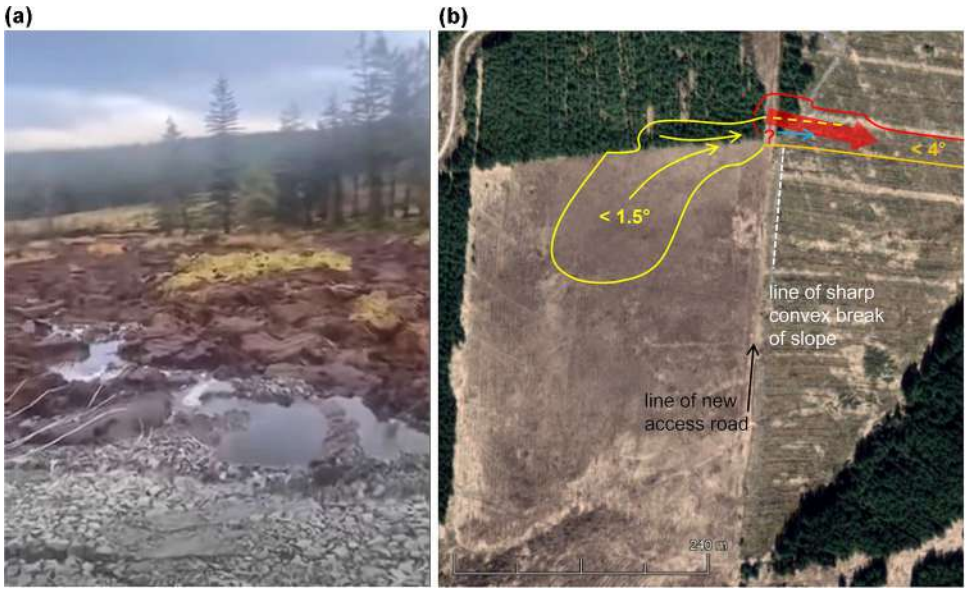



**Fig. 4** **a** The head of the initial peat flow with the collapsed end of the gravel road in the foreground and trees floating past from right to left around 40–50 m ahead. Source: 0 m 26 s in Donegal Daily (2020). **b** Outline plan of the site: red = initial peat flow, yellow = bogflow, orange = southern margin of both failures, light blue arrow = moving trees in the video of the bogflow. Note the steep slope rising from the unplanted plot at the bottom of the image




**Fig. 5** The 'Mount Eagle' bog slides on Knockanefune Mountain. KFM-20 is the lower slide with a head extending into the open blanket bog above the forest (lower left). The straight, narrow track around 1/3 of the way down the slope coincides with the main convex break of slope, where distinct failure surfaces are visible in both landslides. Source: Google Earth (Image © 2021 CNES/ Airbus; ©2021 Google)

before the Meenbog event (Save Kerry 2020a, b). Rainfall records from the nearest Met Eireann stations show a significant (but not exceptional) widespread rainfall event on 11 November with very high antecedent rainfall, which seems to be the most likely trigger.

## Characteristics of the landslide

Dykes and Warburton (2007b) defined a 'bog slide' as 'Failure of a *blanket bog* (i.e. bog peat) involving sliding of intact peat on a shearing surface within the basal peat' (p. 81, their italics). The morphology of a bog slide can be variable between that of a bogflow and a peat slide, but in general the lateral marginstend to be more clearly defined (fewer subsided strips or 'rafts' of intact peat). The forestry context makes it more difficult to see the features clearly, but some extensive areas of basal shear surface can be seen in Fig. 6a and the geometry is essentially longand linear although widening slightly in the downslope direction. The upper 250 m length, above the 400 m contour, is almost planar at around 5.8°; then, the slope steepens to around 10.8° (1:50,000 map, OSI sheet 72).

Figure 5 appears to show that KFM-20 developed throughout most of its length at the same time, given that there are effectively no strips or rafts of peat formed by tensile stresses at the margins right up to the head margin. The high density of peat rafts stranded within the upper 150 m can be attributed to basal sliding friction on the lower gradient retarding their movement. Figure 5 also shows that the upper part of the older landslide may have formed by retrogressive expansion above the break of slope, indicated by the much wider head zone above a narrow 'neck'. This would suggest that failure initiated somewhere around the break of slope, probably therefore in both cases given the similarity of the context and, most likely, the peat and condition of the forest.

The depth of peat is unknown, but the blocks and rafts of peat visible in the videos (e.g. Figure 6b) appear consistent with




**Fig. 6** **a** View down the latest bog slide KFM-20 from just above the convex break of slope. The older slide can be seen at the extreme upper left. Source: 0 m 34 s in Save Kerry (2020a). **b** Displaced rafts and blocks of peat within the lower part of the source area. Source: 0 m 06 s in Save Kerry (2020b)

peat up to 2 m deep although probably less on the steeper lower part of the slope. The total length of the source area is around 480 m and the width increases from ~ 30 m at the head to ~ 60 m throughout the lower half. If the depth of peat is assumed to be 2 m at the head and 1.5 m on the lower slope, then the total failure volume is around 40,000 $m^3$. Again, at least several hundred tonnes of solids are likely to have reached the natural watercourses with much of this eventually polluting River Clydagh.

## Discussion

### Comparisons with previous bogflows and bog slides

Despite the small sample size (even for Ireland), some distinct patterns can be identified that provide context for the events of 2020 reported above:

1. *Occurrence*—The frequency of occurrence of these large blanket bog failures appears to have been increasing throughout the last 130 years—although the average remains just below three per decade. This should perhaps be viewed in the context of apparently increasing annual rainfall for Ireland (Fig. 7a), although there is no significant statistical relationship. For the failures with known dates of occurrence, a higher frequency associated with higher autumn rainfall is clearly indicated in Fig. 7b but very heavy summer rainfall following prolonged hot and dry periods—predicted to become a more common scenario—is a recognised risk factor. The overall pattern has shifted 2–3 months earlier compared with a similar analysis by Alexander et al. (1985). The BBM-20 bogflow is the first example known to have occurred in June but changing rainfall patterns may be expected to give rise to more in future years.

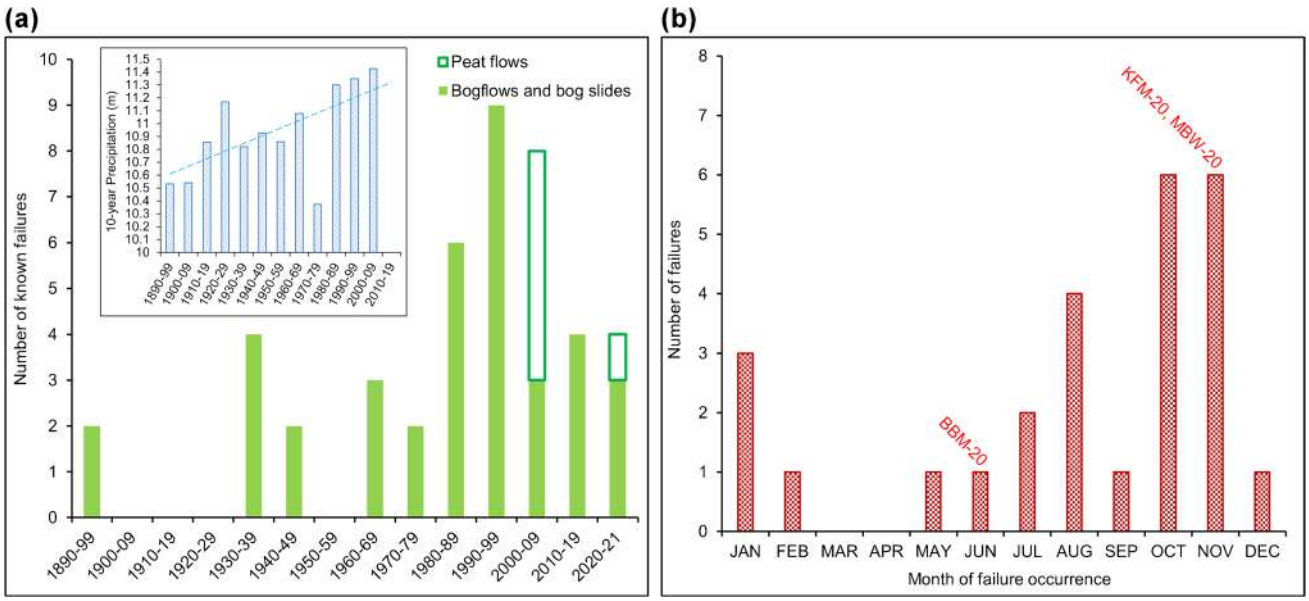



**Fig. 7** Occurrence of reported bogflows and bog slides in Ireland. **a** Frequency by decade. Peat flows are also shown to highlight the period of accelerated onshore windfarm developments leading to greater awareness and regulation of the risks. Inset: Decadal rainfall totals for the Republic of Ireland (Met Eireann 2020b). The data for 2010–2019 are not yet available. **b** Seasonal occurrence of bogflows and bog slides

2. *Site characteristics*—Several commonly occurring features of bogflow and bog slide failure locations have been noted in previous published accounts of specific examples, and reviewed for all types of peat failures by Dykes and Kirk (2006) and Dykes (2008a). These are summarised in Table 2. The 'drainage or boundary ditches' include all types of hydrological and/or structural influences of cut or excavated features, but ditches and ploughing for forestry planting are considered separately. The different topographic contexts associated with the two failure types are worthy of note and the three recent landslides can be seen to have features common to their respective types.
3. *Topography*—The relationship between gradient of slope and depth of peat is thought to be a key factor in understanding blanket bog failures. Figure 8a shows peat depths corresponding with dominant gradients at all the landslides examined for this study. Two things are readily apparent. Firstly, bogflows tend to be associated with slightly deeper peat on lower gradient slopes than bog slides, and that the two groups of failures appear to be separated by a threshold slope of 4.75°. Secondly, with one exception (the Moanbane bog slide: Mitchell 1938), a peat depth-gradient curve obtained from 32 landslides on Dooncarton Mountain, Co. Mayo (Dykes and Warburton 2007a) appears to define an upper limit for these types of failures. Although MBW-20b has an unusually low gradient, the three recent failures are otherwise consistent with the previous recorded examples.
4. *Geometry*—Several simple geometrical parameters were examined to determine whether any other relationships existed that could help to explain the different characteristics of bog slides and bogflows. In both types of landsides, deeper peat generally allows greater volumes of peat to fail but the relationships differ. Figure 8b shows that bog slides tend to be smaller and that bogflows can develop to be extremely large, with the larger bog slides (> 200 m long) being 4½ to 8½ times longer than their maximum widths while most bogflows show much greater lateral expansion relative to their lengths. No other relationships could be identified. Only the gradient showed a clear threshold dividing the two groups.
5. *Peat characteristics*—Ash content, mass fraction water content and field-wet or saturated bulk density are key indicators of the in situ characteristics of the peat (Hobbs 1986; O'Kelly 2015). Even the qualitative scale of peat humification determined by the von Post 'squeeze test' provides a degree of information that engineers find useful for characterising peat (Hobbs 1986; Carlsten 1993). Quantitative data from blanket bogs are now providing a basis for investigating the geotechnical properties and behaviour of peat in new and more detailed ways to improve our quantitative assessment of in situ peat strength (e.g. O'Kelly 2017) and understanding of mechanisms of failure. Table 1 presents data obtained from lower catotelm peat, i.e. the assumed failure zone, at five bogflows and three bog slides plus a recent 'peat slide' in Co. Antrim (Dykes 2019). It shows that the characteristics of lower catotelm peat that may relate to in situ strength seem to be broadly consistent throughout the island of Ireland (Dykes 2019), and are probably representative of the peat at all of the three recent landslides.

## Implications for peat failure hazard assessment

The three recent peat landslides seem to reinforce known common risk factors for the respective types of failure, in particular the possibility of very large bogflows from very low gradient (< 5°) convex slopes and smaller, probably less mobile bog slides from steeper slopes—although both types can deliver hundreds or thousands of tonnes of polluting peat particles to watercourses and so cause potentially significant economic as well as ecological damage for many kilometres downstream. Climate change predictions of

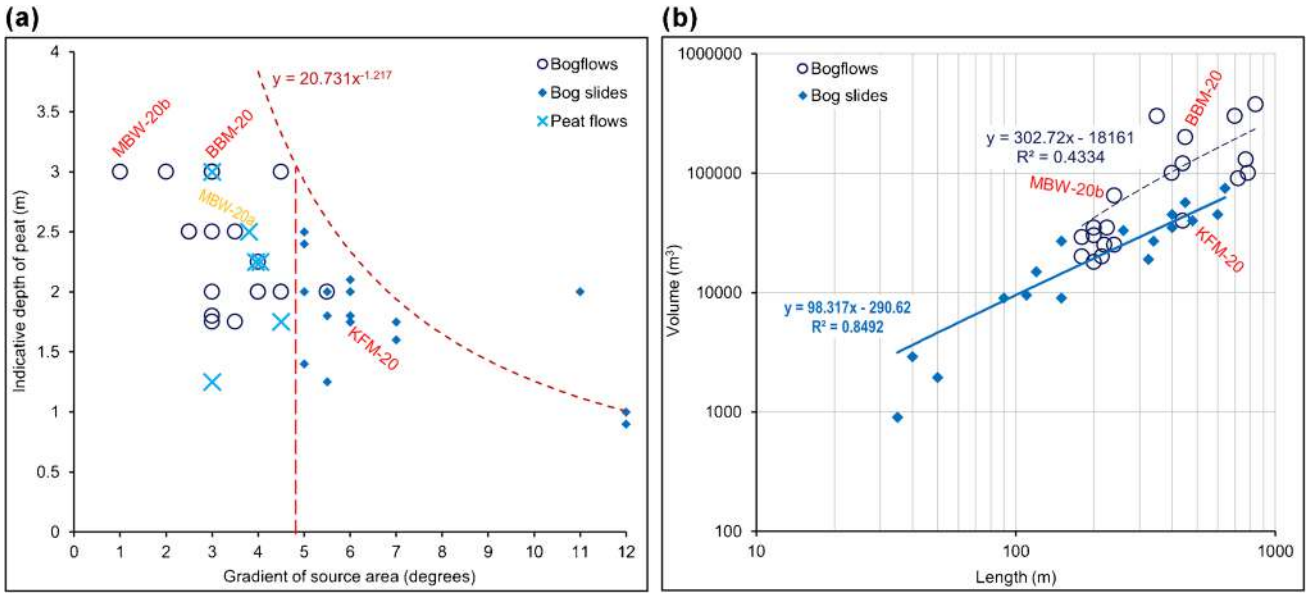



**Fig. 8** Geometrical characteristics of Irish bogflows and bog slides, showing how the 2020 landslides compare with earlier examples. **a** Gradient vs. estimated peat depth showing an empirical threshold from Co. Mayo (after Dykes and Warburton 2007a). **b** Volume of displaced peat vs. centre-line length of source area

warmer, drier summers but with a generally higher frequency of high magnitude rainfall events may be expected to cause more such landslides in the spring or summer than has been the case over the last century. Figure 7a suggests an increasing frequency of these types of failures but this may reflect greater scientific and management interest in recent years with more detailed and complete reporting of events.

All three of the landslides in this study involved blanket bog subjected to commercial forestry to some extent. A previous study suggested that mature forests provide a significantly reduced susceptibility to failure of the peat due to the combination of root reinforcement and drying of the peat by evapotranspiration processes (including interception losses) as a forest grows and matures (Dykes 2012). However, pre-forestry drainage and deep ploughing leave deep peat susceptible to failure from concentration of diverted runoff at certain slope locations or zones (Hendrick 1990), at least for the first few years while the peat remains substantially saturated but structurally weakened by the interventions. Cross-slope ditches associated with forestry sites, including drainage for the roads, may create longer lasting weaknesses, effectively removing toe support for the peat upslope of the excavations. This may have been a contributory factor for KFM-20, as observed elsewhere (e.g. Lindsay and Bragg 2005), with the reinforcing effects of the mature forest being overcome by the developing instability on the much steeper lower part of the slope. At BBM-20, it seems likely that forestry plough lines and drains passing a high volume of excess runoff towards an area of deep blanket bog constituted a significant causal factor, but that further retrogression of the failure was restricted by either the root networks or possibly because the peat mass was not continuous. At Meenbog, forestry drainage probably had little influence on the initial head-loaded peat flow (MBW-20a) due to low antecedent rainfall, but the net effect of the forest was to limit the lateral expansion of the subsequent bogflow (MBW-2b). Attention should perhaps be focused on reviewing the susceptibility to failure of intact blanket bogs outside the downslope edges of plantations.

## Conclusions

The occurrence of three large bogflows and/or bog slides in a single year is exceptional given the average of 0.3 such (reported) events per year over the last 130 years. Two were most likely triggered by high but not exceptional rainfall, and the third appears to have been initiated by a separate head-loaded peat flow associated with construction of a windfarm access road. Remote investigations were made possible by the current trend of ordinary people to obtain photos or videos of unusual things and to post them on-line to be viewed by anyone. Examination of such non-field evidence suggests that all three landslides have site characteristics that are consistent with known risk factors, particularly convex breaks of slope but also the structural and hydrological effects of forestry plough lines and ditches. At BBM-20, these forestry modifications to the bog probably contributed hydrologically to the occurrence of the failure, and possibly structurally at KFM-20, but at the same time further retrogression of BBM-20 and MBW-20b into adjacent forest may have been retarded by the preventative effects of root networks and evapotranspiration. Finally, the geometric characteristics of the source areas are consistent with the reported ranges of values from previous failures. As such, there do not appear to be any novel or unexpected features among the three recent landslides.

## Acknowledgements

I am grateful to the owners of the videos for their respective permissions to reproduce images from those videos.

## Author contribution

APD: All.

## Data availability

Data sharing is not applicable to this article as no datasets were generated during the current study.

# Declarations

**Conflict of interest** The author was included in a bid for a contract to investigate these landslides; this paper was almost complete by the time of the tender deadline.

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An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service

# ASSESSMENT OF MAIN CONTRIBUTING FACTORS LEADING TO THREE MAJOR PEATLAND FAILURES IN LEITRIM, KERRY AND DONEGAL

## MAIN FACTORS CONSIDERED TO HAVE CONTRIBUTED TO THREE MAJOR PEAT FAILURES IN 2020

Prepared by Fehily Timoney and Company on behalf of Geological Survey Ireland (Department of the Environment, Climate and Communications and National Parks and Wildlife Service (Department of Housing, Local Government and Heritage).

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# MAIN FACTORS CONSIDERED TO HAVE CONTRIBUTED TO THREE MAJOR PEAT FAILURES IN 2020

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**Client:** GSI/NPWS

**Keywords:** landslide, bogflow, bog slide, upland blanket peat, Ireland, forestry, rainfall.

**Overview:** Task 2 and 3 of the project involves a review of available data to determine the key contributory factors to three major landslides (peat failures) in upland blanket bog and afforested upland blanket bog that occurred in Ireland in 2020.

Reports issued as part of this Project are as follows:

- Task 1 - Literature review of Conditioning and Triggering Factors in Peat Failures
- Task 2 and 3 - Main factors considered to have contributed to three major peat failures in 2020
- Task 4 - Assessment Note: Potential to update National Landslide Susceptibility map
- Task 5 - Technical Advisory Note: Data gaps relating to impact assessments and planning
- Task 6 - Technical Advisory Note: Impact assessment of land use change on blanket bog/peatland habitats
- Task 7 - Project Summary Report

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# 1. Introduction

## 1.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has approx. 100 members of staff, including engineers, scientists, planners and technical support staff. We deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

FT have been involved in over 100 wind farm developments in both Ireland and the UK at various stages of development i.e. preliminary feasibility, planning, design, construction and operational stage and have established themselves as one of the leading engineering consultancies in peat stability assessment, geohazard mapping in peat land areas and investigation of peat failures.

## 1.2 Project Description

This project has been commission by Geological Survey of Ireland (Department of the Environment, Climate and Communications) and National Parks and Wildlife Service (Department of Housing, Local Government & Heritage) and its objective is to determine the main factors that led to three major landslide (in blanket bog and afforested blanket bog) that occurred in counties Donegal (Meenbog), Leitrim (Shass (Boleybrack Mountain) and Kerry (Mount Eagle) in 2020. .

The landslide at **Meenbog** occurred on open and on afforested upland blanket bog on the 12 November 2020 during the construction of a wind farm.

The landslide at **Shass** (**Boleybrack Mountain**) occurred on upland blanket bog on the 28 June 2020, upslope of the 'Dawn of Hope' bridge, on the downslope edge of a forestry plantation, but extending upslope into this plantation.

The landslide at **Mount Eagle** occurred on the 15 November 2020, within a forestry plantation on blanket bog and an open area of upland blanket bog upslope of the plantation.

Dykes (2022) reports that landslides involving peat are relatively common in Ireland, upland areas of Great Britain and sub-Antarctic islands. However, he also states that **bog slides** (as occurred at Mount Eagle) and **bogflows** (as occurred at the other 2 sites) are less common types of peat failure and almost unknown outside Ireland. However, these types of events may be described differently elsewhere.

These landslides had a range of significant economic, environmental and infrastructural impacts including on farmlands and designated biodiversity conservation sites, both terrestrial and aquatic, and also resulted in losses to peatland carbon stores accumulated over thousands of years. The landslides also released several thousand tonnes of polluting solids into sensitive natural water courses. Some of these impacts were temporary however others are permanent/irreversible.

This project seeks to characterise the environmental settings of these three landslide sites; determine the main factors that contributed to the failures; and further determine any shared conditions that may identify susceptibility in three additional areas of interest (control sites) to GSI and NPWS.

The services that form this project comprise carrying out a detailed scientific assessment, using available data and data provided, along with appropriate site surveys, to determine the main environmental factors, and where relevant, the land uses and human activities that led to these major landslide events.

**Application of Results**
The results of this scientific assessment will be used to inform recommendations on the potential to update Geological Survey Irelands' **National Landslide Susceptibility Map** and to produce **Technical Notes** for use by Local Authorities and other bodies concerning peatland land use and land use activities in relation to peat stability in Ireland.

**Scope of this Report**
This Report covers Task 2 and Task 3 of the project Specification of Requirements, namely:

Task 2
*Assess and analyse available data (and data provided by GSI/NPWS) within the relevant catchment areas to determine the main environmental factors (geological, geomorphological, ecohydrological, climatic) and, where potentially relevant, the anthropogenic factors that contributed to the 3 major peatland failures recorded in Ireland in 2020 (GIS-based analyses to include assessment and interpretation of appropriate time series Earth Observation data)*.

Task 3
*Identify sites or locations within the study area sites where key data is lacking and collect accordingly via focused field visits (in order to validate the analyses carried out under Task 2). Produce a short report on the validation of analyses carried out under Task 2 and identify additional data sources and collect/calculate the cost accordingly*.

## 1.3 Methods used in the Assessment

The following were used in the undertaking of the assessment:

- Review of publicly available data from sources such as GSI, NPWS, EPA, TE
- Site visits to each of the three sites by experienced engineers, ecologists and hydrologists.

## 1.4 Limitations of Data

The data used in this report has been gathered from publicly available sources supplemented by site visits to all three sites by ecologists, geotechnical engineers and hydrologists. The publicly available data is presented as provided by the originator, with no comment on the potential accuracy of such data.

No intrusive ground investigation has been undertaken as part of this project and no monitoring of conditions at the three failure sites has been undertaken.

# 2. Overview of Study Sites

The locations of the three landslides sites are shown on Figure 2.1. A summary of each is provided below and discussed in detail in Sections 3 and 4. A further three control sites were examined using publicly available datasets to determine if similar conditions were present to those at the three failures sites. These sites are described in Section 2.4.

The three landslides are also described by Dykes (2022), based on drone footage and other available data.

## 2.1 Meenbog, Co Donegal

This landslide is classified as a **bogflow** by Dykes (2022) and occurred within an area of open upland blanket bog and afforested blanket bog at Meenbog on 12 November 2020, during the unauthorised construction of a wind turbine access road across blanket bog. The surrounding lands are heavily afforested in commercial conifer plantations located on peatlands.

The following outlines the planning history of the site at Meenbog:

- 2016: Case PA05.PA0040 Provision of up to 49 no. Wind Turbines, two permanent Meteorological Masts, two 110kv Electrical Substations and all associated works at Meenbog and other townlands, County Donegal. Permission Refused.
- 2018: Case PA05E.300460. Provision of 19 no. wind turbines, one permanent Meteorological Mast, one 110kv Electrical Substation and all associated works. Permission Granted. The planning conditions attached to this Permission included “The developer shall ensure that construction works associated with the upgrade of the existing access track adjacent to the Croaghonagh Bog Special Area of Conservation (site code: 000129) shall not encroach upon the Special Area of Conservation.”
- 2019: Case reference PM05E.303729. Proposed alteration to utilise a larger rotor diameter which remains within the consented design envelopes and parameters of the previously approved Meenbog Wind Farm (ABP-300460-17). Permission Granted.
- 2023 (October): Case reference LS05E.314062. Leave to Apply for Substitute Consent for alterations to the permitted Meenbog Wind Farm. Permission Granted.
- 2024 (January): Case reference SH05E.318669. Request for an Extension of Time for an Application for Substitute Consent for a windfarm. Permission Granted.
- 2024 (Lodged 2 April): Case reference SU05E.319466. Substitute Consent application for 25 no. deviations from the permitted Meenbog Windfarm development (granted under ABP PA05E.300460). Live case (no decision as of 29/10/2024).
- 2024 (10 April): High Court Judgement by Mr. Justice David Holland (Docket number 2023/96 MCA, Donegal County Council v Planree Ltd.) prohibiting any further development on the Meenbog Wind Farm site. Decision appealed by Planree Ltd (reviewed by the Court of Appeal in October 2024).

The failure scar morphology comprises 3 distinct parts, namely an upper scar and lower scar which provided the source area for the failed peat, and a run-out trail along which the failed peat was deposited. The scar morphology indicates that failure was most likely a flow slide.

The run-out distance of the failed material was estimated as 3.2km. The total volume of displaced peat based (as estimated in Dykes, 2022) on a mean peat depth of slightly less than 3m gives the failure a volume of 65,000m$^3$.

The bogflow entered and flowed in the Shruhangarve stream and then flowed into the Mourne Beg River. (The eastern part of the site drains to the Shruhangarve stream which flows for about 2.4km from the site in a northeasterly direction where it joins the Mourne Beg River).

Note: **Bogflow** slides are commonly recognised due to the scar forming a "bottleneck" morphology as material locally and retrogressively fails by localised sliding from the side and upslope margins of the initial failure point and also at the downslope margin (mouth) of the scar. The failed material subsequently flows out of the mouth of the scar. In this manner, the scar is retrogressively widened with increasing distance from the initial localised failure point. This is explained in further detail in Section 4.1.

## 2.2 Shass Townland (above Dawn of Hope bridge on Boleybrack Mountain), Co Leitrim

This landslide is also classified as a **bogflow** and occurred on the 28 June 2020 at Shass on the southwestern end of Boleybrack Mountain, 6km northeast of Drumkeeran, Co Leitrim, approximately 1.2km to 1.4km upstream of the Dawn of Hope bridge. The slide initiated within an area of upland blanket bog on a south facing slope and extended retrogressively upslope into a densely afforested area of upland blanket bog.

The evacuated peat initially entered existing watercourses and deposited large volumes of peat for example (c. 25,000m$^3$ upstream of Dawn of Hope bridge and 15,000m$^3$ at Courcuill Upper). The peak flow height of the peat above Dawn of Hope bridge was up to 4.5 m. Based on a failure area of 10ha combining the upper and lower scars, the total estimated volume of failed peat is estimated as 260,000m$^3$.

The deposited peat thickness was up to 3 metres but deceasing downstream and at Courcuill Lower it was estimated as generally < 0.4m in thickness. Collectively the excavated peat covered an area of 45 ha (111 acres) and resulted in flooding of the flood plains in the townlands of Corcormick and Derrindangan and erosion of the watercourse down to Courcuill Upper (iCRAG, 2020).

The majority of the peat carried downstream of the Dawn of Hope bridge remains on these flood plains. The Diffagher River carried some peat sediment and other debris to Lough Allen, approximately 8.45km from the starting point, where it has been observed washed up on the shoreline, e.g. at Corry Strand (RPS, 2020).

The failure scar is defined in 2 parts, namely:

- Upper scar. This comprised the main source area of the failed material. The upper scar is 450m long and 200m to 250m wide. The head of the failure scar is within the forestry plantation, where 2 notable head features are readily apparent. The estimated total area of the upper scar is 8ha.
- Lower scar. The lower part of the failure scar followed an existing incised stream channel where there appeared to be scouring of material, and a net removal of material. Based on inspection this is assumed not to extend as far as the Dawn of Hope bridge. Below this scar there was a net accumulation of failed material. The lower scar along the incised channel was 700m long by about 20m wide. The estimated total area of the lower scar is 2ha.

The peat failure occurred on the south-western part of Boleybrack Mountain Special Area of Conservation (SAC) (Site Code: 002032). Boleybrack Mountain SAC comprises an extensive upland blanket bog and heath covered plateau situated to the north of Lough Allen in Co Leitrim. The SAC is bounded on the north and south

by commercial conifer forestry plantations, and on the west by the Scardan River. It is designated for protection of Annex I Habitats' Directive habitats: Natural dystrophic lakes and ponds [3160]; Northern Atlantic wet heaths with *Erica tetralix* [4010] European dry heaths [4030]; *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410]; and Blanket bogs [7130/7130*] (* if active bog).

## 2.3 Mount Eagle, Co Kerry

This peat failure is classified as a **peat slide and debris slide** and commenced within a densely afforested area of upland blanket bog on 15 November 2020 on Mount Eagle, County Kerry. The peat failure extended upslope into the adjacent blanket bog in the Mount Eagle Bog Natural Heritage Area (Site Code 002449) which is designated for the protection of blanket bog and associated habitats.

Details of the failure are also reported in the Irish Farmers Journal (2020).

The total length of the source area or upper failure scar is estimated to be 650m long by about 30 to 50m average width. (Dykes (2022) reports that the width increases from ~30 m at the head to ~60 m throughout the lower half).

The lower part of the failure scar within the forestry plantation is narrower, which suggests that this represents material running out from the scar and is likely not part of the failure scar. Based on the above the estimated plan area of the failure scar covers 2.6ha.

It is understood that peat debris from the failure entered a nearby tributary stream of the River Clydagh, which originates from this area. At least several hundred tonnes of solids are likely to have reached natural watercourses with much of this eventually polluting the River Clydagh.

The 2020 landslide occurred adjacent to a previous landslide in the forestry plantation and in a similar topographic scenario (prior to March 2018). The head of the 2020 failure however extended into the open blanket bog upslope of the forestry plantation. Given the shape of the peat failure scar, the likely mode of failure was a progressive bog slide which downslope degraded into a debris slide before being channelised as a flow, which in many cases results in a long run-out. The run-out distance was estimated as 2.5km.

## 2.4 Control Sites

In addition to the three failures sites, three control sites were provided by GSI for review as part of these works. These were at Knocknageeha, Co Kerry, Cuilcagh/Anierin and Geevagh, both Co Sligo/Leitrim. Each of these three sites has recorded historical peat failures of various types. These sites were reviewed to determine if any locations contained similar conditions to those at the three failure sites. The review of these areas was undertaken remotely, with no site visits or analysis of rainfall data. Limited reviews of other of publicly available datasets from the GSI, NPWS and EPA were carried out.

### 2.4.1 Knocknageeha

The historical failure within this control area occurred in December 1896 and is considered to be the largest known peat failure in Ireland. It has been described as a bog burst and resulted in the deaths of 8 people. This failure occurred within a flat area of open deep peatlands where deep turf cutting was being undertaken. The cause of the failure was considered to be a combination of open vertical excavations within the peat and extremely heavy rainfall.

The majority of this control area is not underlain by peat, and the topography is characterised by relatively uniform slopes, with only occasional breaks in slope. The areas around the perimeter of forestry areas were examined, however no significant erosion of firebreaks or areas of bare peat was noted. Numerous areas of worked peat were present within this control area, covering most of the open peatland visible on aerial imagery, however no evidence of instability was noted around these areas.

In general, only very limited areas within this control area were recorded to have similar features to the three failure sites.

2.4.2 Cuilcagh/Anerin

The topography of this control area is dominated by a northwest-southeast trending ridge line, with the slopes falling to the southwest and northeast away from this feature. Three lakes are present along the top of this ridge, Lough Nambrack, Knockgorm Lough and Manter Eolus Lough.

A review of GSI's landslide database indicates that a number of historical failures have occurred within this control area. A paper by Dykes (2001) describes a multiple peat slide event that occurred on Cuilcagh Mountain during October 1998, following a storm event. The analyses presented in that paper appear to indicate that the combined effects of the presence of a degraded drain and of pipes within the pale clay present below the peat were necessary for this failure to occur, although other 'preparatory' factors may also have contributed to the onset of instability (Dykes, 2001).

While peat is indicated to be present on GSI's Quaternary mapping across approximately 50% of the control area, the slope angles across most of the blanket peatland indicate that the peat, where present, is relatively shallow, likely similar to the <1m recorded by Dykes (2001). This contrasts with the three failures areas where peat depths were notably deeper. The majority of the blanket peatland does not appear to have been worked. Numerous drainage networks are visible through the blanket peat; however, the irregular shape of these networks indicate that they are generally natural in origin, with the exception of an area to the south of Lough Nambrack. The areas around the perimeter of forestry areas were examined, however no significant erosion of firebreaks or areas of bare peat was noted.

In general, only very limited areas within this control area were recorded to have similar features to the three failure sites.

2.4.3 Geevagh

The majority of this control area is underlain by peat, and the topography is characterised by relatively steep slopes, with only occasional breaks in slope. The areas around the perimeter of forestry areas were examined, however no significant erosion of firebreaks or areas of bare peat was noted. Numerous areas of worked peat were present within this control area, covering a large area of open peatland in the north of the control area.

A review of GSI's landslide database indicates that a number of historical failures have occurred within this control area. the majority of the failures are associated with a steep southwest facing slope that runs northwest to southeast through the control area. Two historical failures are associated with the area of peat working in the northern part of the control area.

In general, only very limited areas within this control area were recorded to have similar features to the three failure sites.

**Figure 2.1: Locations of Peat Failures (2020) and Control Sites**

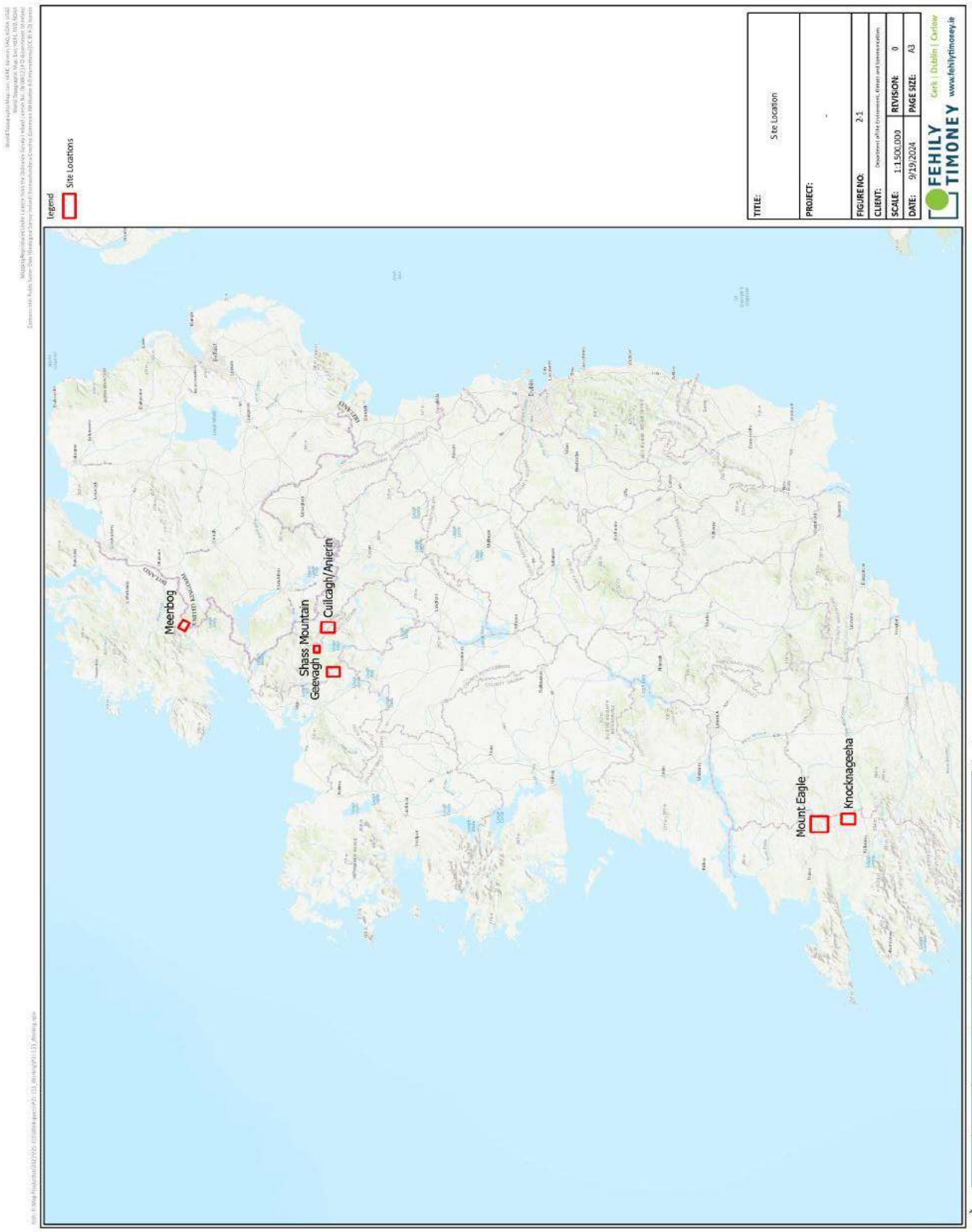


**Figure 2.2: Control Site - Knocknageeha**

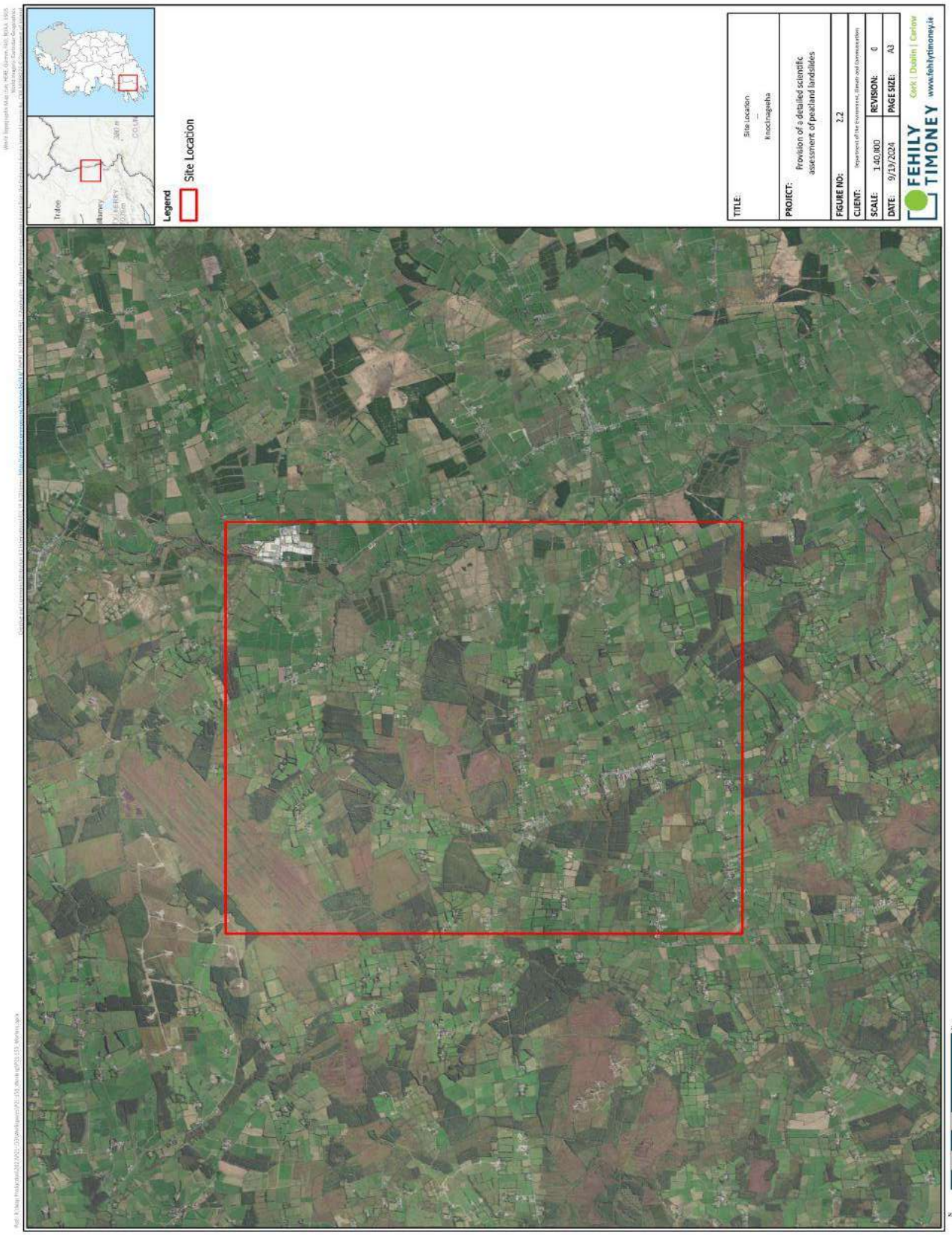


**Figure 2.3: Control Site - Cuilcagh**

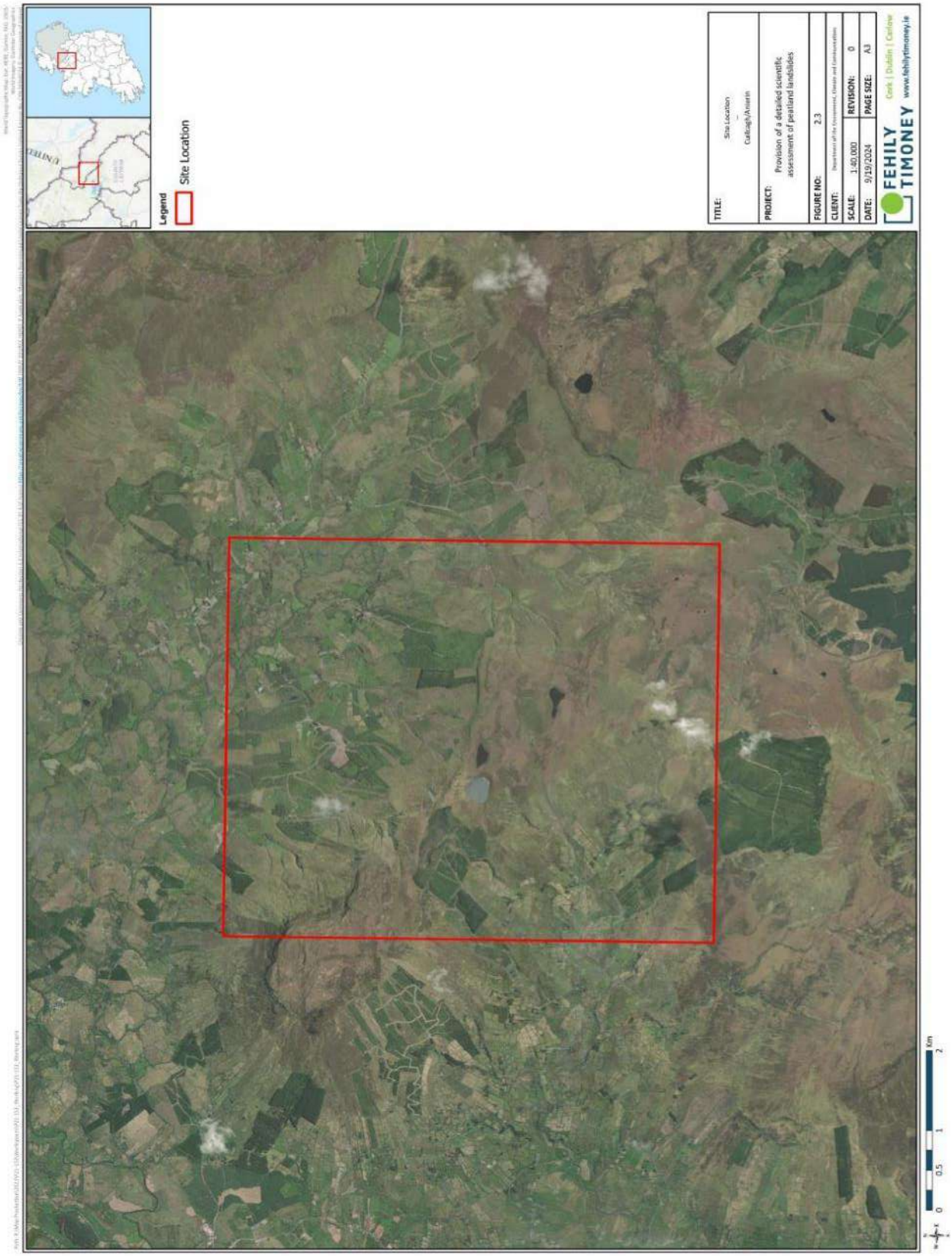
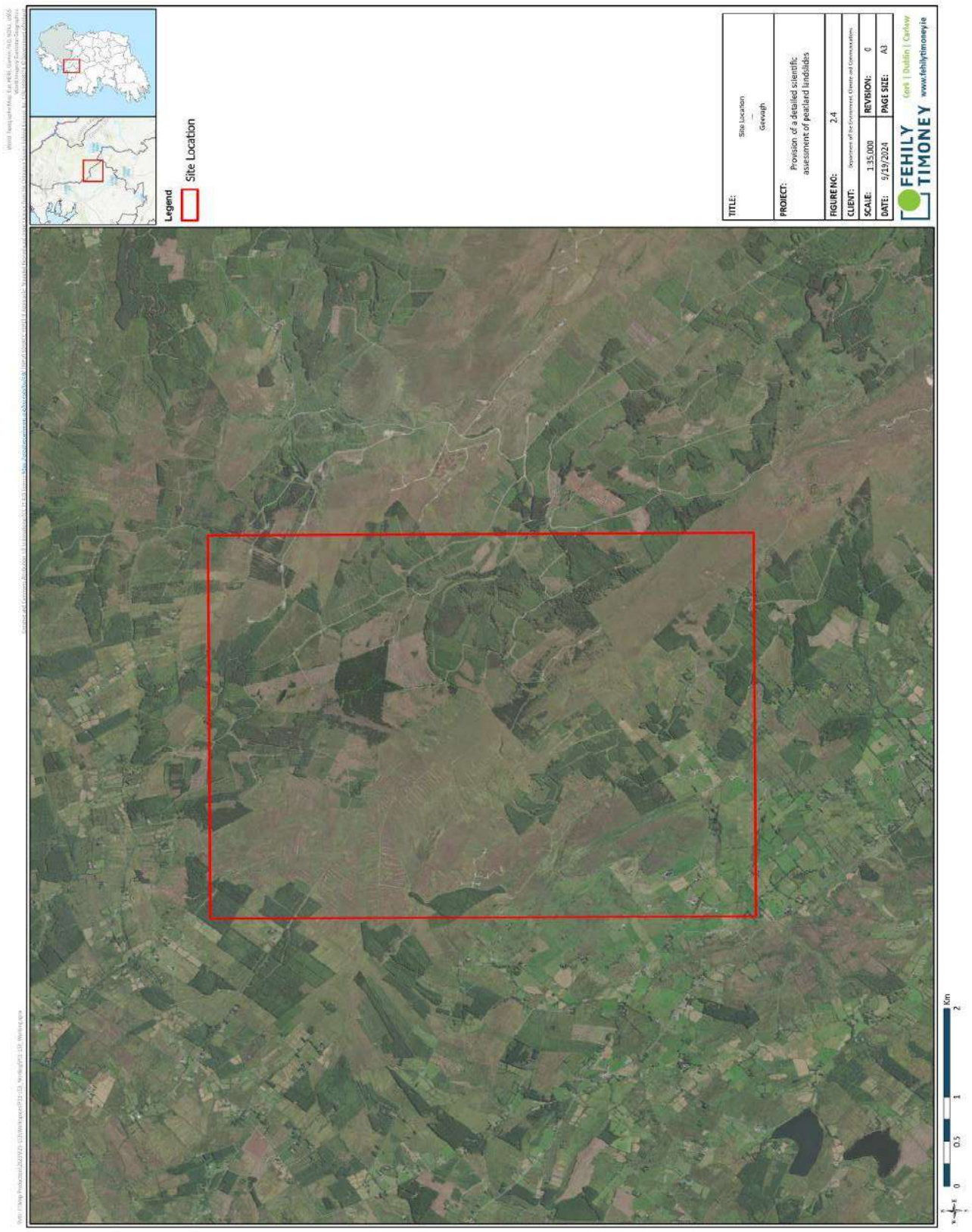


**Figure 2.4: Control Site - Geevagh**



# 3. Data Review

The text in this report makes reference to both conditioning and triggering factors in relation to peat failures. These terms are defined below and are discussed in more detail in the Project Task 1 report "*Literature Review of Conditioning and Triggering Factors in Peat Failures*".

**Conditioning factors** are site-specific characteristics and of its immediate vicinity including from land uses past or ongoing that may have had continuing impacts on peatland properties and ecosystem functioning and that may predispose an area to increased susceptibility of peat failure.

**Triggering factors** are specific events or actions that can be directly linked to the onset of a peat failure.

## 3.1 Datasets

A number of publicly available datasets from the GSI, NPWS and EPA were reviewed to gather background data on the three sites prior to undertaking site visits to the three failure sites. Additional information, such as LIDAR data for Meenbog; high quality aerial imagery for Shass Mountain; Conservation Ranger report and images for the Mount Eagle peat failure was provided by GSI and/or NPWS.

The following datasets are considered, along with the source of the data:

- Soils and Geology (GSI)
- Topography (GSI/NPWS)
- Landslide Susceptibility (GSI)
- Geomorphology (GSI)
- Hydrology/Hydrogeology (GSI)
- Ecology (NPWS)
- Rainfall (Met Éireann)
- Land Use/Site History (OSI)

## 3.2 Meenbog, Co Donegal

### 3.2.1 Soils and Geology

The majority of the study area around the Meenbog failure is recorded as blanket peat (Figure 3.1). The peat cover ranges in thickness from 0m to 5.8m and is underlain by various strata on the site such as glacial till (in thin layers), weathered rock and bedrock. The bedrock underlying the site comprises Precambrian quartzites, gneisses and schists with granites and intrusive rocks (Figure 3.2). GSI's mapping indicates that the bedrock dips (at 40 to 50 degrees) to the NE. A fault, the Laghy Fault, which is 40km long and trends NW-SW, is indicated to the southeast of the failure area. Multiple rock outcrops are indicated on the bedrock 100k map and outcropping rock was observed by GSI during a site visit. The rockhead dipped NE.

### 3.2.2 Topography

The general topography across the Meenbog study area is undulating, described as mountain to hill/mountain ridge on GSI's Physiographic Units Map. Elevations range from 150 to 300m AOD across the site. This indicates relatively varied topography, often with relatively steep slopes, as found in locations across the Meenbog study area. Figures 3.3 and 3.4 show the contours across the study area and around the failure respectively. Figure 3.5 provides a slope interpolation of the failure area, with the contours divided into 2 degree bands.

The Lidar data available for this site allows for refined slope analysis to be carried out. It can be seen from Figure 3.5 that the approximate failure point for the Meenbog failure occurred close to a convex break in slope between an almost flat area to the west/southwest and a shallow (2-4 degree) slope to the east. This change in slope is considered to be a conditioning factor in the failure, even though the slopes would be considered to be shallow in general terms.

### 3.2.3 Landslide Susceptibility

The landslide susceptibility of the study area around Meenbog ranges from low to high based on GSI's Landslide Susceptibility Mapping (Figure 3.6). The failure site is classified as having low susceptibility to failure, with a rise to moderately low susceptibility just to the east of the failure on the shallow slope towards the Shruangarve stream. This is to be expected given the relatively shallow slopes present in the area around the peat failure, as slope angle is one of the factors used in the GSI landslide susceptibility methodology.

Historical landslides have been recorded to the west of the Meenbog site, one at Barnesmore, which occurred in 1963. This failure is described as occurring "at a marked break in slope where morainic sands and gravels beneath the peat had recently been moved for road work". Little to no information is available for the second location, some 6km west of the Meenbog site.

### 3.2.4 Geomorphology

Quaternary geomorphology of the study area is shown on Figure 3.7. The Meenbog peat failure remains on the outskirts of any major geomorphological features with a Moraine Ridge being the nearest recorded feature to the failure, however as this feature is present at a lower level within the Barnesmore Gap, it does not appear to have influenced the location of the peat failure.

The southern part of the site is dominated by a ridge line that extends northeast from Carrickaduff Hill. The top of the ridge line varies in elevation from 180 to 310mOD. The northern part of the site is within the Bunadaowen River valley, which runs parallel to the ridge line.

The top of the Carrickaduff Hill ridge line comprises in many places a broad level surface. Eastwards the ridge line declines in elevation and a number of broad level benches are present, again with notable depths of peat. Slope gradients along the ridge line are typically from 1 to about 10 degrees, with locally up to about 20 degrees.

Adjacent to the high point (at 313mOD) of the ridge line there is an elongated small water body, Carrickaduff Lough. The lough is located within a short steep-sided narrow valley aligned along the axis of the ridge line. This valley feature is possibly controlled by the structural geology control or is a relict glaciation feature.

The northern side of the ridge line comprises a relatively uniform slope which is drained by a number of tributary streams that flow into the Bunadaowen River. The southern side of the ridge line comprises a more

varied slope profile with locally steeper sections as a result of rock near-surface. A limited number of streams are located on the southern slope and drain into the Glendergan River.

The peat cover on the ridge line comprises an almost continuous cover of blanket peat. Multiple rock outcrops are indicated on GSI's bedrock mapping. The peat cover shows little signs of erosion, though it has been heavily dissected by drainage excavated prior to the planting of the trees and by forestry access roads.

### 3.2.5 Hydrology

**Regional and Local Hydrology**

The Meenbog site is situated within the Bunadaowen, Mourne Beg River and the Glendergan River catchments. Both catchments are within the larger Mourne River catchment, which itself is part of the larger Foyle catchment. Most of the site drains directly into the Bunadaowen River which flows in a northeasterly direction through the northern part of the site. The catchment of the failure source area is outlined on Figure 3.8. The failure occurred close to the edge of the catchment of the Shruanagarve River, which flows to the northeast to the Mourne Beg River.

The Bunadaowen River joins the Mourne Beg River about 0.3km to the north of the site. Within the Bunadaowen River catchment the area is also drained by several tributary streams which flow in a general northerly direction towards the Bunadaowen River. Based on the EIAR for Meenbog Wind Farm (2017), the streams are typically deeply incised, narrow eroding streams with a width of 0.5m to 1m.

The eastern part of the site drains to the Shruhangarve stream which flows for about 2.4km from the site in a northeasterly direction where it joins the Mourne Beg River. The 12 November peat failure entered and flowed in the Shruhangarve stream and then flowed into the Mourne Beg River.

**Forestry Drainage**

Within the site there are numerous man-made drains, mostly installed prior to the planting of the forestry but drains are also present within the open area of blanket bog upslope of the failure location. Based on the EIAR (2017), the forestry plantations at the site are generally drained by a network of mound drains which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantations. The forestry drainage pattern is influenced by the local topography, ground conditions, layout of the forestry plantations and existing access roads, as would be typical of upland forestry plantation on peatlands in Ireland.

The mound drains and ploughed rill drains are generally spaced about 15 to 20m and 2m respectively. Interceptor drains are generally located both up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of forestry access roads. Rill drainage is shown in Figure 3.9 and 3.10 and is visible in Plate 3-1.

The catchment area upslope (south) of the failure is divided, with the western side draining to an interceptor or collector drain on the western edge of the open peatland, and from there draining to the Bunadaowen River and the eastern side draining to a collector drain that runs south-north, following the edge of the felled forestry, at a break in slope. This drains outfalls to the east towards the Shruhangarve stream at several locations, the most prominent of which is at a topographical low point some 80m to the south of the failure.

Firebreaks have also been excavated on this site and generally run in a North-South direction. It is not known how the material excavated from the fire breaks was reused on the site.

### 3.2.6 Hydrogeology

The Precambrian quartzites, gneisses and schists, which are mapped and underlie the Meenbog site are classified by GSI as a Poor Aquifer, comprising bedrock which is generally unproductive except for local zones (Pl) and has groundwater flows of less than $10m^2/d$.

The Precambrian rocks generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10m thick, and a zone of isolated poorly connected fissuring typically less than 150m (GSI, 2004).

Overburden (glacial till) is only present in pockets across the site, is limited in thickness and is laterally disconnected. The potential for groundwater flow at the base of peat is considered to be limited.

The vulnerability rating of the aquifer in the area around the peat failure ranges between "Moderate to High" and this reflects the varying depth of local subsoils and peat. In areas where subsoil is shallow or absent and where bedrock is outcropping, such as to the south of the failure location, an Extreme (E) or Extreme (X) Rock at or near Surface vulnerability rating is given. Extreme (X) indicates bedrock at or within 1m of the surface. Extreme (E) indicates bedrock at or within 1m to 3m of the surface.

Due to the low permeability nature of the Precambrian bedrock aquifer underlying the site, groundwater flowpaths are likely to be short (30 – 300m), with groundwater discharging to nearby streams and small springs. This means there is a low potential for groundwater dispersion and movement within the aquifer. There is a lack of mapped springs and flush areas at the site, and this suggests that groundwater has a limited local influence at this site. Bedrock aquifer properties can be considered a conditioning factor since the relative impermeability of the underlying rock will not facilitate drainage of surface water and, is instead more likely to cause flow at the base of the peat where it lies directly on bedrock.

### 3.2.7 Ecology

Orthophotography indicates that the Meenbog failure site is located within an area of upland peatland habitat (blanket bog and heath) surrounded by conifer plantations on blanket peat. The flat topography of the area in which the failure occurred represents conditions that favoured deeper peat formation and blanket bog.

Rows of drains running north-south through the open bog to the south of the failure are visible in orthophotography. These drains are absent from the areas to the west, east and south-east of the failure, and in pre-failure orthophotography they are also absent from the area of the failure.

Meenbog wind farm EIAR (EIAR – 2017.11.22 – F) identified the peatlands in the area of the failure as Upland blanket bog/Wet heath Mosaic (PB2/HH3) and the EIAR habitat map identifies the entire area as this mosaic. More nuanced detail is provided in the habitat description, which notes that blanket bog is present in flatter areas (i.e. at the failure site), while wet heath is present on steeper ground. The failure site is identified as Upland blanket bog in a photograph, with Wet heath noted as covering the higher elevation in the background. (Blanket bog (7130/7130*) and Wet Heaths (4010) are Habitats Directive Annex I habitats). Active Blanket bog is Code 7130* and is a priority habitat. It is defined as having a significant area of vegetation that is normally peat-forming. Most of the blanket bog at this site would conform to Active Blanket bog habitat (7130*).

The presence of White-beaked sedge (*Rhynchospora alba*) was noted in this mosaic. This species occurs in very wet conditions and is typically indicative of either the Annex 1 habitat 'Depressions on peat substrates of

the *Rhynchosporion* [7150]', or the sub-community *Rhynchospora alba* quaking bogs within the Annex 1 habitat 'Transition mires and quaking bogs [7140]', the latter of which would be associated with deep peat with a very high water content.

No commentary on the wetness or physical state of the blanket bog in this area was included in the EIAR habitat description, other than noting blanket bog occurred in flatter areas while wet heath was present on steeper slopes. The photograph of the failure area included in the EIAR shows a densely vegetated surface, similar in character to the vegetation surrounding the failure which persists at present.

The site is not overlapped by any protected areas; however, the peat failure drains to the Mourne Beg River within the Finn River SAC (002301) via the Sruhanagarve River which receives drainage flows from the site approx. 500m from the failure inception point. The SAC is approx. 2.4km downstream of the point the peat failure entered the Sruhanagarve.




*Geohive/MapGenie (2013)*

**Plate 3-1: Meenbog Pre-Failure Orthophotography (2013).**




*Google Earth/Maxar (2020)*

**Plate 3-2: Meenbog Pre-Failure Orthophotography (2020).**




*Google Maps (2024)*

**Plate 3-3: Meenbog Post-Failure Orthophotography (2024).**

### 3.2.8 Rainfall

A number of weather stations are in the vicinity of the site, and these have been used to examine recorded rainfall data as they are considered to be good proxies for rainfall pattern and magnitude at the site. The nearest weather station to the site is the Met Éireann Lough Mourne Automatic Climate Station (ASC) some 5.3km to the north of the failure site. The rainfall data from the Met Éireann Weather Station at Finner, near Bundoran some 34km to the southwest of the failure site has also been used.

The rainfall data from the Lough Mourne ASC, which is at an elevation of about 33m OD, has rainfall data available typically in 30 minute intervals. The daily rainfall data from January to November 2020 has been examined.

The Finner Weather Station is at an elevation of about 33m OD, and as such the rainfall pattern at the Weather Station may only provide an indication of the rainfall at the failure site which is at an elevation of generally over 250m OD. Continuous rainfall records are available since about the start of 2011, which has been examined.

Daily rainfall data for the Lough Mourne ASC has been analysed. Rainfall records for the Finner Weather Station for hourly, daily, and monthly amounts were analysed for the period preceding the peat failure on 12 November 2020. Results are included graphically in Appendix A.

#### *3.2.8.1 Analysis of Rainfall Data*

The results of the rainfall analysis are given below.

(1) The rainfall data from the Lough Mourne ASC shows that the wettest period in 2020 was in February and March 2020. The highest daily rainfall was recorded on 21st February 2020 (68mm). On 11th November 2020 the day preceding the peat failure the daily rainfall amount was 28mm. On the day of the failure the daily rainfall amount was only 6mm.
(2) In 2020 from the Lough Mourne ASC, the daily rainfall amount was 30mm or greater on the 10 days preceding the failure on 12 November 2020. In the month preceding the failure, there were four days where the rainfall exceeded 25mm, however there is no evidence that peat failures occurred on the site immediately after this rainfall.
(3) Using the data from Finner Weather Station, for all antecedent rainfall duration periods the rainfall amounts preceding the peat failure on 12 November 2020 were exceeded a number of times during 2020, and also a notable number of times since 2011. This indicates that (antecedent) longer duration period rainfall events were not a significant contributory factor to the peat failure.
(4) The nearby Barnesmore station also recorded a similar rainfall event on 28 June 2020 to that which occurred at Shass Mountain without any evidence of peat failure on the site.
(5) What is particularly notable with respect to rainfall duration periods is the sustained dry spell in April and May 2020, which exceeds all previous dry spells recorded since 2011 at Finner.
(6) The significant and sustained dry spell in April and May 2020 nationally was one of the driest recorded for this period. All rainfall totals across the country were below their Long-Term Average (LTA) for the period with the driest on record for Dublin and Meath. At Finner, rainfall was 58% of the average expected amount (Met Éireann 2020).
(7) The Finner records show the lowest recorded 7 and 14-day cumulative rainfall amounts occurred in April 2020.
(8) A review of the Finner records for the preceding 10 years shows annual rainfall ranging from 1067 (2013) to 1691mm (2015), with 1492mm recorded in 2020.

There was no clear significant peak rainfall duration period immediately prior to the peat failure on 12 November 2020. The combination of the dry April and May followed by high daily rainfall amounts (notably in June, September and November at Lough Mourne ASC) may have exacerbated the ongoing effects of the modified hydrology and peat properties of the drained and afforested blanket bog upslope of the failure initiation point however to what extent is unknown.

### 3.2.9 Land Use/Site History

Historical aerial photography was examined for the site covering the years 1995 to 2020, see Table 3-1. Based on this examination and on published information, there were no apparent peat failures on the site prior to construction of the Meenbog wind farm. The closest failure recorded is some 3.5km to the west of the site (Barnesmore) and occurred in 1963. This failure is noted to have occurred at a break in slope, adjacent to an area where sand and gravel had been removed and drainage trenches had been ploughed nearby to drain the peat for cutting.

The area to the south and west of the 2020 failure is notable because it has never been planted with forestry. This would typically represent an area where poor tree growth was expected and hence poor returns or because of a particularly wet area of deep peat which was difficult to drain or where it would have been considered dangerous for an excavator to traverse the bog.

The presence of relict peat failures or clustering of relict failures would indicate that site conditions existed that pre-dispose a site to failure. The site has been extensively planted with conifers for a number of years and with felling having been carried out at various locations with no signs of peat failure. However, there are a number of significant differences between wind farm construction operations and forestry operations therefore direct parallels cannot be made between the potential effects on peat stability of these different operations.

Although there is no indication, from the examination of orthophotography (from 1995 to 2020), that any recent peat failure had occurred at any locations in the immediate vicinity of the Meenbog site it is documented, as mentioned above, that a peat slide (the large Barnesmore bogflow) occurred in 1963 just 3.5km further northwest on the same tract of upland as Meenbog (Dykes 2022).

At the time of the failure an unauthorised wind farm access road was under construction at the location of the failure. The road was being constructed using a ‘floating’ technique, which uses either one or multiple layers of geogrid reinforcement within a layer of crushed rock to create an access road without excavating any peat. In the case of Meenbog, brash (in the form of tree trunks and offcuts) was being placed along the line of the access road to act as an additional layer below the road to spread the loading from the road over a larger area. This type of construction is often used in the construction of roads within forestry when crossing peatland/blanket bog areas.

**Table 3-1: Meenbog Historical Orthophotography Review**

| Year | Comments |
|---|---|
| 1995 | The Meenbog site is blanket bog covered in conifer forestry plantation. The southern part of the site has a cover of trees. In the northern part of the site, trees have been /recently planted.<br><br>The site of the 12 November 2020 failure is an open upland blanket bog that covers an area of about 340m by 280m (9.5ha). Drainage furrows are present in the southern part of the open blanket bog area.<br><br>There are no apparent signs of peat failure within the site.<br>The 1963 failure is visible on the orthophotography. It is noted that the peatland to the east of the site entrance shows concentric mounds; this is a flat lying area and this possibly represents either peat growth or creep movement. |
| 2005 | The site is covered in forestry plantation. The southern part of the site has a cover of trees. In the northern part of the site, trees have been recently planted. Removal of some stands of trees in the west of the site.<br><br>The site of the subsequent 12 November 2020 failure is open peatland and remains unchanged from the earlier photograph.<br><br>There are no apparent signs of recent peat failure within the site. |
| 2013 to 2018 | The site is covered in forestry plantation. The southern part of the site has a cover of trees. In the northern part of the site, trees have been recently planted. Further removal of some stands of trees in the west and south of the site. The forestry extraction route appears to align with the western edge of the open bogland and turns slightly in the area where the peat failure initiated.<br><br>The site of the subsequent 12 November 2020 failure remains as open peatland and remains unchanged from earlier photographs.<br><br>There are no apparent signs of recent peat failure within the site. |
| September 2020 | The site remains covered in forestry plantation. Areas of forestry have been removed for the wind farm works together with some stands of trees, including trees downslope of the location of 12 November 2020 peat failure. The outline of the wind farm is clearly visible (hence overlay is not included).<br><br>The site of the subsequent/12 November 2020 failure is open peatland and remains unchanged from earlier photographs. The failure scar has been added to show its extent. |

### 3.2.10 Summary

The Meenbog site comprises an area of upland blanket bog that has been heavily afforested over the past 50 years. Bedrock underlying the site comprises Precambrian quartzites, gneisses and schists with granites and intrusive rocks. A fault is present to the SE of the failure but is not considered to impact on the landslide susceptibility at the failure location.

The topography across the site comprises a mountain ridge between 150 and 300m AOD. The approximate failure point for the Meenbog failure occurred close to a convex break in slope between an almost flat area to the west/southwest and a shallow (2-4 degree) slope to the east.

Orthophotography indicates that the Meenbog failure site is located within an area of upland peatland habitat (blanket bog and heath) surrounded by conifer plantations on blanket peat. The flat topography of the area in which the failure occurred represents conditions that favoured deeper peat formation and blanket bog.

Within the site there are numerous man-made drains, mostly installed prior the planting of the forestry but drains are also present within the open area of blanket bog upslope of the failure location. The catchment area upslope (south) of the failure is divided, with the western side draining to an interceptor or collector drain on the western edge of the open peatland, and from there draining to the Bunadaowen River and the eastern side draining to a collector drain that runs south-north, following the edge of the felled forestry, at a break in slope.

A review of rainfall records indicates that there was no clear significant peak rainfall duration period immediately prior to the peat failure on 12 November 2020. The significant and sustained dry spell in April and May 2020 nationally was one of the driest recorded for this period.

In terms of predisposition to landslides, GSI's landslide susceptibility mapping indicates that the area around the failure was considered to be at low to moderately low susceptibility to failure. However, the presence of a break in slope close to the failure location, the presence of peat across this slope, and the presence of forestry drains close to the failure location, would all be considered conditioning factors for peat failures. The presence of these conditioning factors would indicate that the area would be at higher risk of peat failure. GSI's landslide mapping was designed for landslides in general, not specifically peat failures, and as such is does not specifically consider the possibility of specific peat failure mechanisms or the possibility of peat failures on relatively shallow slopes.

**Figure 3.1: Meenbog Quaternary Geology**

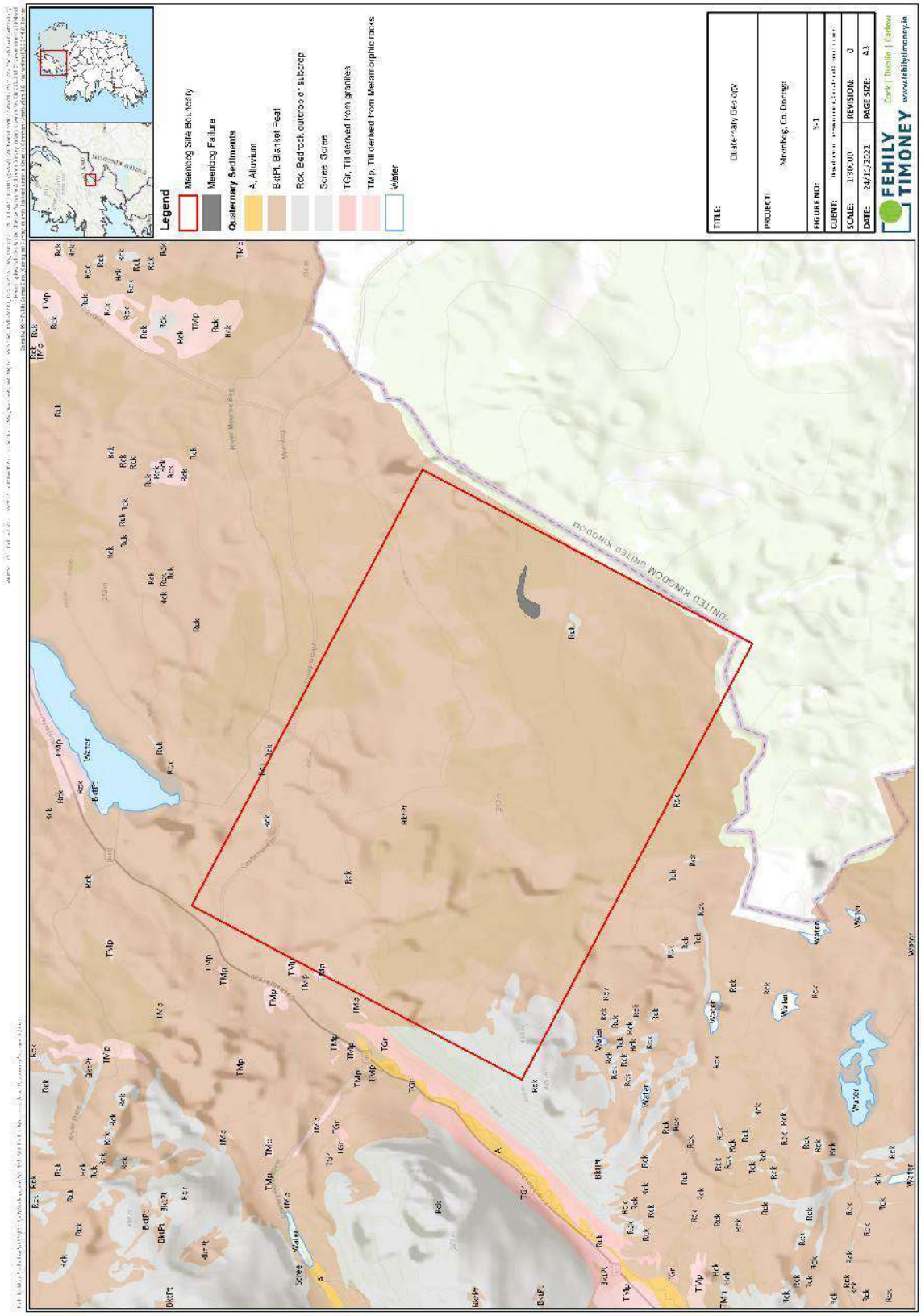


**Figure 3.2: Meenbog Bedrock Geology**

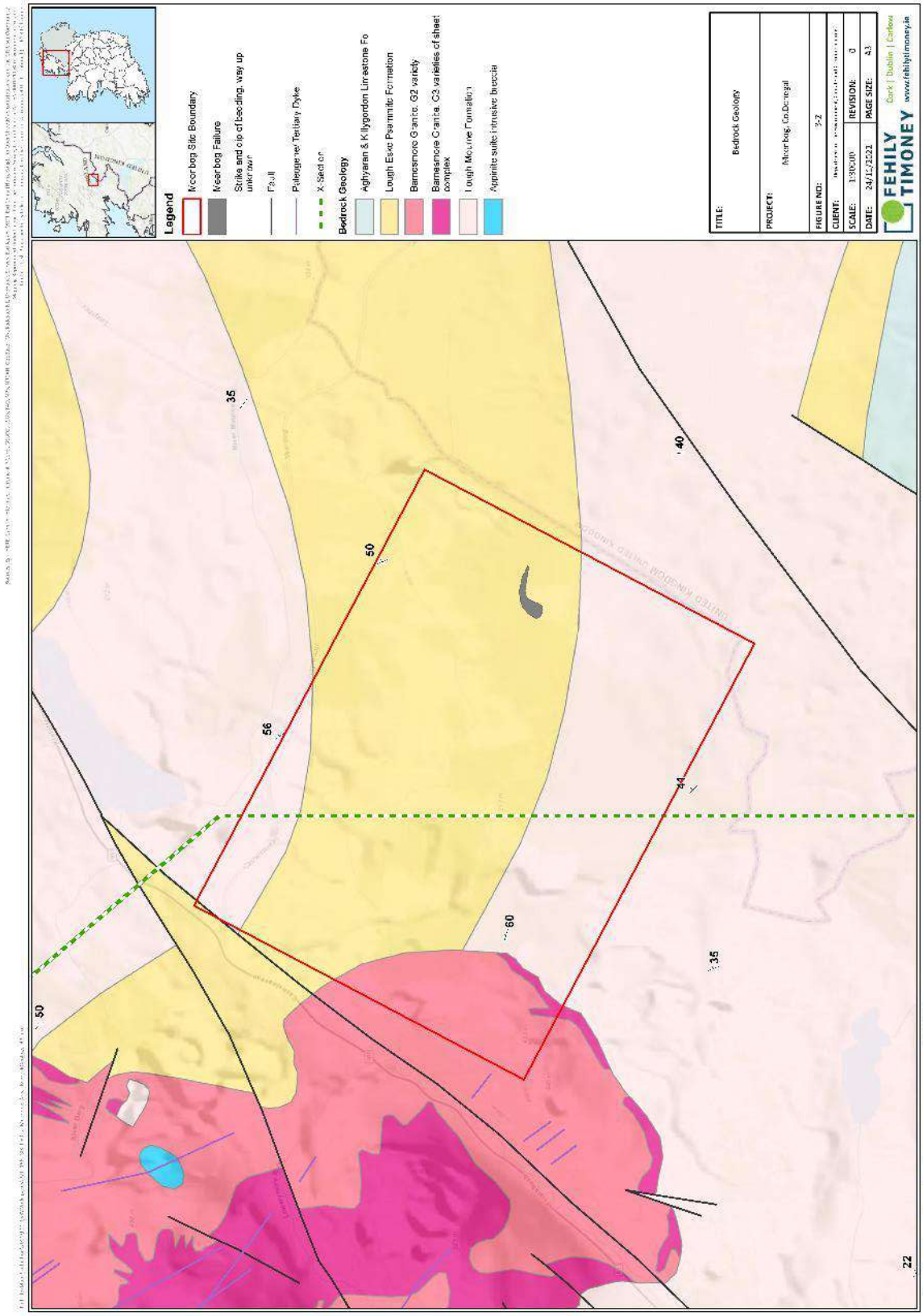


**Figure 3.3: Meenbog Topography**

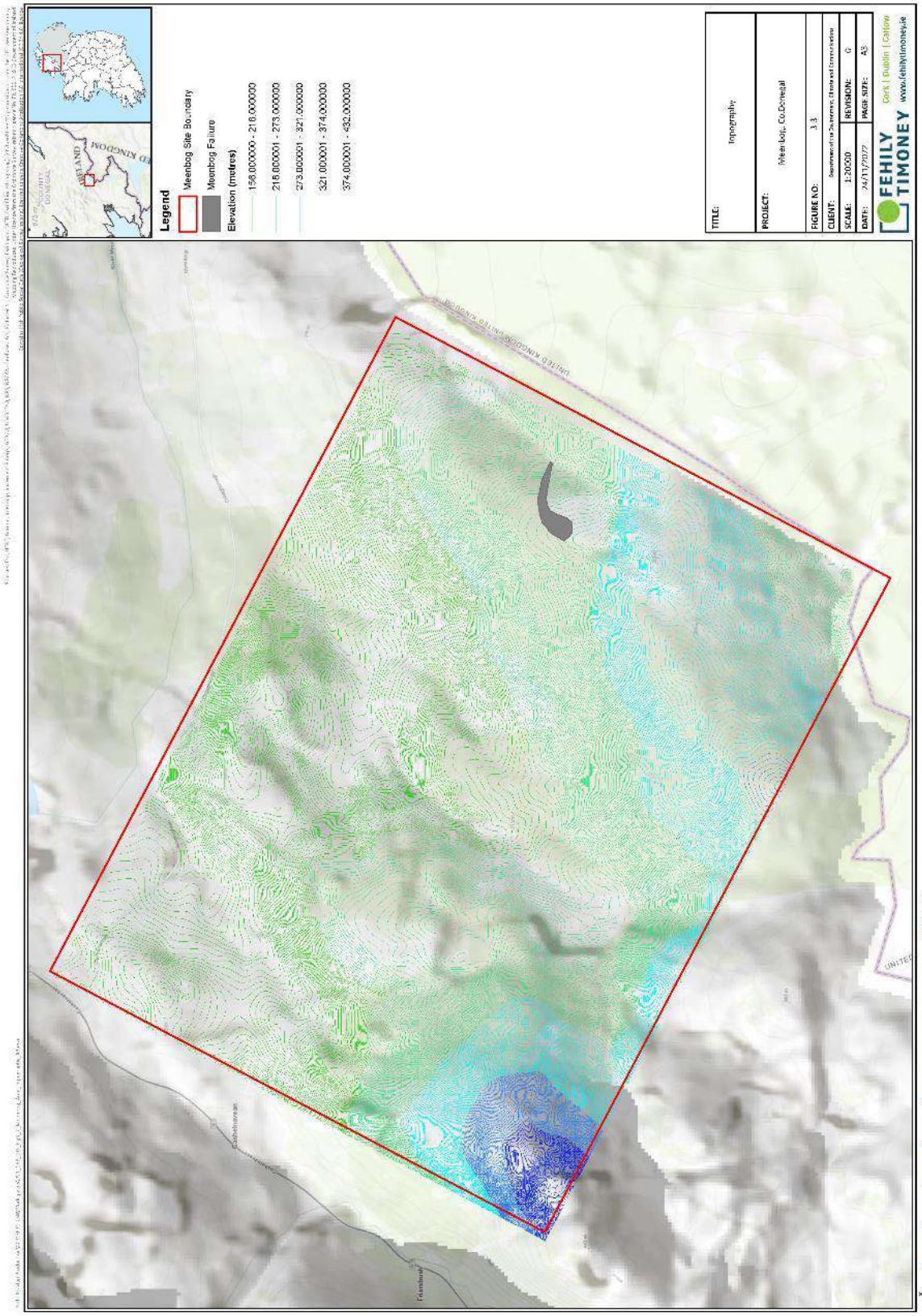


**Figure 3.4: Meenbog Post Failure Contours**

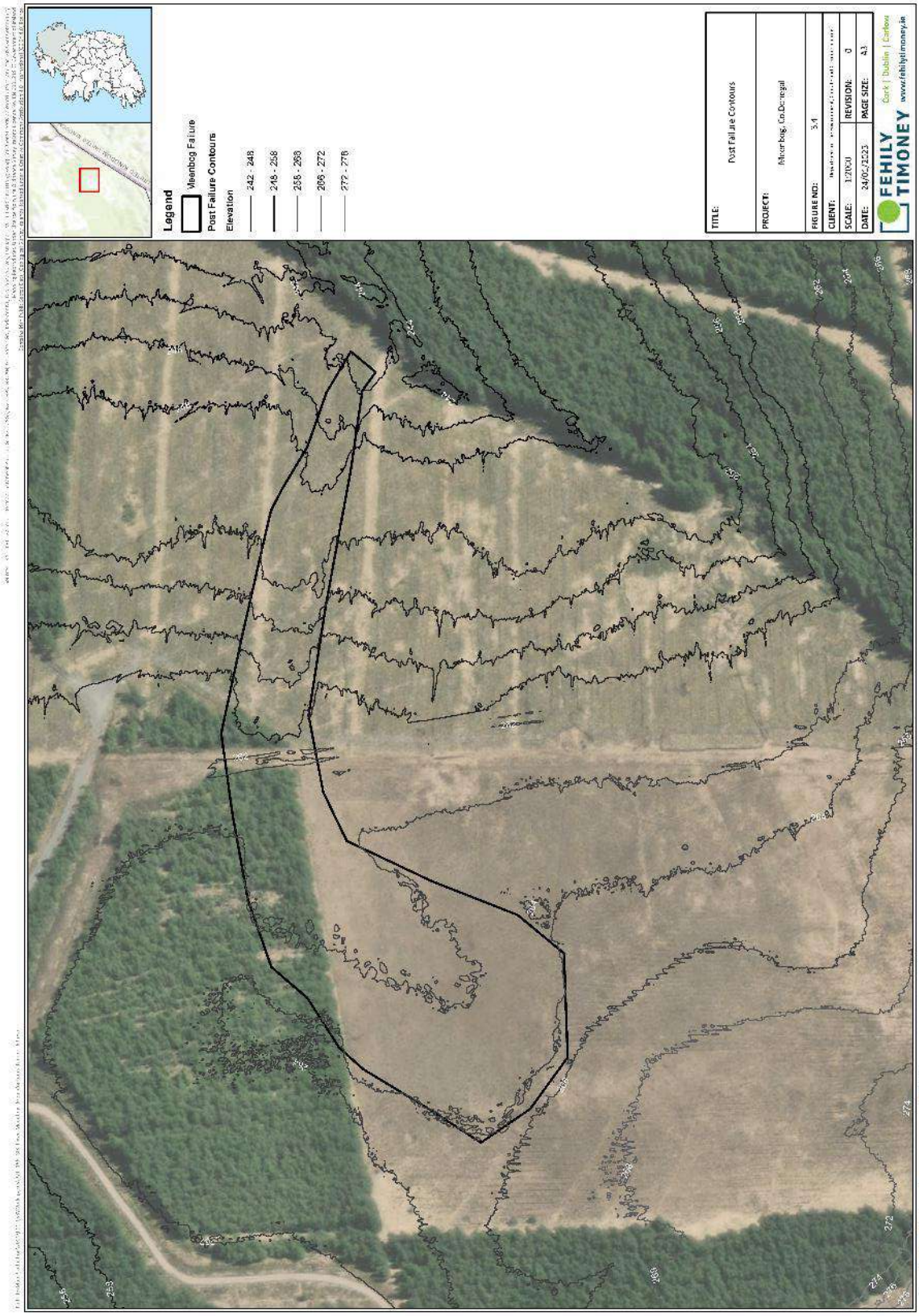


**Figure 3.5: Meenbog Slope Interpolation**

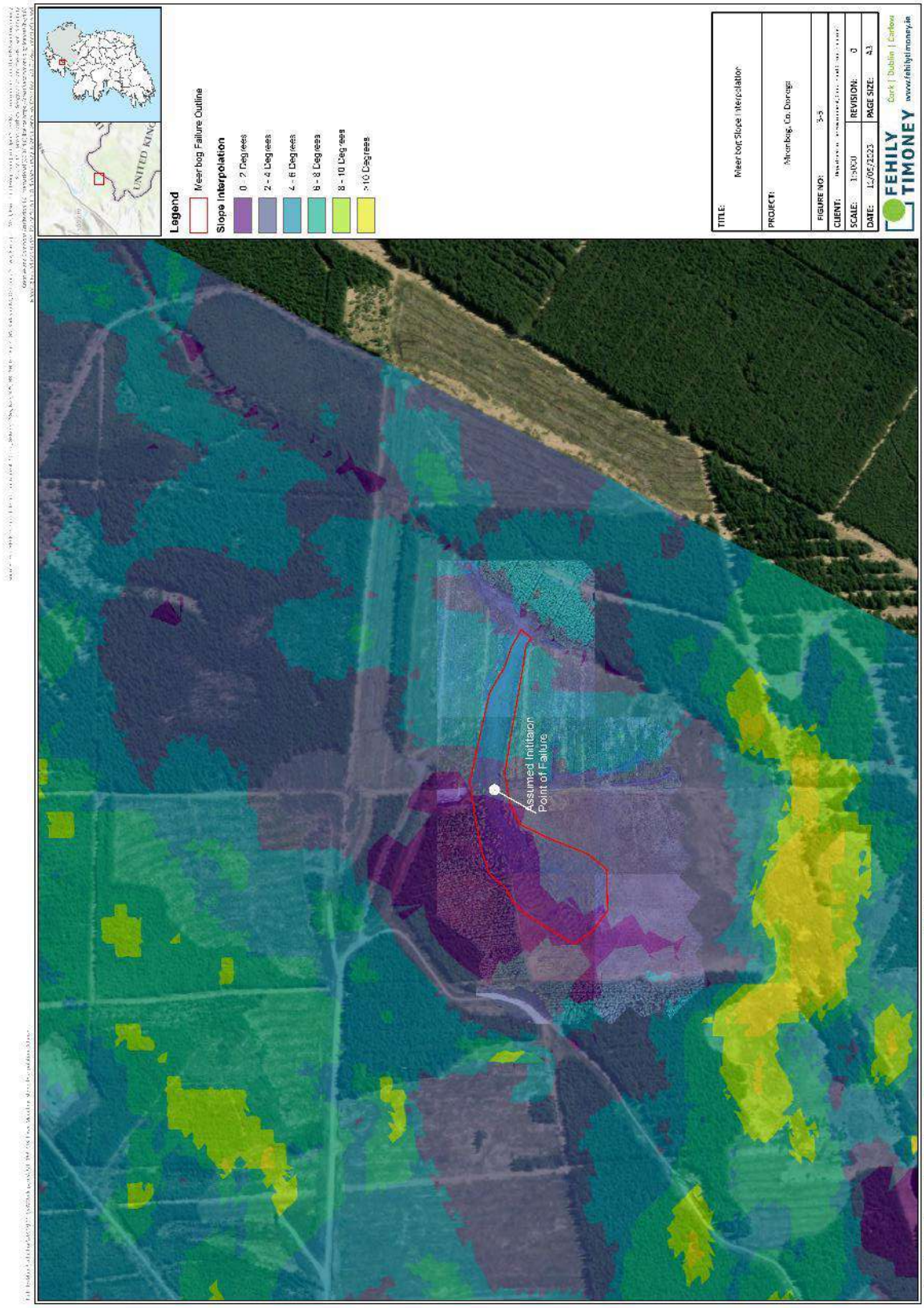


**Figure 3.6: Meenbog Landslide Susceptibility**

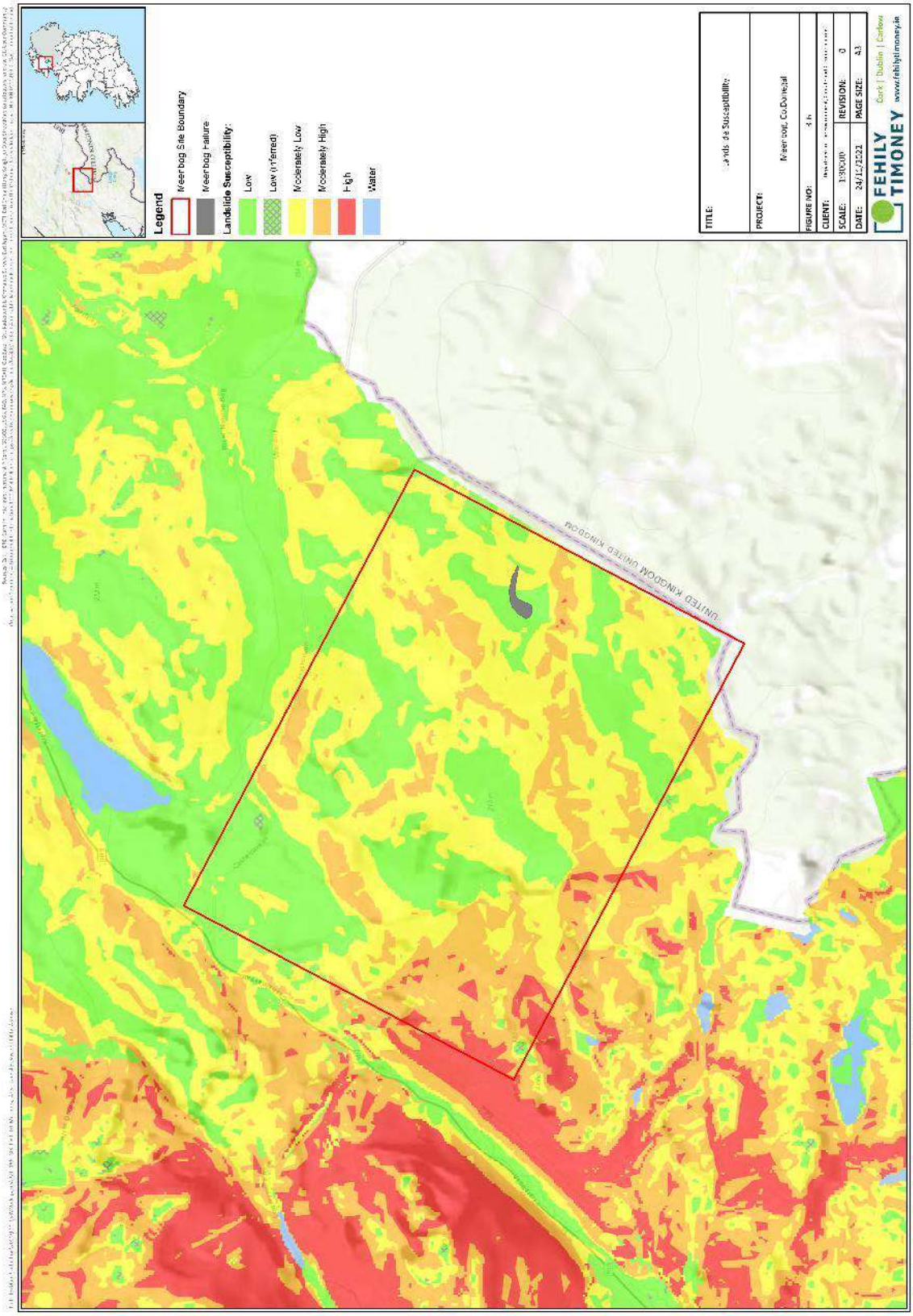


**Figure 3.7: Meenbog Quaternary Geomorphology**

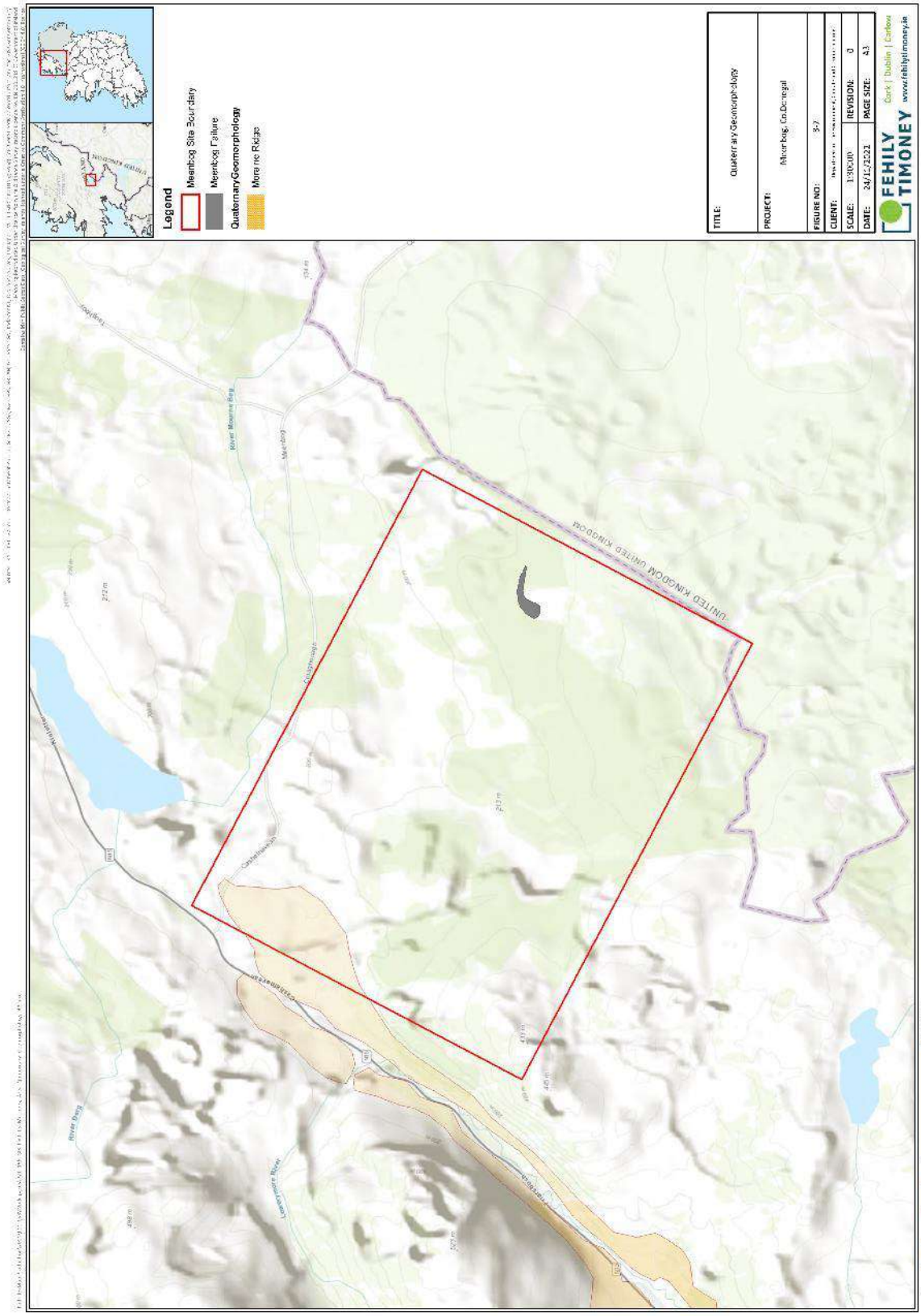


**Figure 3.8: Meenbog WFD Catchments**

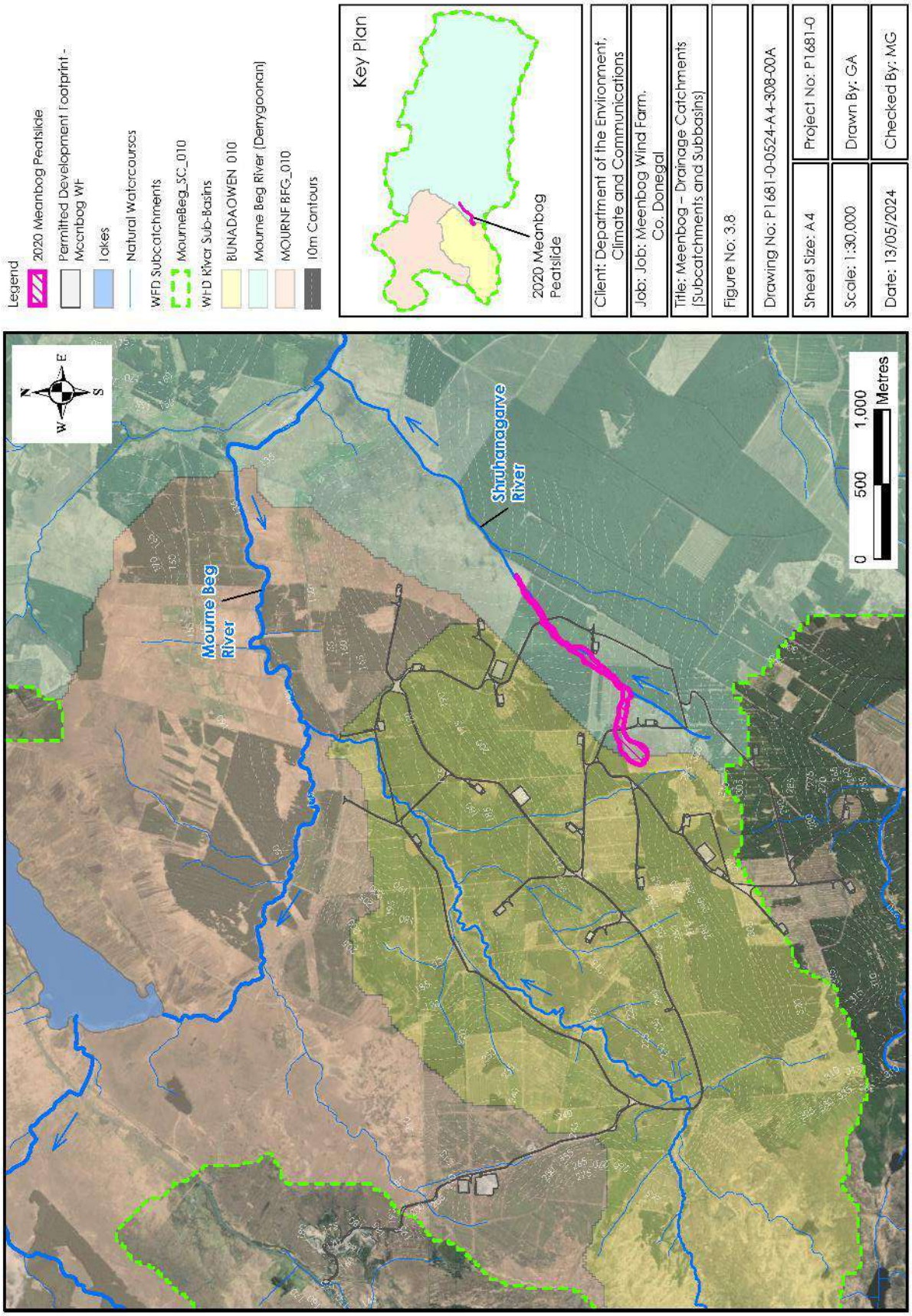


**Figure 3.9: Meenbog Pre-Failure Site Drainage**

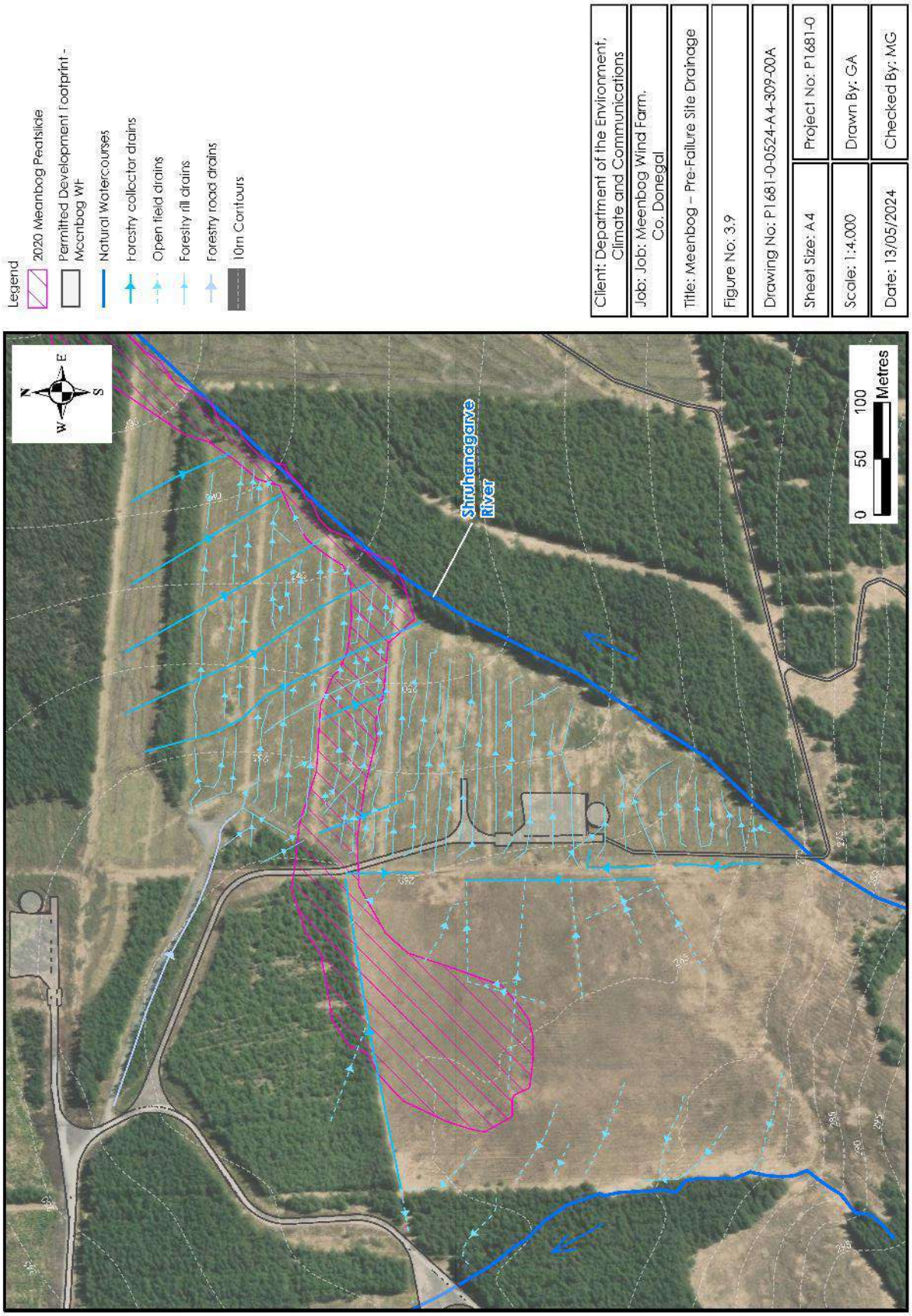
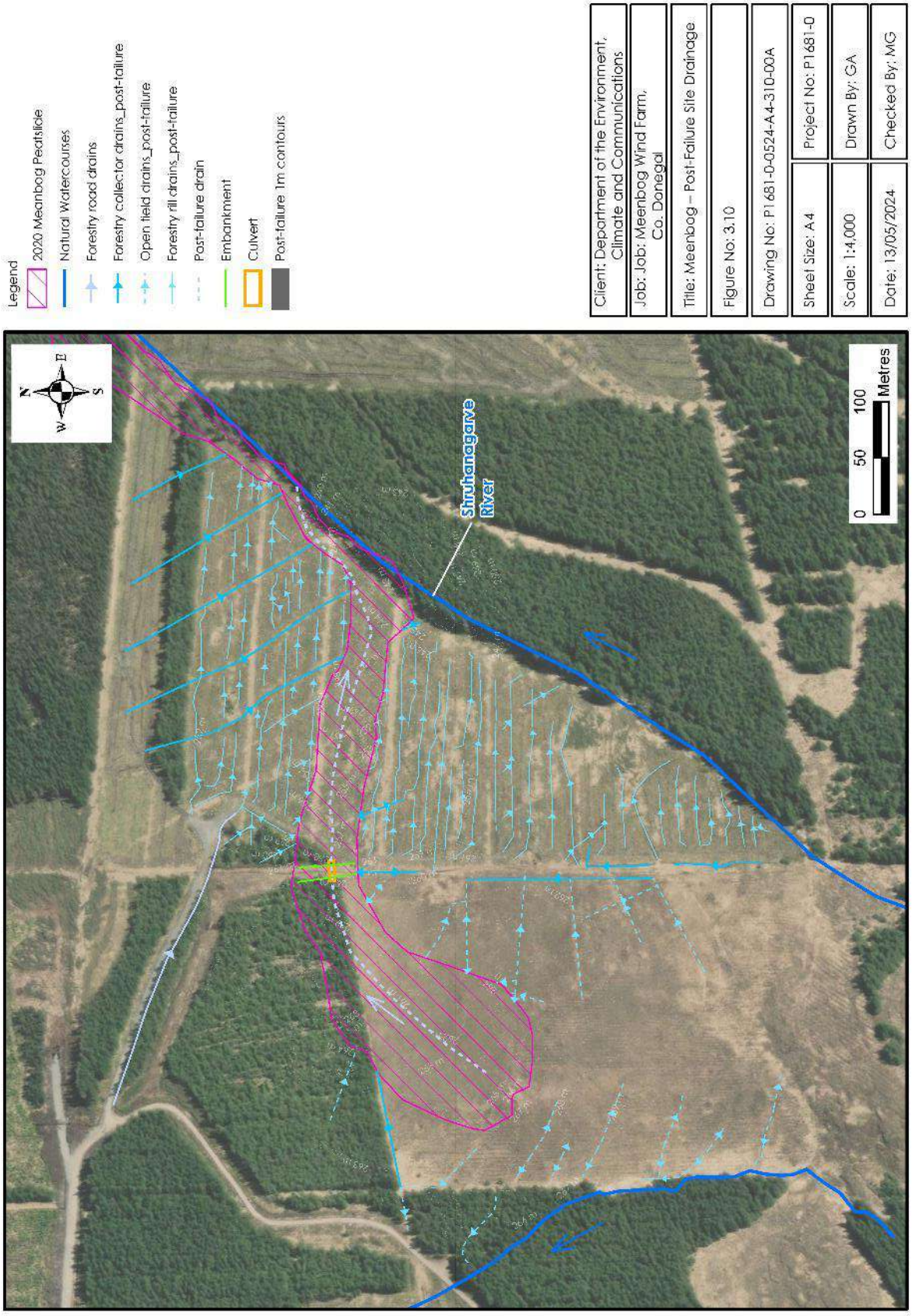


**Figure 3.10: Meenbog Post-Failure Site Drainage**



## 3.3 Shass townland (Boleybrack Mountain)

### 3.3.1 Soils and Geology

The majority of the study area around the Shass failure is recorded as blanket peat, with areas of till derived from Namurian sandstone and shales present at lower elevations across the study area (Figure 3.11). Outcropping or subcropping rock is indicated in the stream bed upstream of the Dawn of Hope bridge and also to the southeast of the failure location.

The bedrock underlying the study area (Figure 3.12) comprises Namurian sandstone and shales: the Dergvone and Gowlaum Shale Formations and the Briscloonagh Sandstone Formation (GSI, 2022). Two faults are noted close to the peat failure, one trending northeast-southwest and the other northwest-southeast. The northeast-southwest trending fault approximately coincides with a break in slope to the southeast of the failure area and lies ~450m SE of the failure The bedding in these bedrock formations is recorded as being almost horizontal (<10 degrees dipping east).

Investigations undertaken as part of a study by Holohan et al (2021), indicate the presence of a layer of soft clay below the peat at locations adjacent to the failure scar. This layer was at least 0.5m in thickness. Peat thickness ranges from 1.7 m to 5.5 m at the failure site thus all indicative of blanket bog.

### 3.3.2 Topography

The general area around the failure site comprises a relatively constant slope falling to the south at an angle of around 4-8 degrees (Figure 3.13). The ground to the east and south of the failure falls to the south/southeast at an angle of 3-4 degrees for around 250m, where a convex break in slope is noted (Figure 3.14). This break in slope is linked to a number of historical peat failures, but not to the 2020 failure. The slope to the north of the failure is around 4 degrees and there is a slight increase in slope angle (convex break in slope) close to the assumed failure point (to around 6 degrees), which appears to form the headwaters of a stream. Figures 3.13 and 3.14 show the contours across the study area and around the failure respectively. Figure 3.14 provides a slope interpolation of the failure area, with the contours divided into 2 degree bands.

The slight convex break in slope upslope of the 2020 failure would not be considered to be a significant conditioning factor to the failure.

### 3.3.3 Landslide Susceptibility

The landslide susceptibility of the study area around Shass ranges from low to high based on GSI's mapping (Figure 3.15). The failure site is classified as having low to moderately low susceptibility to failure, which is to be expected given the relatively shallow slope angles, as slope angle was one of the main factors used in the landslide susceptibility methodology.

A number of localised historical failures (three no.) are associated with valley heads some 600m to the southeast of the 2020 failure. The historical failures correspond to a convex break in slope to the south/southeast of the 2020 failure, however these are not related to the more recent failure.

### 3.3.4 Geomorphology

Quaternary geomorphology of the study area is shown on Figure 3.16. Shass Mountain is composed of deglacial landforms (formed during deglaciation) and ribbed moraines.

The overall topography is that of a streamlined mountain plateau. The maximum elevation within the study area is 340mOD, with the ground falling along a relatively uniform slope to a level of 280mOD at the failure site. The sides of the plateau in the study area are drained by a series of streams that eventually flow into Lough Allen.

The peat cover on the plateau around the failure comprises an almost continuous cover of blanket peat. The blanket peat cover shows little signs of erosion, but significant areas upslope of the open blanket bog where the peat failure commenced are densely afforested and thus heavily dissected by forestry drainage and occasional access roads. A convex break in slope is present some 250m to the south and southeast of the 2020 failure.

### 3.3.5 Hydrology

**Regional and Local Hydrology**
Regionally the Shass Mountain site is located within the Owengar catchment and is immediately adjacent to the Shannon (Upper) catchment. The lands affected by the Shass Mountain peat failure drain to the southwest to an unnamed tributary of the Diffagher River. The Diffagher River and tributaries drain the lands between Lough Allen and Behaval Lough, with headwaters reaching up into Boleybrack Mountains to the northeast and Corrie Mountain to the west. The Diffagher also forms an outflow from Belhavel Lough.

Natural drainage and inferred flush zones, based on historical mapping and aerial photography, are shown in Figure 3.18. Drainage patterns within this catchment are believed to converge towards a point that coincides with the toe of the surface of rupture.

**Forestry Drainage**
Within the site there are numerous man-made drains, mostly installed to drain the blanket bog for establishment of the forestry plantations. The forestry drainage pattern is influenced by the local topography, ground conditions, layout of the forestry plantations and existing access roads, as would be typical of any upland peatland forestry site in Ireland. The forestry plantations are generally drained by a network of mound (rill) drains which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantations. The rill drains are generally spaced about 15m to 20m apart. Interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of existing forestry access roads.

The interceptor drain along the southern boundary of the forestry should have been directing water towards the west, which would connect into the stream which drains to the south. It appears, however, that this drain has historically allowed some water to discharge onto the open peatland, as can be seen in the flushes visible in the colour aerial photograph in Plate 3-5. However, it can be seen from the pre-forestry aerial imagery that some of these flushes are natural features, but some may have been augmented by the volumes of forestry drainage run-off which is diverted onto this slope.

Modelling of the drainage pattern (Holohan et al, 2021) has shown that the slide source area occupies much of a small catchment on the western side of this upland area at Shass. Drainage within the catchment converges towards a point that coincides with the toe of the surface of rupture.

### 3.3.6 Hydrogeology

The Namurian sandstones and shales, which are mapped to underlie the Shass Mountain site are classified by GSI as a Poor Aquifer, comprising bedrock which is generally unproductive (PU). and typically exhibits groundwater flows of less than $10m^2/d$.

The Namurian rocks generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a narrow broken and weathered zone, a zone of interconnected fissuring 10m thick (GSI, 2003).

The vulnerability rating of the aquifer in the area around the peat failures ranges between "Moderate to High" and this reflects the varying depth of local subsoils and peat. In areas where subsoil is shallow or absent and where bedrock is outcropping, such as to the southeast and southwest of the failure location, an Extreme (E) or Extreme (X) Rock at or near Surface vulnerability rating is given. Extreme (X) indicates bedrock at or within 1m of the surface. Extreme (E) indicates bedrock at or within 1 to 3m of the surface.

Due to the low permeability nature of the Namurian bedrock aquifer underlying the site, groundwater flowpaths are likely to be short (30 – 300m), with recharge emerging close by at seeps and surface streams.

The soft clay mapped below the peat, where present, is likely to impede recharge to bedrock, or conversely block or divert bedrock spring emergence to downslope areas where the clays are thinner or absent.

There are an apparent abundance of mapped flushes and headwater springs in the upland area around this failure site, and this suggests that groundwater has a potential local influence on the eco-hydrology of the bog.

### 3.3.7 Ecology

Boleybrack Mountain Special Area of Conservation (SAC) (Site Code: 002032) comprises an extensive upland plateau situated to the north of Lough Allen in Co Leitrim. The SAC is bounded on the north and south by forestry plantations, and on the west by the Scardan River. The peat failure started in the south-west of section of the SAC.

Orthophotography indicates the site of the peat failure is in an area of upland peatland (blanket bog and/or heath) bordered by conifer plantations to the west and north. The relatively flat topography of the site favours deep blanket bog formation.

The areas to the south and east are predominantly open. Flushes can be inferred from variations in vegetation colour and patterns visible in orthophotography. The flushes become visible channels further downslope, as flows of surface water coalesce to carve small valleys in the hillside. The flush patterns visible in 1995 aerial imagery (pre-afforestation) sweep south and west in the north-western corner and centre of the site, southwards in the south-central portion, and south-east in the eastern part. While some alteration of flush patterns is evident due to the east-west forestry collector drain and peat spoil bank in the north of the site (focusing of flows through narrower points and diversion of water to the western end of the drain), the same general pre-afforestation flush patterns existed before the peat failure however their ecology and hydrology would be altered by the additional water volumes diverted though them by the forestry drainage.

Pre-failure orthophotography from 2013 (Plate 3-6) indicates flushes fed from the conifer plantation upslope were focused through points along the plantation/bog interface. These points are considered to align with breaks in the peat spoil bank which allowed water from upslope to continue flowing towards the bog. All the

surface flushes draining south/west ran towards the failure inception. One narrow flush running directly south towards the failure inception which was visible in earlier imagery is no longer visible in post-failure imagery (this flow is now likely to travel east along the forestry drain before entering the eroded area).

Prior to the failure, the south/west-aligned flush patterns converged on the valley head running towards the un-named tributary of the Tullilntowell stream. The surface drainage patterns described above align with the inferred drainage patterns identified by iCRAG in the RPS Factual Report (2020) where they were noted to converge on the failure inception location.

A high abundance of *Sphagnum* moss in forestry drains upslope of the bog was noted during an NPWS site visit (Fernandez and Douglas, 2022), indicating substantial and regular flows of surface water downhill through the conifer plantation occur. It is considered that prior to the afforestation, based on surface flush patterns visible in 1995 orthophotography (Geohive, 2023) there would have been a more diffuse pattern of flow on the general bog surface and more directional flows within these flushes whereas the current dense of pattern forestry drains running parallel with the direction of slope would have considerably increased the volumes water within the drains and diverted it either through cracks and fissure that are likely to be have formed beneath the afforested bog as it is of > 20 years planted) and/or out onto the blanket bog and flushes above the peat failure initiation site. Low cover of *Sphagnum* in the north-western corner of the area upslope of the failure site was noted during the NPWS site visit which may mean that surface flows may have been diverted into such cracks and fissure beneath the plantation or that such flows were intercepted by the interceptor drain upslope of this location.

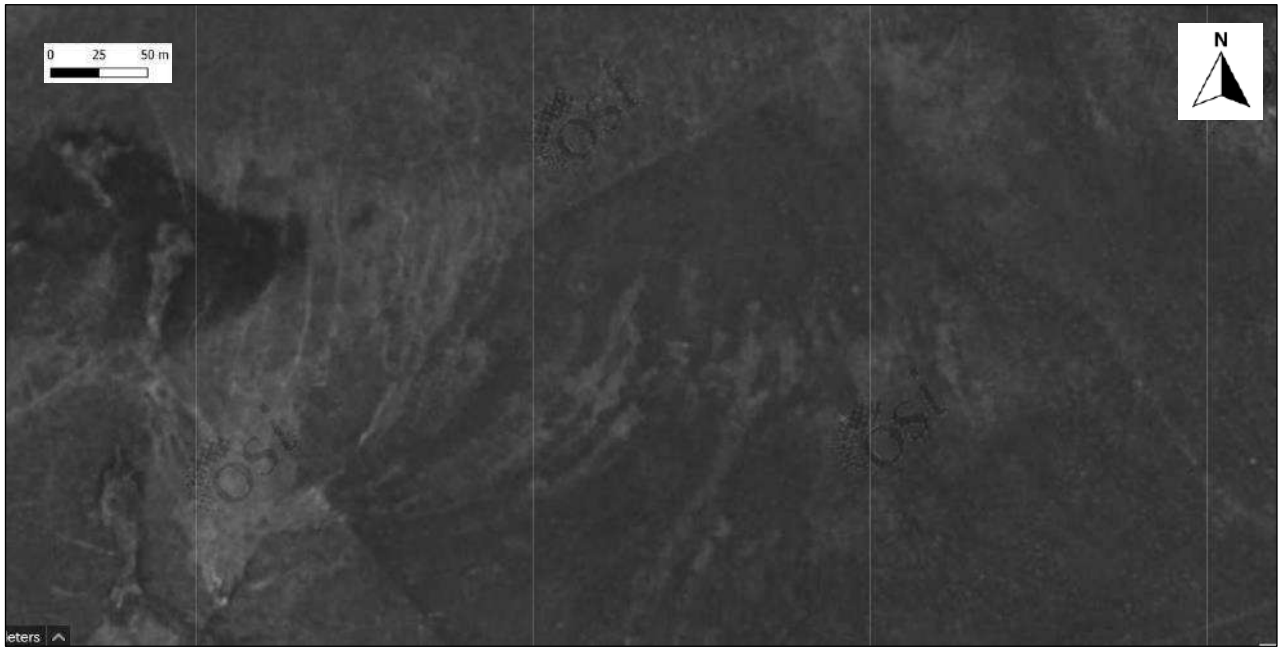
A fence line separating the eastern part of the site from the west can be seen in pre-failure orthophotography (parts of the fence were carried away with the peat failure but other sections remain). The area inside the fence (to the south-east) is visibly darker where heather is more dominant. Green patches indicating the presence of grass are visible on both side of the fence line in orthophotography but are more extensive on the western side/outside of the fenced area. This contrast suggests more intensive grazing has occurred outside (west of) the fence. The presence of trees (invading conifers) inside the fence also indicates lower grazing pressure in the enclosed area, as noted in the NPWS site visit report.

The bright green colour outside (west of) the fence near the headwaters of the un-named Tulllitowel tributary visible in 2013 orthophotography (Geohive, 2023) is indicative of short-cropped grassland due to sheep grazing. There is also potential for nutrient enrichment to have contributed the lighter green colour. This could occur due to waste from sheep, unintentional nutrient runoff from surrounding conifer plantations or a combination of these factors.

Large areas of lighter green vegetation are prevalent inside and outside the fence in 2005 orthophotography (Geohive, 2023), suggesting higher levels of nutrient runoff from uphill conifer plantations or more intensive grazing at that time. Orthophotography from 2013 shows most of the heather-dominated areas as black, possibly indicating burning; however, this is more likely due to the method of orthophotography or image sensor, light conditions or time of year. The differences in colour and resolution between orthophotography from different periods and providers reduces the confidence inferring historical conditions and changes over time using this source. Controlled burning for red grouse management has previously been carried out in the northern part of Boleybrack Mountain SAC, however there is no record that burning was carried out in the area of the peat failure[1]. No evidence of burning was recording during the ecological site visit undertaken by Fehily Timoney.

[1] https://www.face.eu/sites/default/files/attachments/8_birds_directive_d._scallan_j._carslake_brussels.pdf

The excavated firebreak along the northern edge can be confirmed as present in 2001 orthophotography (Plate 3-7). The excavated firebreak along the western side of the bog is difficult to identify conclusively in pre-2013 orthophotography but is clearly visible in the 2013 imagery.




*Geohive/MapGenie (1995)*

**Plate 3-4: Shass Mountain Pre-Failure Orthophotography (1995).**




*Geohive/MapGenie (2001)*

**Plate 3-5: Shass Mountain Pre-Failure Orthophotography (2001).**




*Geohive/MapGenie (2013)*

**Plate 3-6: Shass Mountain Pre-Failure Orthophotography (2013).**




*Bing Maps (2024)*

**Plate 3-7: Shass Mountain Post-Failure Orthophotography (2024).**

### 3.3.8 Rainfall

A number of weather stations are located in the vicinity of the site, and these have been used to examine recorded rainfall data. The nearest weather station to the site is the Met Éireann Manorhamilton (Amorset) weather station some 12km to the north of the failure site, at an elevation of 77mOD.

The rainfall data from the Met Éireann Dromohair weather station (27mOD), some 15km from the failure site has also been reviewed. The daily rainfall data from January to June 2020 has been examined. This weather station is at an elevation of about 27m OD, and as such the rainfall pattern at the weather station may only provide an indication of the rainfall at the failure site which is at an elevation of generally over 400m OD and thus would be likely to experience considerably higher average rainfall levels those at 27m OD.

#### *3.3.8.1 Analysis of Rainfall Data*

The results of the rainfall analysis are given below and presented graphically in Appendix A.

(1) The rainfall data from the Manorhamilton weather station shows that the wettest period in 2020 was in February and March 2020. The highest daily rainfall in this period was recorded on 8 February 2020 (56mm). In the week prior to the peat failure on 28 June 2020 there were three days where rainfall exceeded 20mm. On the day of the failure the daily rainfall amount was 60.6mm, with 38mm recorded on the preceding day, and on another two days in the preceding week the rainfall exceeded 20mm.
(2) A similar amount of rainfall (56mm) was recorded on 8 February, however there is no indication that this event led to any peat failures in the area.
(3) Rainfall data from Dromohair shows 48mm of rain on the day of the failure, with a total of 80mm of rain recorded in the week prior to the failure.
(4) What is particularly notable with respect to rainfall duration periods is the sustained dry spell in April and May and early June 2020.
(5) The significant and sustained dry spell in April and May 2020 nationally was one of the driest recorded for this period. All rainfall totals across the country were below their Long-Term Average (LTA) for the period with the driest on record for Dublin and Meath (Met Éireann 2020).
(6) The significant and sustained dry spell would have likely caused drying of the peat surface which may have led to cracking of the near surface peat particularly along forestry furrows and drainage lines within the forestry.
(7) A comparison with the preceding 10 years of rainfall data indicates that 2020 (1815mm) recorded the highest rainfall within that decade (range 1428-1815mm), despite the dry spell in April and May. Only one other day (14 November 2015, 61.1mm) recorded in excess of 60mm of rainfall over the decade.

### 3.3.9 Land Use/Site History

Historical aerial photography was examined for the site covering the years 1995 to 2020, see Table 3.2.

Prior to the 2020 failure there were several small peat failures close to the failure site (Section 3.3.3). These failures are clustered to the southeast of the 2020 failure and are located at a convex break in slope which appears to coincide with a mapped fault in the bedrock but may also be due to the outcropping pattern in the area. Little is known of these failures, but from aerial photography two of the failures are located in what appear to be stream channels or headwaters.

**Table 3-2: Shass Mountain Historical Aerial Photographic Review**

| Year | Comments |
|---|---|
| 1995 | The 2020 failure site appears to be open peatland, with evidence of several flushes across the failure area and mostly oriented in a south-westerly direction.<br>There are no apparent signs of peat failure close to the location of the 2020 failure site. |
| 2004-2006 | The site just upslope of the initiation point of the 2020 peat failure is covered in forestry plantation, which appear to be recently planted. Drainage furrows are visible running north-south (close to alignment with the direction of slope of the mountain side) through the forestry.<br>There are no apparent signs of peat failure close to the location of the 2020 failure site. |
| 2005 | The site just upslope of the initiation point of the 2020 peat failure is covered in forestry plantation, which appear to be recently planted. Drainage furrows are visible running north-south through the forestry.<br>There are no apparent signs of peat failure close to the location of the 2020 failure site. |
| 2013 to 2018 | The site just upslope of the initiation point of the 2020 peat failure is covered in forestry plantation. Drainage furrows are visible running north-south through the forestry.<br>There are no apparent signs of peat failure close to the location of the 2020 failure site. |
| May 2020 | The site just upslope of the initiation point of the peat failure is covered in forestry plantation. Drainage furrows are visible running north-south through the forestry.<br>There are no apparent signs of peat failure close to the location of the 2020 failure site. |

3.3.10 Summary

The Shass site comprises an area of upland blanket bog that has been heavily afforested over the past number of years. Bedrock underlying the site comprises Namurian sandstone and shales: the Dergvone and Gowlaum Shale Formations and the Briscloonagh Sandstone Formation. Two faults are noted close to the peat failure, one trending northeast-southwest and the other northwest-southeast. The northeast-southwest trending fault approximately coincides with a break in slope to the southeast of the failure area and lies ~450m SE of the failure. A number of localised historical failures (three no.) are associated with valley heads some 600m to the southeast of the 2020 failure. The historical failures correspond to a convex break in slope to the south/southeast of the 2020 failure.

The overall topography is that of a streamlined mountain plateau. The maximum elevation within the study area is 340mOD, with the ground falling along a relatively uniform slope to a level of 280mOD at the failure site. Orthophotography indicates the site of the peat failure is in an area of upland peatland (blanket bog and/or heath) bordered by conifer plantations to the west and north. Pre-failure orthophotography from 2013 (Plate 3-6) indicates flushes fed from the conifer plantation upslope were focused through points along the plantation/bog interface. All the surface flushes draining south/west ran towards the failure inception point.

Upslope of the failure there are numerous manmade drains, mostly installed to drain the blanket bog for establishment of the forestry plantations. Natural drainage and inferred flush zones, based on historical mapping and aerial photography, are shown in Figure 3.18. Drainage patterns within this catchment are believed to converge towards a point that coincides with the toe of the failure area.

In terms of predisposition to landslides, GSI's landslide susceptibility mapping indicates that the area around the failure was considered to be at low to moderately low susceptibility to failure. However, the presence of a break in slope close to the failure location, the presence of deep peat across this slope, and the presence of

forestry drains close to the failure location, and the location close to the headwaters of a stream/within a flushed area would all be considered conditioning factors for peat failures. The presence of these conditioning factors would indicate that this area would be at higher risk of peat failure. GSI's landslide mapping was designed for landslides in general, not specifically peat failures, and as such is does not specifically consider the possibility of specific peat failure mechanisms or the possibility of peat failures on relatively shallow slopes.

**Figure 3.11: Shass Mountain Quaternary Geology**

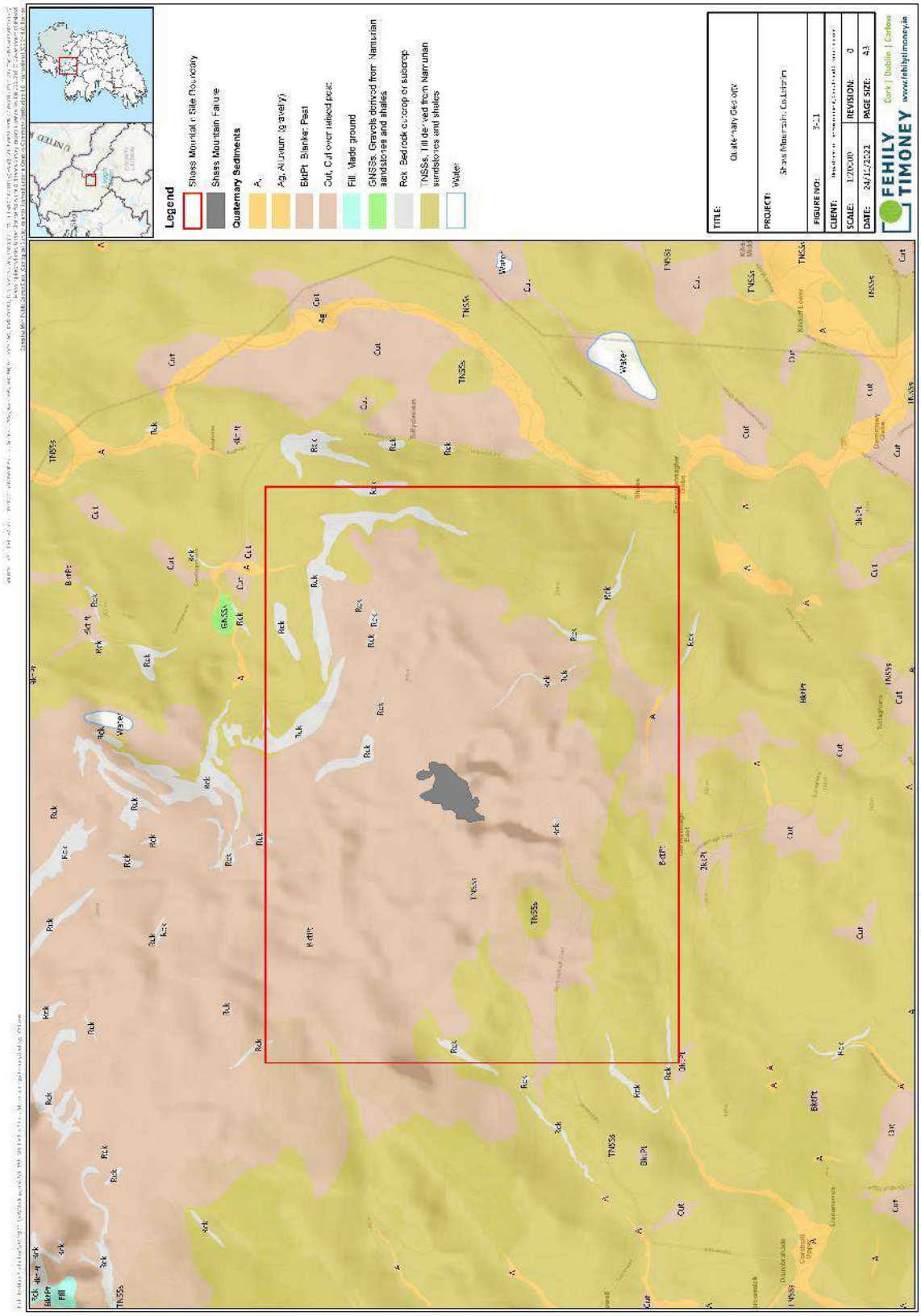


**Figure 3.12: Shass Mountain Bedrock Geology**

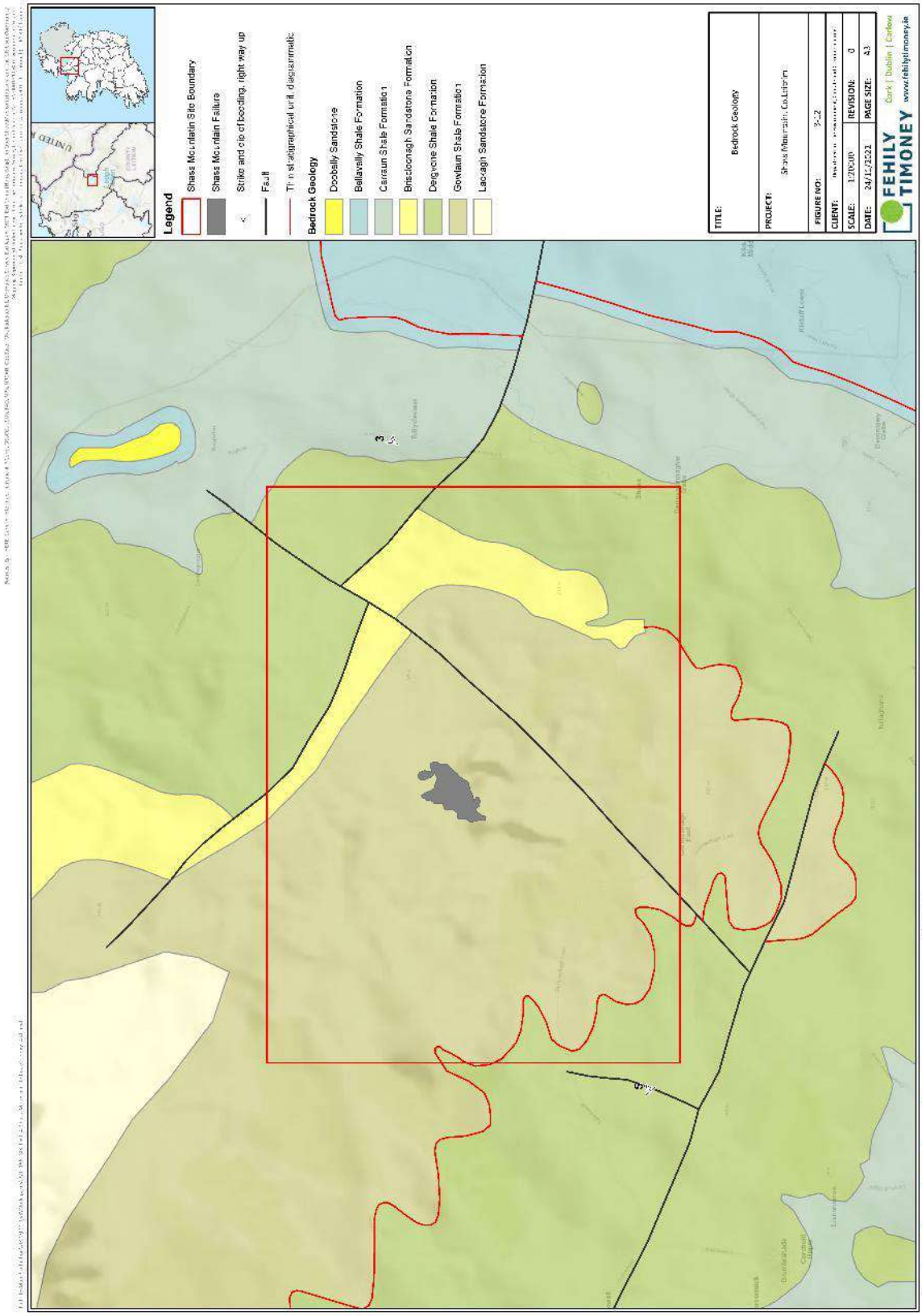


**Figure 3.13: Shass Mountain Topography**

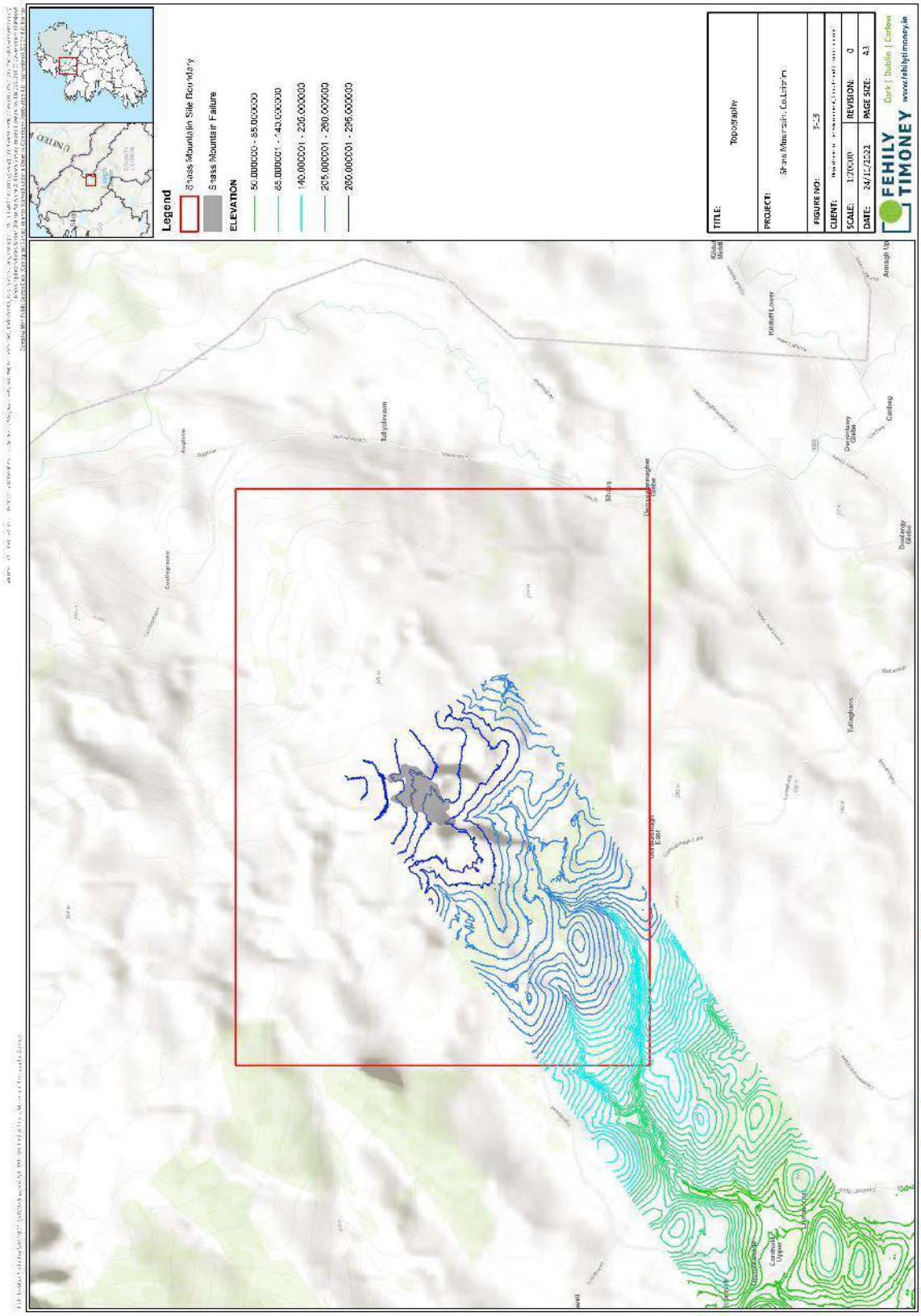


**Figure 3.14: Shass Mountain Slope Interpolation**

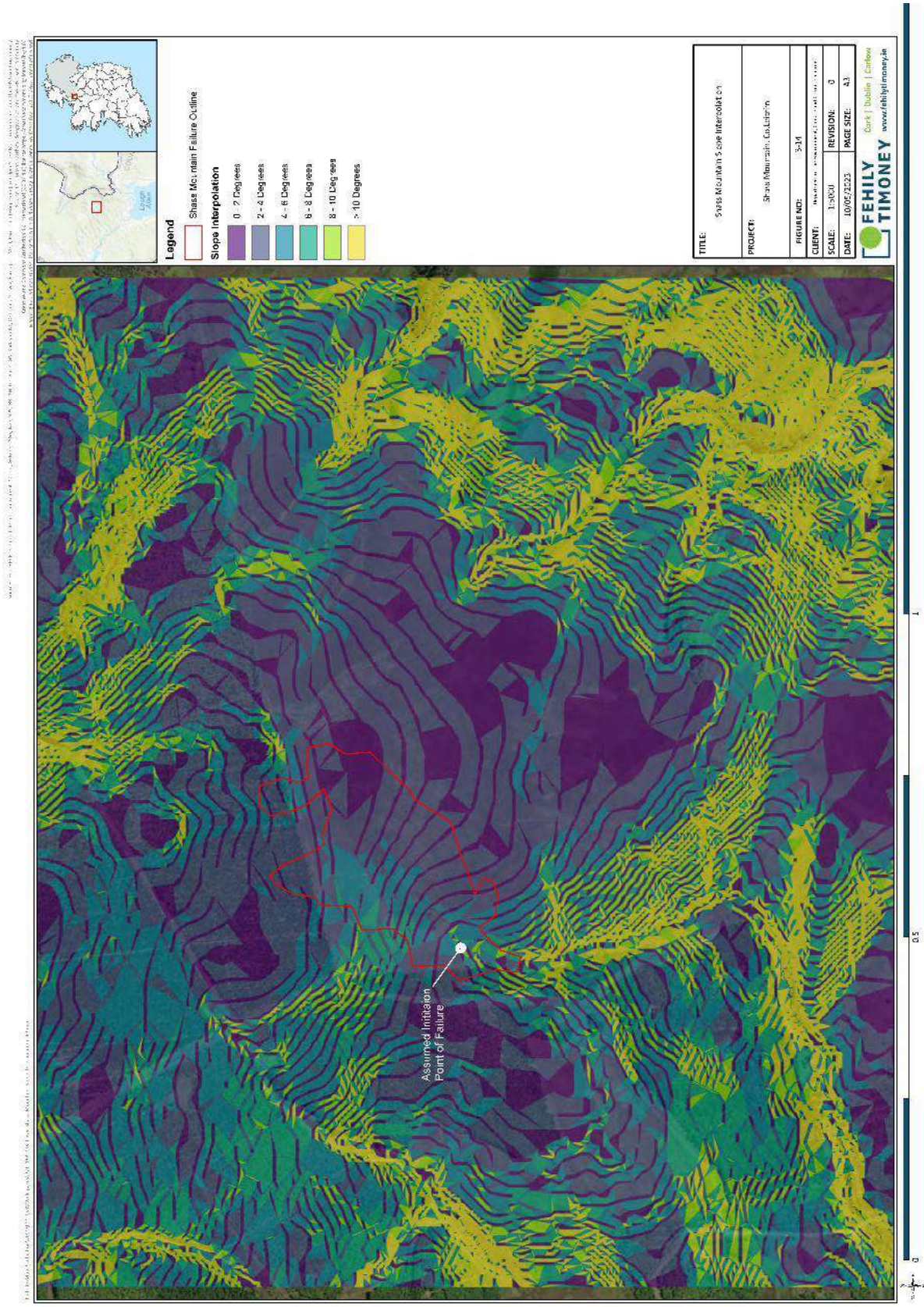


**Figure 3.15: Shass Mountain Landslide Susceptibility**

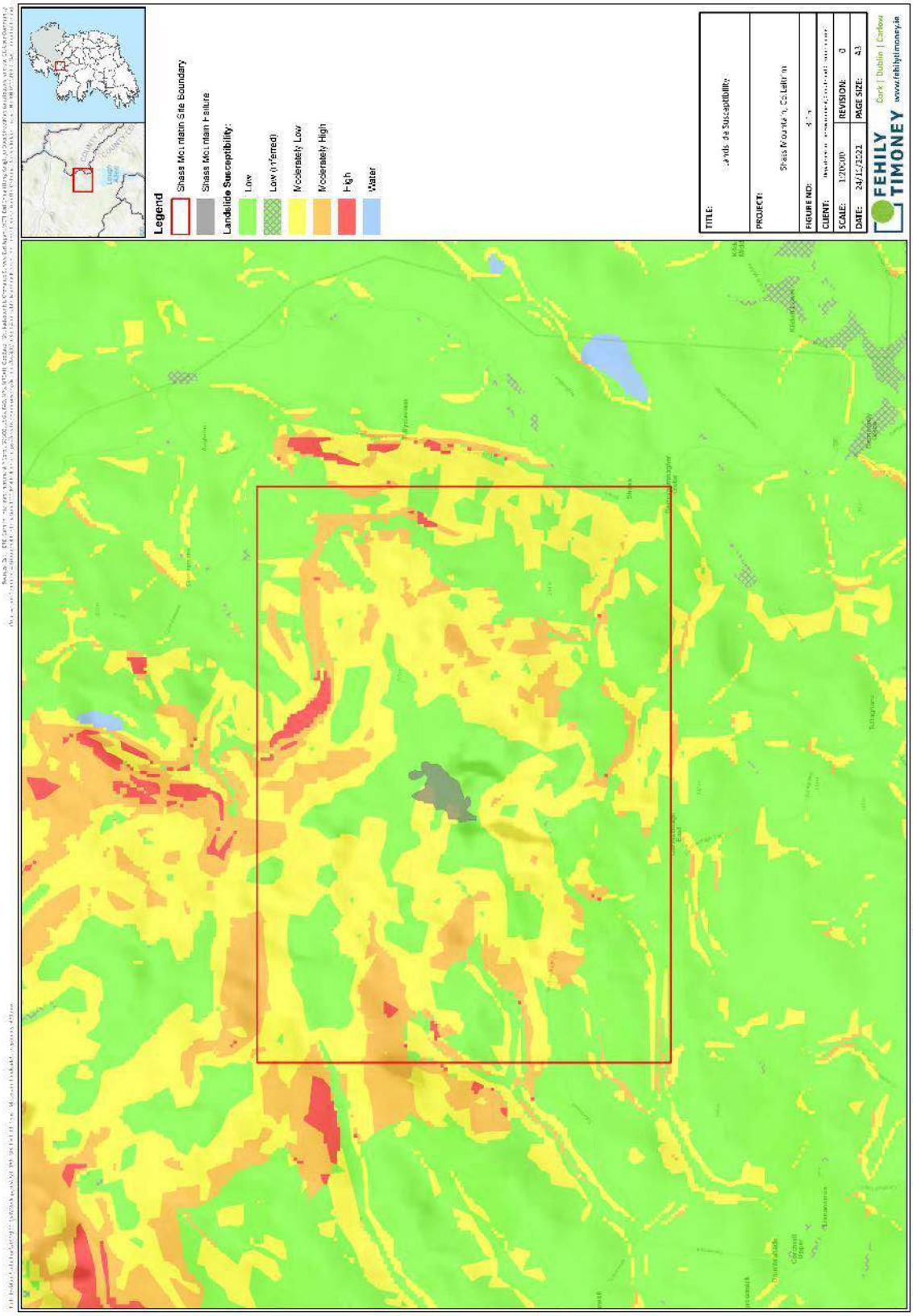


**Figure 3.16: Shass Mountain Quaternary Geomorphology**

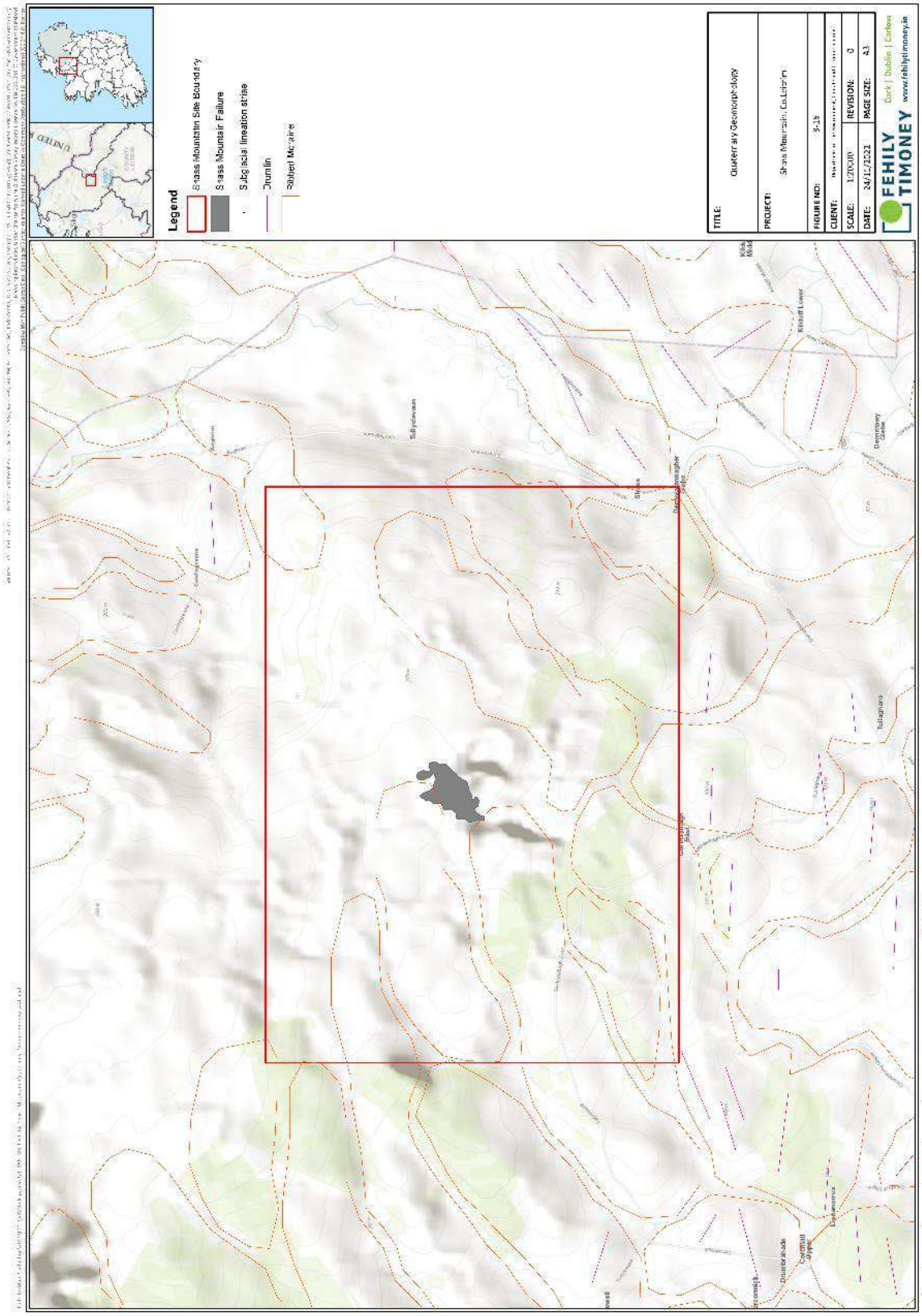


**Figure 3.17: Shass Mountain WFD Catchments**

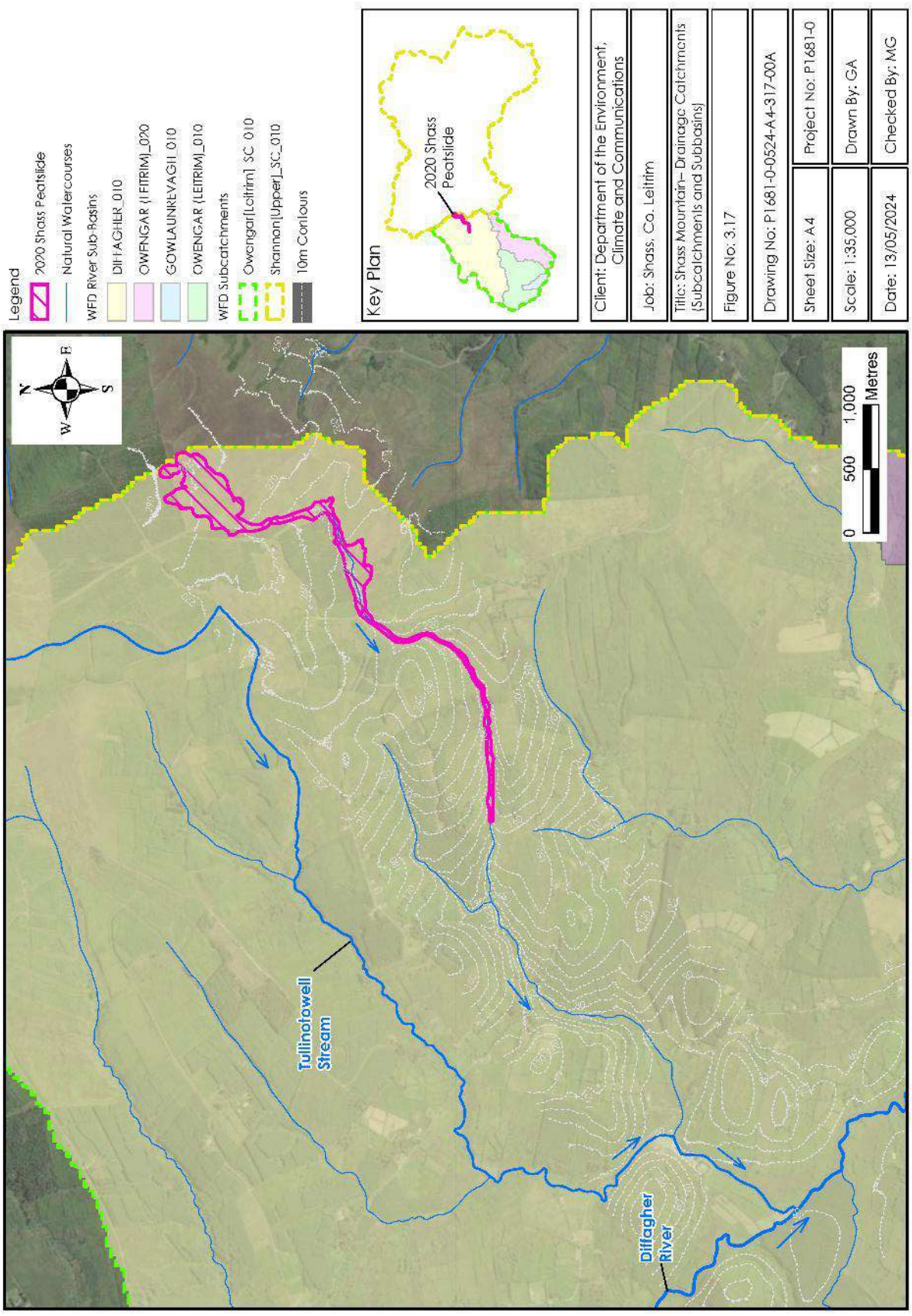


**Figure 3.18: Shass Mountain Pre-Failure Site Drainage**

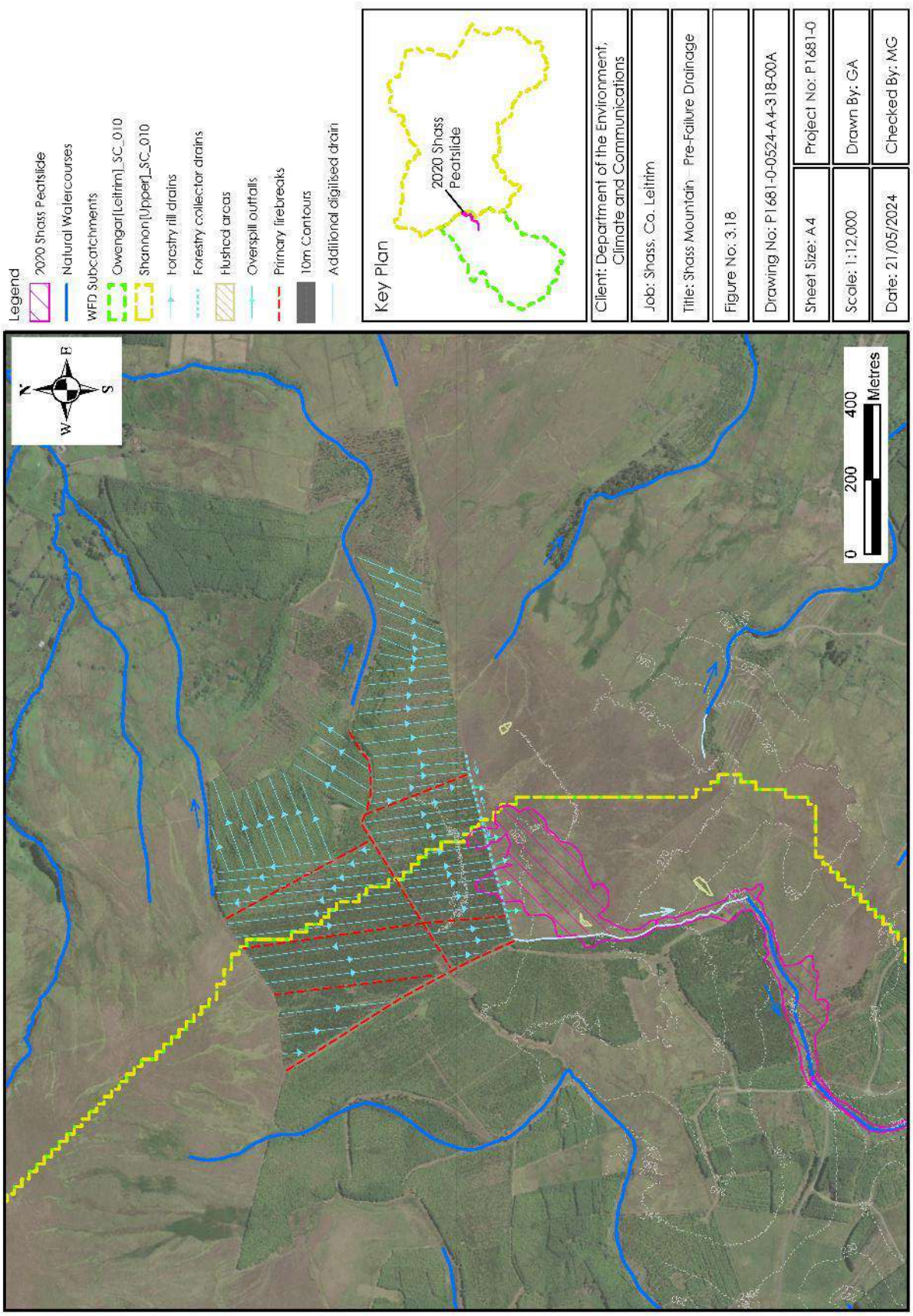
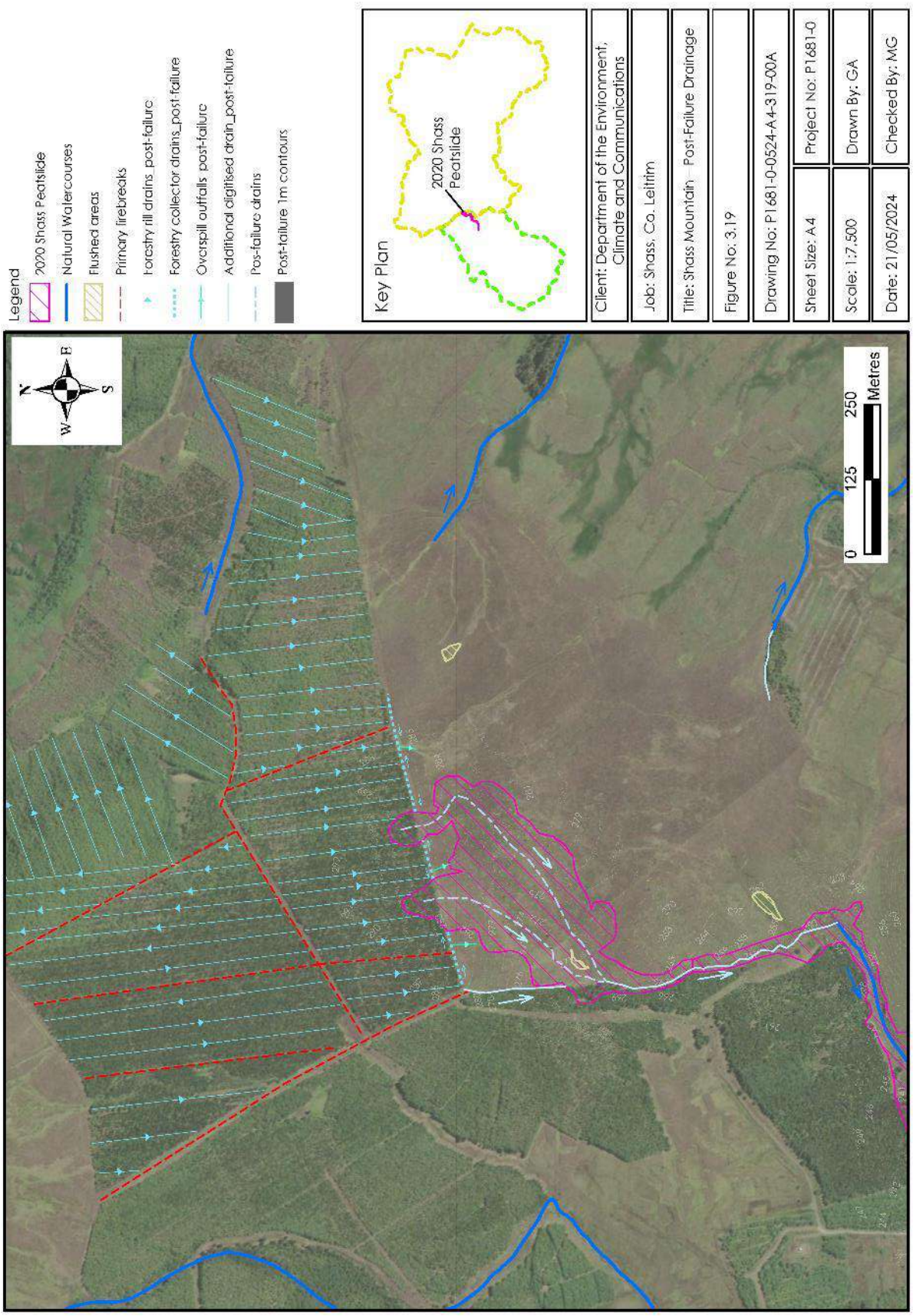


**Figure 3.19: Shass Mountain Post-Failure Site Drainage**



## 3.4 Mount Eagle

### 3.4.1 Soils and Geology

The majority of the study area around the Mount Eagle failure site is recorded as blanket peat, with areas of till derived from Namurian sandstone and shales present at lower elevations across the study area (Figure 3.20). Occasional areas of bedrock outcrop/subcrop areas also recorded across the study area.

The bedrock underlying the study area comprises sandstone, siltstone and shales from the Cloone Flagstone Formation, the Glenoween Shale Formation and the Feale Sandstone Formation (Figure 3.22). Multidirectional regional dips are noted. A NNW-SSE trending fault is indicated 500m west-northwest of the failure location and is three kilometres long.

### 3.4.2 Topography

The Mount Eagle peat failure site is located at an elevation approximately 430mOD. The area around the failure site comprises a relatively constant slope falling to the north at an angle of around 5 degrees (Figure 3.22).

There are no obvious concave or convex breaks in slope that are often associated with the locations of peat failures, however there is a slight convex break in the slope to the north of the 2020 failure with the slope angle increasing from 4-6 degrees to around 6-8 degrees.

Figure 3.23 provides a slope interpolation of the failure area, with the contours divided into 2 degree bands.

### 3.4.3 Landslide Susceptibility

The landslide susceptibility of the study area around Mount Eagle ranges from low to high based on the GSI mapping (Figure 3.24). The failure site is classified as having low to moderately low susceptibility to failure.

There are no historic failures noted in GSI's national landslide database, however aerial photography shows a failure immediately adjacent to the 2020 failure, on the west side of the 2020 failure. An exact date for this failure is not known, however it appears to have occurred between 2013 and 2018. This peat failure post-dated the planting of the forest.

### 3.4.4 Geomorphology

Quaternary geomorphology of the study area is shown on Figure 3.25. Mount Eagle encompasses sub-glacial lineation with streamlined bedrock. The overall topography is that of a mountain streamlined plateau. The maximum elevation within the study area is 450mOD, with the ground falling along a relatively uniform slope to a level of 430mOD at the failure site. This slope continues to the north and is drained by a series of streams that feed into the Glenagharan stream.

There was a previous failure located adjacent to the 2020 failure site. This is visible on Plate 3.10. This failure appears to have occurred between 2013 and 2018. This earlier failure has altered the geomorphology of the area very close to the 2020 failure site, forming a shallow depression in the slope.

### 3.4.5 Hydrology

**Regional and Local Hydrology**
Regionally the Mount Eagle site is located within the Feale subcatchment. The lands affected by the Mount Eagle 2020 peat failure drain to the north into the Clydagh River. The subcatchment extent and historical drainage is shown on Figure 3.26 and 3.27.

**Forestry Drainage**
Within the forestry plantation at the 2020 failure site there are man-made drains, installed prior to planting to drain the peat. The forestry plantations are generally drained by a network of mound (rill) drains (Figure 3.28) which typically run perpendicular to the topographic contours of the site (also visible in Plate 3-7) and feed into collector drains, which discharge to interceptor drains down-gradient of the plantations.

An excavated firebreak (approximately 5m in width) is visible on the upslope side of the forestry in the orthophotography below (Plate 3-7 to 3-9). This firebreak would act as a cut-off drain upslope of the forestry, likely connecting to the north-south trending drains within the forestry. It appears that this material was deposited on the peat up slope of the firebreak.

The rill drains appear to be spaced about 15m to 20m apart. Interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of existing forestry access roads.

### 3.4.6 Hydrogeology

The Namurian sandstones, mudstones and shales, which are mapped as underlying the Mount Eagle site are classified by GSI as a Locally Important Aquifer, comprising bedrock which is moderately productive in local zones (LI) and typically exhibits groundwater flows of less than $10m^2/d$.

The Namurian rocks generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part (upper 15m) of the aquifer comprising a narrow broken and weathered zone, and a connected fractured zone below this (GSI, 2003). Where faulting is present this may result in a zone of higher permeability bedrock, increasing groundwater flow.

The vulnerability rating of the aquifer in the area around the peat failures ranges between “Moderate to High” and this reflects the varying depth of local subsoils and peat. In areas where subsoil is shallow or absent and where bedrock is outcropping, such as to the northeast and south of the failure location, an Extreme (E) or Extreme (X) Rock at or near Surface vulnerability rating is given. Extreme (X) indicates bedrock at or within 1m of the surface. Extreme (E) indicates bedrock at or within 1 to 3m of the surface.

Due to the low permeability nature of the bedrock aquifer underlying the site, groundwater flow paths are likely to be short (30 – 300m), with groundwater discharging to streams and small springs.

There are some mapped flushes and headwater springs in the upland area close to the failure site, but not associated with the failure location, and this suggests that groundwater has a potential local influence on the ecohydrology of the bog.

### 3.4.7 Ecology

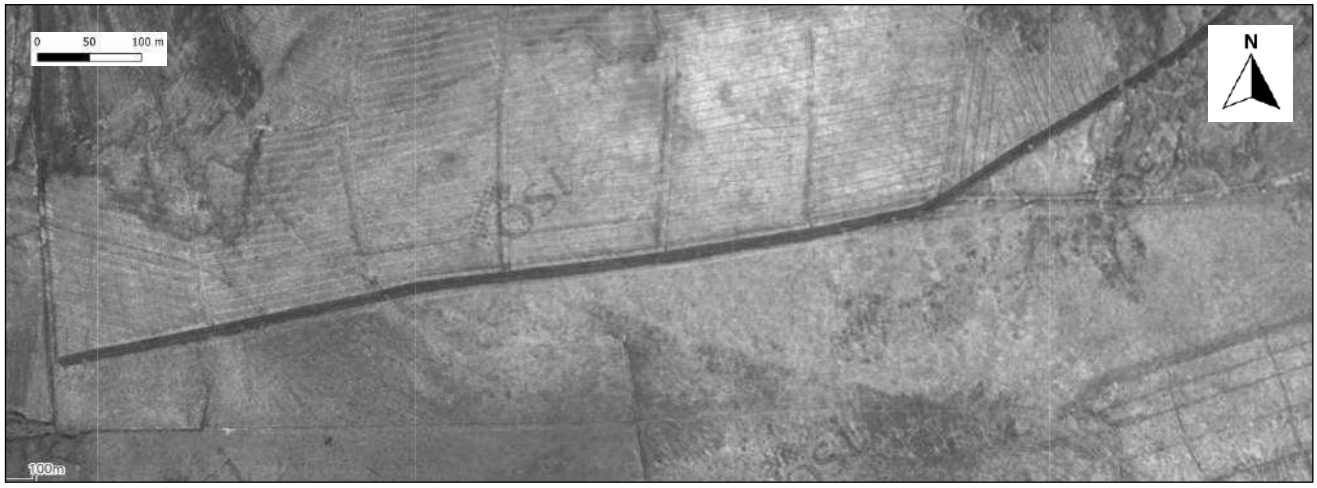
The Mount Eagle peat failure of 2020 occurred near the upper region of the River Shannon catchment that flows down to the Lower River Shannon SAC. The Lower River Shannon SAC encompasses counties Clare, Cork, Kerry, Limerick, and Tipperary. This SAC supports several EU Habitats Directive listed habitats and species which includes sandbanks, reefs, alluvial forest, otters, river vegetation.

The 2020 peat failure occurred within Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (004161), which is designated for Hen Harrier (*Circus cyaneus*) [A082]. The open bog south of the conifer plantation is within Mt. Eagle Bogs NHA (002449) which is designated for protection of peatlands [4]. The head of the 2020 failure extends into the NHA for approximately 25m.

Orthophotography from 1995 (Plate 3-8) indicates the machine excavated firebreak in the open blanket bog along the northern margin of the conifer plantation was established at the same time as the area was planted. Subsequent orthophotography indicates the firebreak began to revegetate but was cleared again around 2013 (Plate 3-9). Post-failure orthophotography from 2023 (Plate 3-10) shows the firebreak revegetating again, but that revegetation is less prevalent around the head of the 2020 failure and south/east of the earlier (pre-2018) failure. Drains running north-south and east-west through open bog approx. 130m south-west of the failures are visible in orthophotography. The north-south aligned drain does not connect with the excavated firebreak – it ends roughly halfway between the ridge to the south and the firebreak.

High level habitat mapping obtained by request from NPWS prepared after the 2020 failure indicates the blanket bog south of the failure is unmodified. This is correct insofar as this area of bog was not directly targeted or drained, however the firebreak and drainage associated with the conifer plantation to the north of this open blanket bog is likely to have contributed to drying out of the bog.

Well-defined surface flush patterns in vegetation are not visible in the area of open bog upslope/south of the failures in the orthophotography. Flush patterns running south and south-west are visible further upslope near the summit of Mt. Eagle, perpendicular with mapped contours. The surface flush paths indicated by vegetation patterns near the summit can be assumed to continue along their same alignments towards the conifer plantation based on contour mapping. It is considered likely that surface flush patterns further downslope are obscured by dense *Molinia* tussocks.




*Geohive/MapGenie (1995)*

**Plate 3-8: Mount Eagle Pre-Failure Orthophotography (1995).**




*Geohive/MapGenie (2013)*

**Plate 3-9: Mount Eagle Pre-Failure Orthophotography (2013).**




*Google Maps (2023)*

**Plate 3-10: Mount Eagle Post-Failure Orthophotography (2023).**

### 3.4.8 Rainfall

A number of weather stations are in the vicinity of the site, and these have been used to examine recorded rainfall data. The nearest weather station to the site is the Met Éireann Castleisland (Coom) weather station some 3km to the north of the failure site, at an elevation of 157mOD. Data from Castleisland (Kilmurry, 5km NW of site) and Knocknagoshel (9km NW of site) was also reviewed.

3.4.8.1 *Analysis of Rainfall Data*

The results of the rainfall analysis are given below and presently graphically in Appendix A.

(1) What is particularly notable with respect to rainfall duration periods is the sustained dry spell in April and May 2020.
(2) The significant and sustained dry spell in April and May 2020 nationally was one of the driest recorded for this period. All rainfall totals across the country were below their Long-Term Average (LTA) for the period with the driest on record for Dublin and Meath (Met Éireann 2020).
(3) The significant and sustained dry spell would have likely caused drying of the peat surface which may have led to cracking of the near surface zone of the peat, or made existing cracking worse, particularly along forestry furrows and drainage lines.
(4) The July and August monthly totals for Knocknagoshel, Coom and Kilmurry are all significantly higher than the nearest available Long-Term Average (LTA) at Valentia.
(5) Rainfall events in excess of 20mm were recorded during August (5 no.), September (1 no.) and October 2020 (4 no.).
(6) In the three weeks preceding the 2020 failure there were six days where rainfall in excess of 20mm was recorded at Knocknagoshal, and four days at Castleisland (Coom).
(7) A comparison with the preceding 10 years of rainfall data indicates that 2020 (1769mm) recorded the highest rainfall within that decade (range 1133-1769mm, average 1468mm), despite the dry spell in April and May. Only one day (11 September 2015, 66mm) recorded in excess of 60mm of rainfall over the decade.
(8) While there isn't a single rainfall event to act as a trigger at this location, it is likely that the frequent rainfall events of the preceding weeks triggered the failure.

3.4.9 Land Use/Site History

Historical aerial photography was examined for the site covering the years 1995 to 2020, see Table 3.3.

Prior to the 2020 failure there is evidence of a peat failure immediately adjacent to the 2020 failure. An exact date for this failure is not known, however it appears to have occurred between 2013 and 2018. This peat failure post-dated the planting of the forest. The remainder of the area shows no signs of peat instability and appears to have been heavily forested for a considerable time.

**Table 3-3: Mount Eagle Historical Aerial Photographic Review**

| Year | Comments |
|---|---|
| 1995 | The site is covered in forestry plantation, which appear to be recently planted. Drainage furrows are visible running east-west through the forestry.<br>There are no apparent signs of peat failure within the site. |
| 1999-2003 | The site is covered in forestry plantation.<br>There are no apparent signs of peat failure within the site. |
| 2005-2012 | The site is covered in forestry plantation.<br>There are no apparent signs of peat failure within the site. |
| 2013-2018 | The site is covered in forestry plantation.<br>There are no apparent signs of peat failure within the site. |
| 2018 | The site is covered in forestry plantation.<br>A peat failure is visible immediately adjacent to the site of the 2020 failure, with the head of the failure in the forestry. |

| Year | Comments |
|---|---|
| April 2021 | The site remains covered in forestry plantation. Both the pre-2018 and the 2020 failures are visible. |

3.4.10 Summary

The Mount Eagle site comprises an area of upland blanket bog that has been heavily afforested over the past number of years. Bedrock underlying the site comprises sandstone, siltstone and shales from the Cloone Flagstone Formation, the Glenoween Shale Formation and the Feale Sandstone Formation. A NNW-SSE trending fault is indicated 500m west-northwest of the failure location and is three kilometres long.

The Mount Eagle peat failure site is located at an elevation approximately 430mOD. The area around the failure site comprises a relatively constant slope falling to the north at an angle of around 5 degrees.

There are no historic failures noted in GSI's national landslide database, however aerial photography shows a failure immediately adjacent to the 2020 failure, on the west side of the 2020 failure. An exact date for this failure is not known, however it appears to have occurred between 2013 and 2018.

Downslope of the failure there are numerous man-made drains, mostly installed to drain the blanket bog for establishment of the forestry plantations. An excavated firebreak (approximately 5m in width) is visible on the upslope side of the forestry (Plate 3-7 to 3-9). This firebreak would act as a cut-off drain upslope of the forestry, likely connecting to the north-south trending drains within the forestry.

In terms of predisposition to landslides, GSI's landslide susceptibility mapping indicates that the area around the failure was considered to be at low to high susceptibility to failure. However, the presence of peat across this slope, the presence of a pre-existing (pre–2018) failure and the presence of forestry drains close to the failure location would all be considered conditioning factors for peat failures. The presence of these conditioning factors would indicate that this area may be at higher risk of peat failure. GSI's landslide mapping was designed for landslides in general, not specifically peat failures, and as such is does not specifically consider the possibility of specific peat failure mechanisms or the possibility of peat failures on relatively shallow slopes.

**Figure 3.20: Mount Eagle Quaternary Geology**

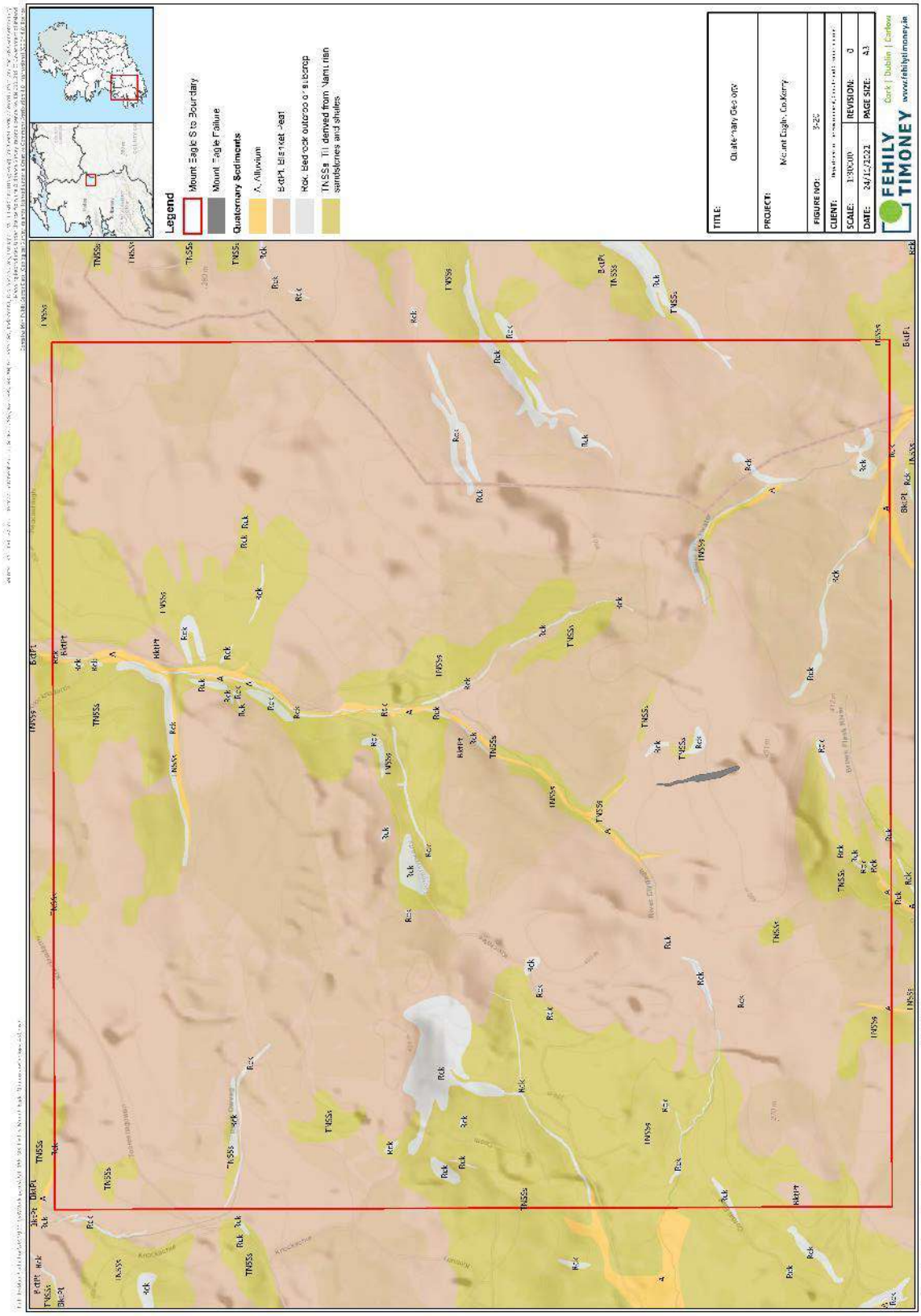


**Figure 3.21: Mount Eagle Bedrock Geology**

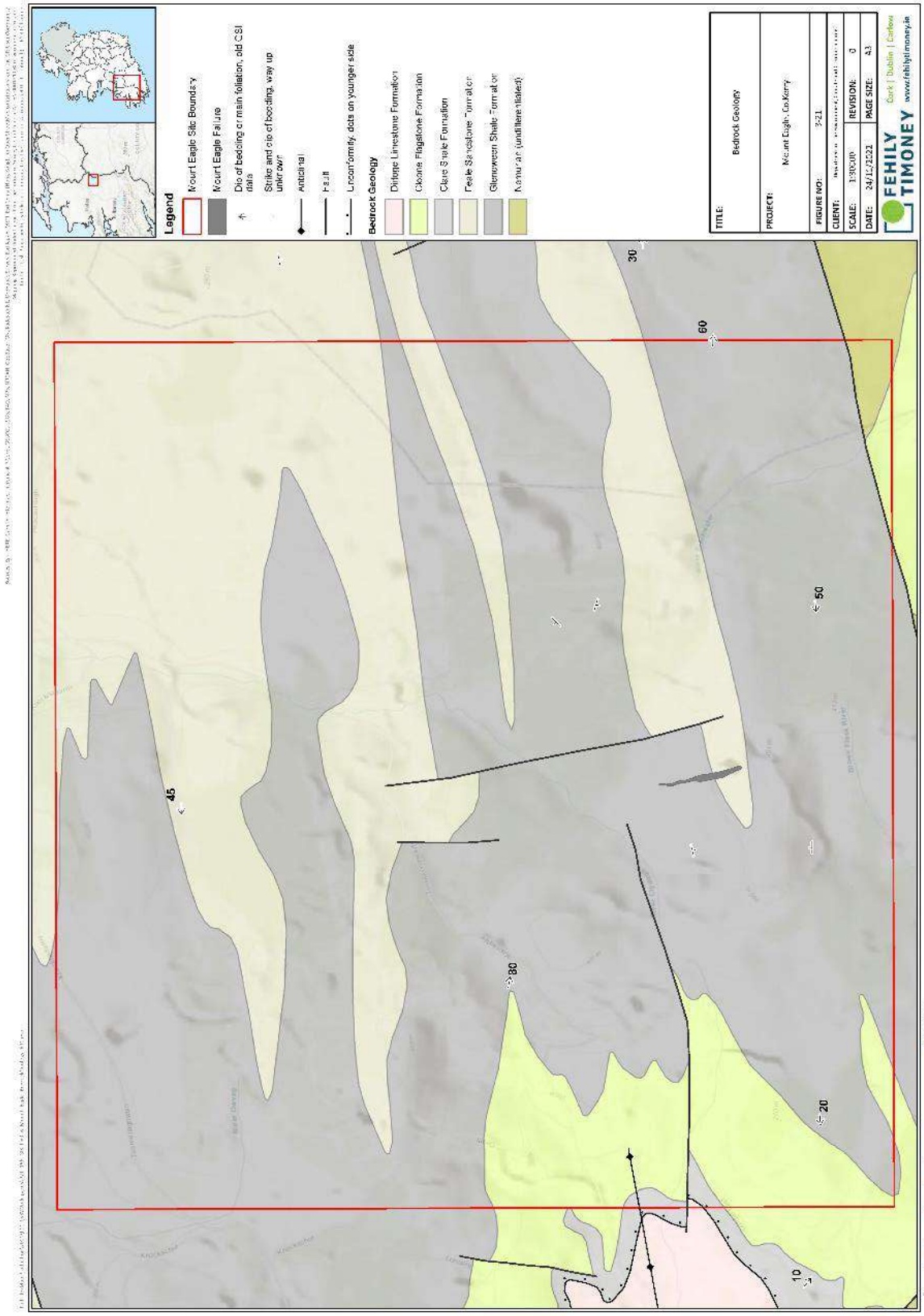


**Figure 3.22: Mount Eagle Topography**

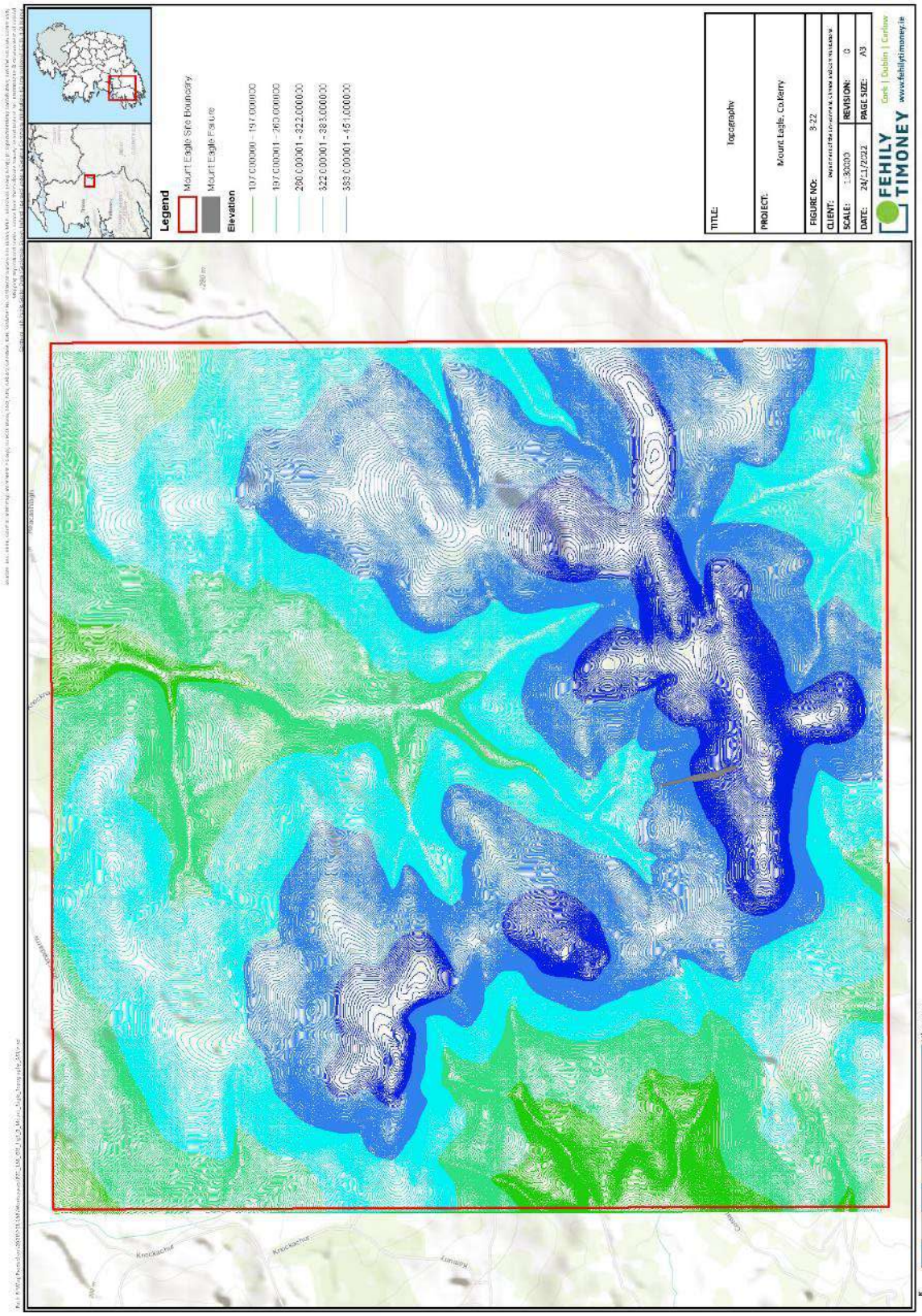


**Figure 3.23: Mount Eagle Slope Interpolation**

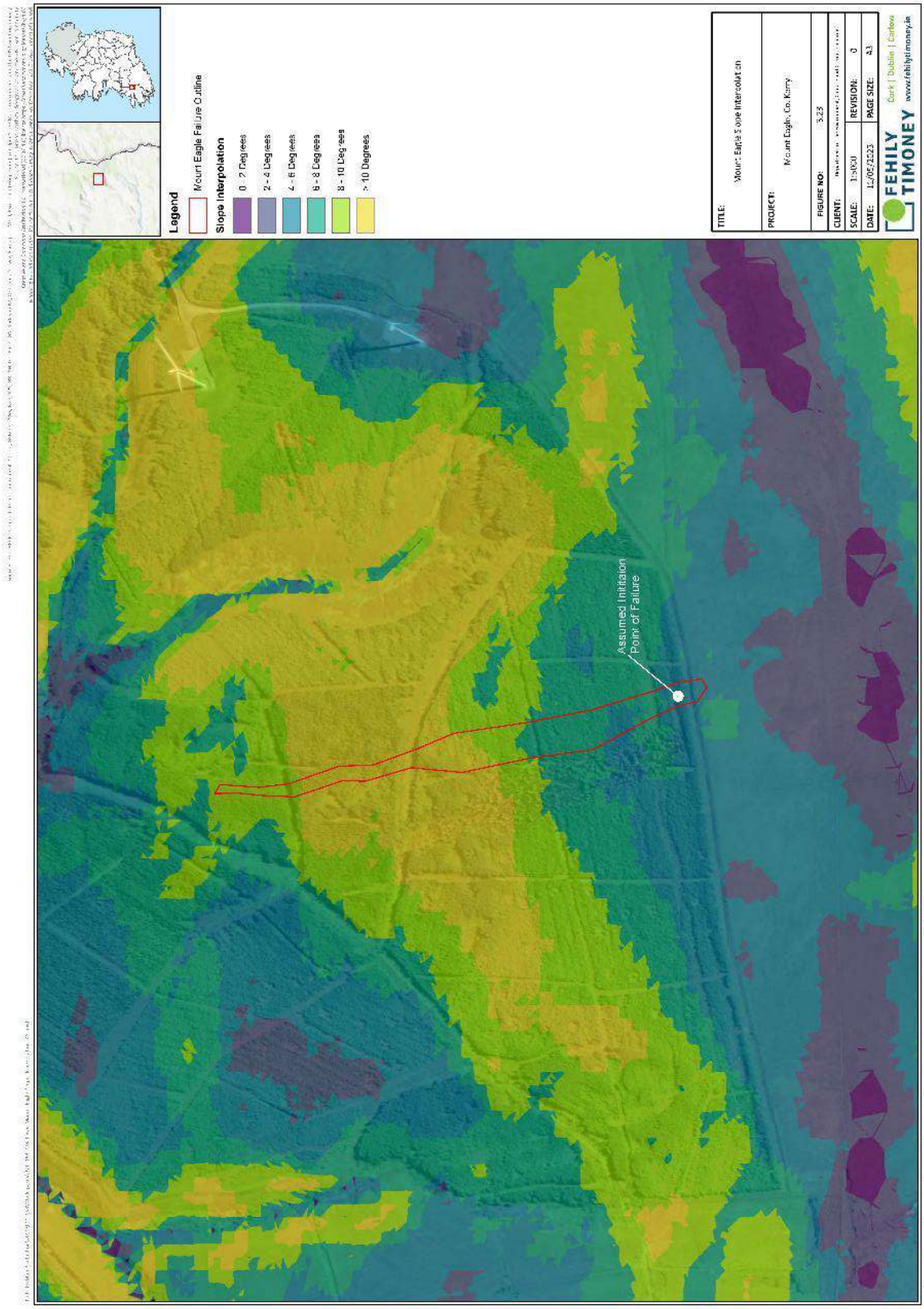


**Figure 3.24: Mount Eagle Landslide Susceptibility**

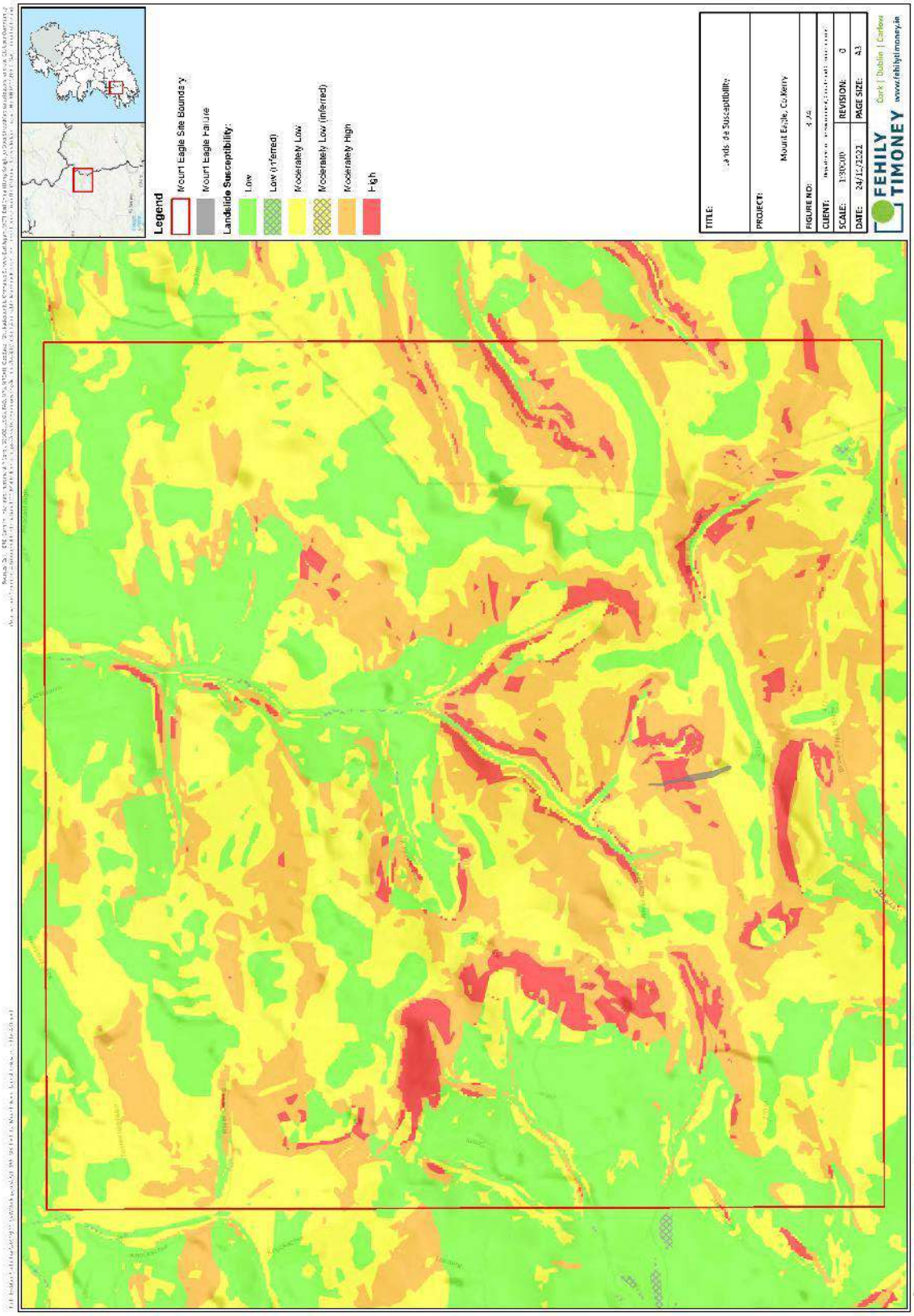


**Figure 3.25: Mount Eagle Quaternary Geomorphology**

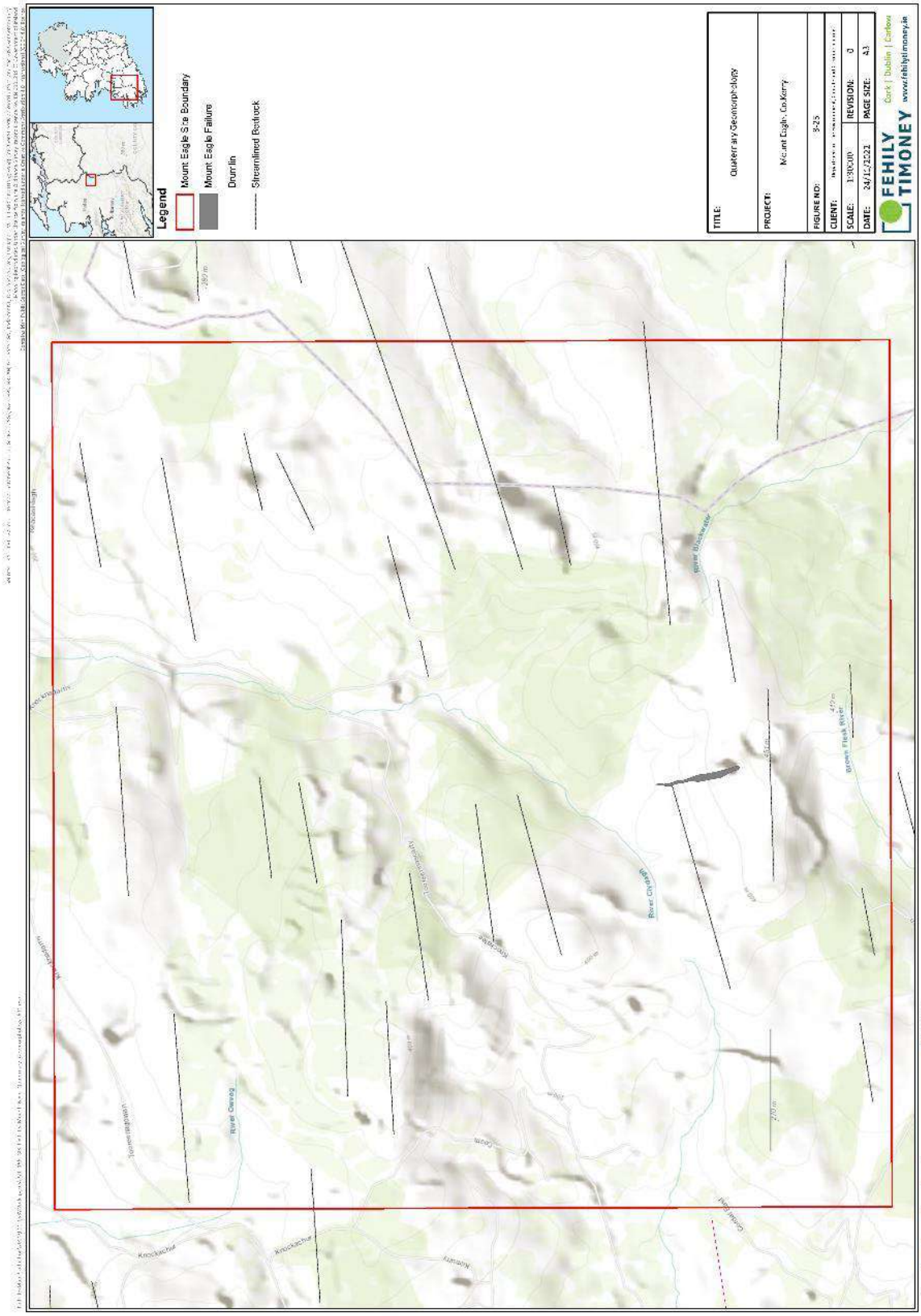


**Figure 3.26: Mount Eagle WFD Catchments**

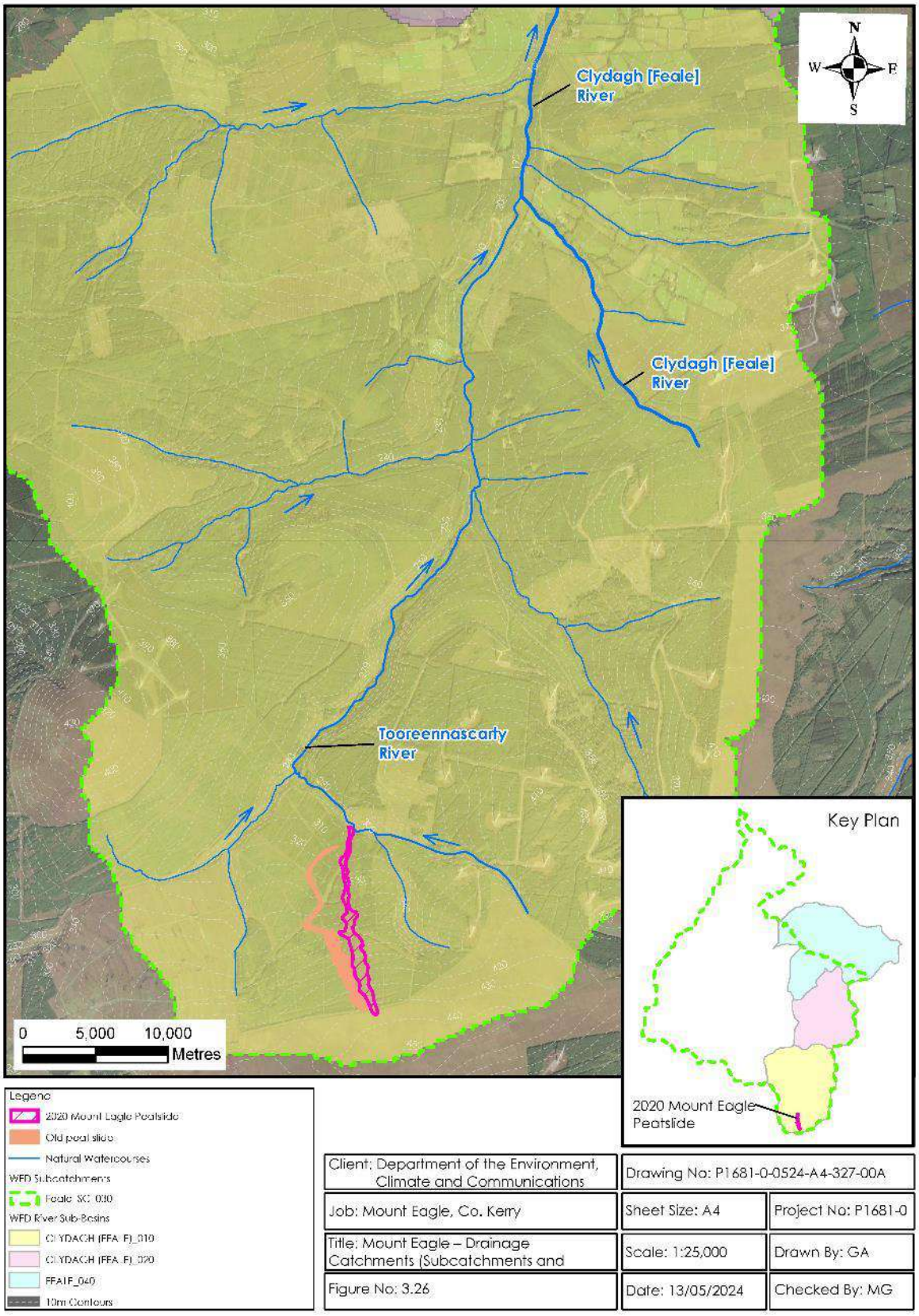


**Figure 3.27: Mount Eagle Pre-Failure Drainage**

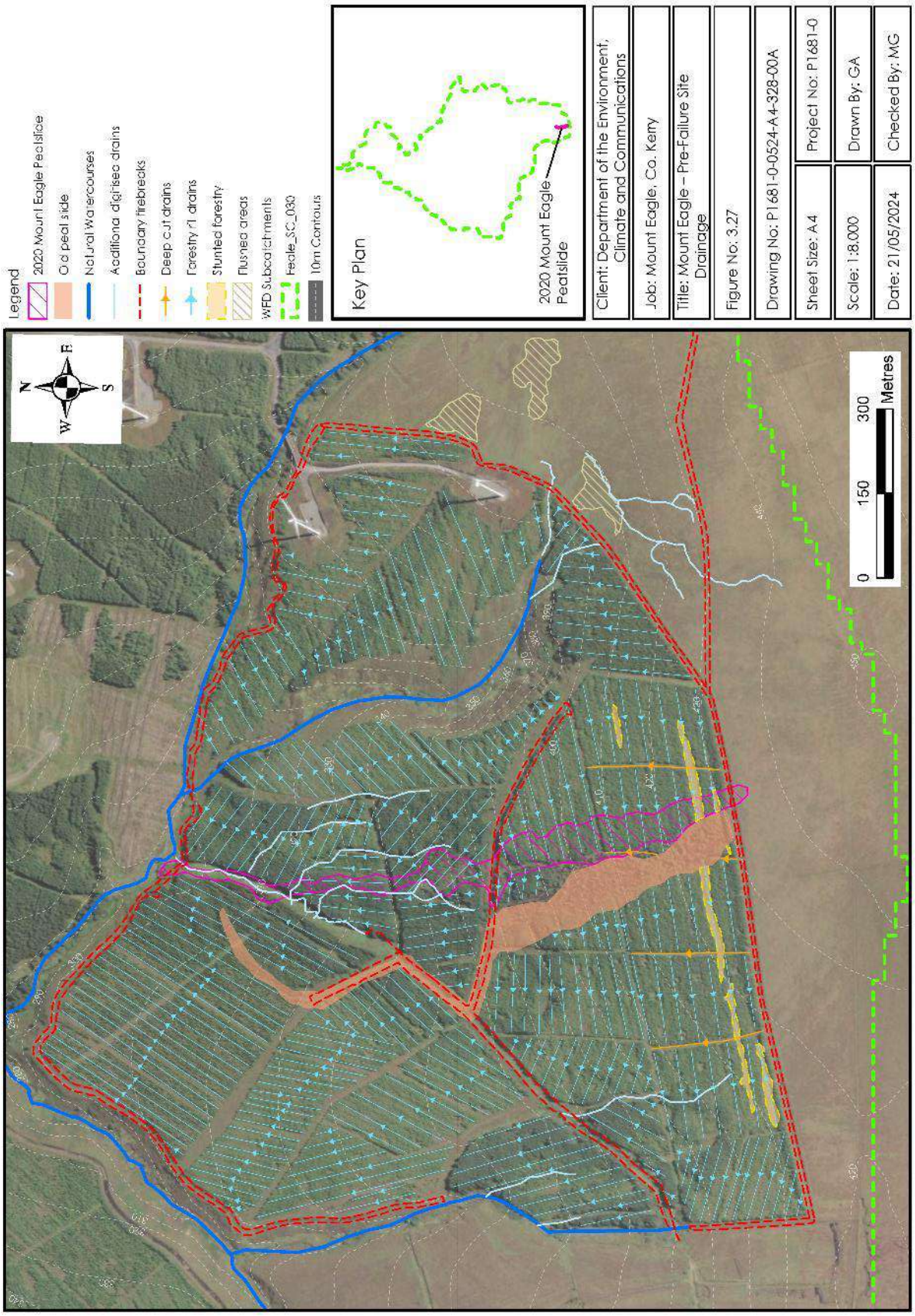
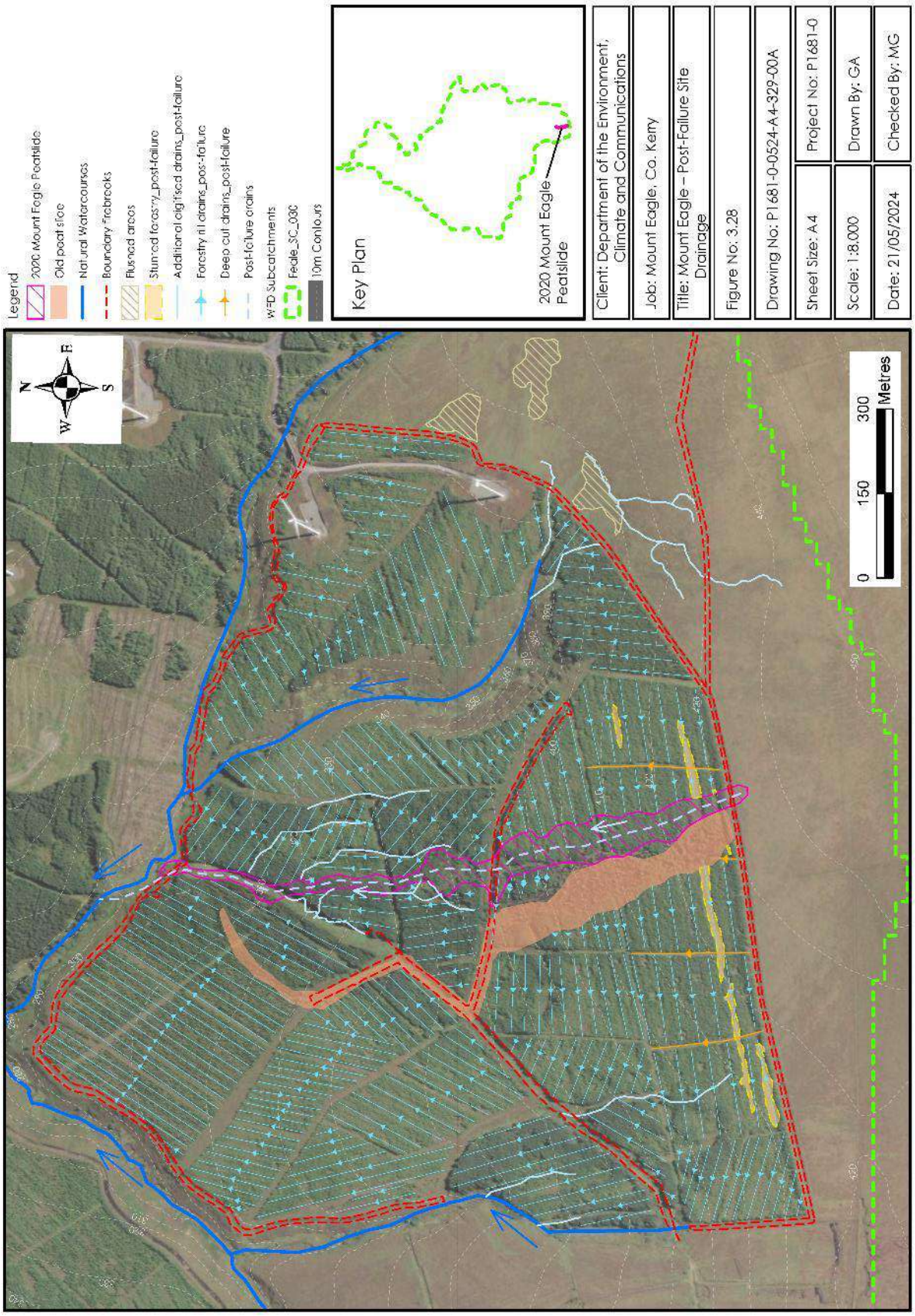


**Figure 3.28: Mount Eagle Post-Failure Drainage**



# 4. Site Visits to the Three Failures

A series of site visits were undertaken to each of the three 2020 failure sites to examine the geotechnical, hydrological, hydrogeological and ecological conditions at each site. Site visits were undertaken by experienced practitioners in their respective disciplines.

## 4.1 Meenbog

### 4.1.1 Geotechnical

The failure scar morphology comprises 3 distinct parts, namely an upper scar and lower scar which provided the source area for the failed peat, and a run-out trail along which the failed peat was deposited. The scar morphology indicates that failure was most likely a bog flow slide.

Bog flow-slides are commonly recognised due to the scar forming a "bottleneck" morphology as material locally and retrogressively fails by localised sliding from the side and the upslope margins of the initial localised failure at the downslope margin (mouth) of the scar. Failed material subsequently flows out of the mouth of the scar. In this manner, the scar is retrogressively widened with increasing distance from the initial localised failure. This is explained in further detail below.

The 3 distinct parts of the peat failure are described below:

(1) Upper scar. This comprised the primary source area of the failed material (Figure 4.1). The upper scar was 260m long by up to 120m wide. The head of the failure scar was within open blanket bog. The southern part of the scar was also within open blanket bog. The northern part of the scar is located within forestry plantation on blanket bog. The upper scar occupies an estimated total area of approximately 2.4ha.

Based on visual inspection the ground level in the central part of the upper scar has dropped by about 3m, however the edge of the failure scar has a similar elevation to the area that did not fail.

The basal failure surface is within the weaker catotelm peat in the lower part of the blanket peat, within an estimated 0.2m of the underlying mineral soil. A minor stream now flows through the central portion of the scar and the base of this stream is on the underlying mineral soil.

The pattern of displaced peat within the upper scar forms a series of concentric rafts that have moved laterally and downslope towards the mouth of the scar. The upper scar forms a saucer shape with the width of the downslope mouth (bottleneck) much narrower (40m) than the maximum scar width (120m).

Whilst most of the area of the upper scar is within open blanket bog that has little or no drainage, the perimeter extent of the upper scar was significantly controlled by existing drainage ditches and forestry furrows in the area. To the south there are a series of parallel drainage ditches (less than about 1m deep) in the open blanket bog that channel water northwards towards the failure scar. These parallel drainage ditches feed into an interceptor drainage ditch aligned west-east. This interceptor drain has controlled the southern limit of the scar. To the east the scar is controlled by an oblique drainage ditch. To the north the scar follows the line of the forestry perimeter drainage ditch before extending further northwards into the forestry plantation where the scar is controlled by the forestry furrows.

(2) Lower scar. This comprised a secondary source area of the failed peat. The lower scar is rectilinear and follows the slope gradient. The lower scar was 260m long by 45m wide. The head of the lower scar is

taken at the downslope mouth of the upper scar and coincides with the upslope boundary of a recently felled forestry plantation. The lateral perimeter of the scar follows the existing forestry furrows. The estimated total area of the lower scar is about 1.18ha.

Based on visual inspection the depth of the lower scar is estimated at 1.5m to 2m. The floor of the scar is undulating and contains some isolated rafts of peat debris. There is evidence of exposed rock within the floor of the scar and a shear surface, which suggests that the shearing has occurred within the basal part of the peat.

The lower scar represents a translational sliding of peat, caused by the additional loading from the upslope failed material. It is considered likely that the lower scar formed due to an initial failure (as a bog flow) at the head of the scar at the location of the wind turbine ''floating'' access road that was being constructed at the time of the failure. This initial failure caused loss of strength at the head of the lower scar which caused the peat to progressively fail downslope.

The perimeter extent of the lower scar was controlled by existing forestry furrows which are aligned downslope in the direction of peat movement. Adjacent to the scar the existing forestry furrows (up to 1.2m wide and typically 10m horizontal spacing) have generally acted as lines of weakness in the upper fibrous layer of peat (acrotelm) with the furrows opening up due to tensions exerted by the failure.

At the downslope margin of the lower scar the peat debris impacted an existing stand of peatland forestry plantation causing some trees to topple, however the forestry resisted the impact of the peat debris and prevented the peat debris from continuing on the same path. At this location, the peat debris entered the channel of Shruhangarve stream which flows in a northeast direction. The peat debris would have initially started to accumulate at this location but due to the preferential flow path provided by the stream channel, and in combination with water flowing within the stream, the debris changed direction and followed the stream channel. Inspection of this location shows that there is peat debris accumulation, which had partly blocked the flow in the stream. Below the lower scar and within the Shruhangarve stream channel there is a net accumulation of failed material.

(3) Run-out trail. The run-out trail follows the Shruhangarve stream for about 2.44km where it passes the Shruhangarve bridge and then extends a further 0.74km to the Mourne Beg River. The total distance along the Shruhangarve stream is about 3.18km. For the purpose of this report the extent of the run-out is taken to be the location at which the peat debris enters the Mourne Beg River.

Inspection of the run-out trail along the channel of the Shruhangarve stream indicates that whilst there is evidence of scouring and erosion of the floor of the channel there is generally a net accumulation of failed material. The accumulation takes the form of isolated rafts of peat but generally peat debris on the banks of the stream forming levees. An approximate estimate of the extent of the accumulated peat debris on the banks is about 5m to 10m either side with a thickness of less than 1m.

It is assumed that on reaching the Mourne Beg River the dilution effect due to the greater flow volume within the river would cause most of the peat debris to go into suspension, and from a geotechnical viewpoint this would not be considered as part of the run-out trail.

**Peat Depth / Slopes / Strength**

Peat depth data recorded during previous visits and site walkovers by Fehily Timoney was used to provide an indication of the peat depth around the area of the failure. Shear strength data from these visits was also reviewed. This indicated that the peat in the flat area around the edge of the failure had a shear strength of typically <10kPa (very soft, weak peat) and occasionally as low as 3kPa, with peat depths ranging from 1.7 to 4.5m (Figure 4.2). Peat depths on the shallow slope adjacent to the failure (east of failure) were generally shallower, ranging from 0.7 to 2.2m. The depth ranges indicate blanket peat. Peat strengths were recorded using a hand-held shear vane and ranged from 2-3kPa in the area of open blanket bog adjacent to the head of

the failure, and up to 15-20kPa on the blanket bog slope to the east of the failure. The peat strengths recorded in the area of open blanket bog would be considered very low and are likely at the lower limit of what can be practically measured with the hand vane. The shear vane results show no appreciable strength gain with depth, which would be typical of a saturated peat mass that has remained essentially water-logged over time. Slope angles recorded on site ranged from 1 to 6 degrees, with the area of the south and west of the failure point almost flat, and the areas to the east of the failure point with a slope angle of 4 to 6 degrees. Shallow bedrock was noted to the north of the failure in drains alongside a forestry track and also NE of the failure initiation point.

**Failure Volume**

The plan extent of the upper and lower failure scars was surveyed using a hand-held GPS. Survey points were taken around the perimeter of the scar together with peat depth probes. Volumes calculated from this survey are an estimate. The failed material comprises almost completely of peat, with a very minor proportion of underlying glacial till that would have been scoured from the lower scar area.

The upper scar is 260m long measured from the furthest upslope point to the downslope limit at the mouth of the upper scar, at the location of the ''floating'' road that was being constructed at the time of the failure. The maximum width of the upper scar is 120m. The estimated total area of the upper scar is 2.4ha. Peat depth probes around the perimeter of the upper scar showed an average peat depth of 2.7m, though locally depths of 4.5m were recorded.

Based on the above assuming the full depth of peat failed, which is considered the case, then the total failure volume from the upper scar is estimated at 24,000$m^2$ by 2.7m which gives 65,000$m^3$.

The lower scar is 260m long measured from the downslope limit at the mouth of the upper scar to where it meets the Shruhangarve stream. The width of the lower scar is estimated as 43m. The estimated total area of the lower scar is 1.18ha. Peat depth probes around the perimeter of the lower scar showed an average peat depth of 1.8m.

Based on the above, assuming the full depth of the blanket peat failed, then the total failure volume from the lower scar is estimated at 11,800$m^2$ by 1.8m which gives 21,240$m^3$.

Total failure volume is therefore 65,000$m^3$ + 21,240$m^3$ which is 86,240$m^3$.

The actual volume of failed material that left the failure scar would be less than the total failure volume as a notable proportion of the failed material still remains in the upper scar. An estimate of failed material remaining in the upper scar is 30%, which means that an estimated 45,500$m^3$ of failed material left the upper scar.

Total failure volume that left the failure scars is therefore estimated as 45,500$m^3$ + 21,240$m^3$ which is 65,740$m^3$.

**Figure 4.1: Aerial image of upper and lower scars, Meenbog**

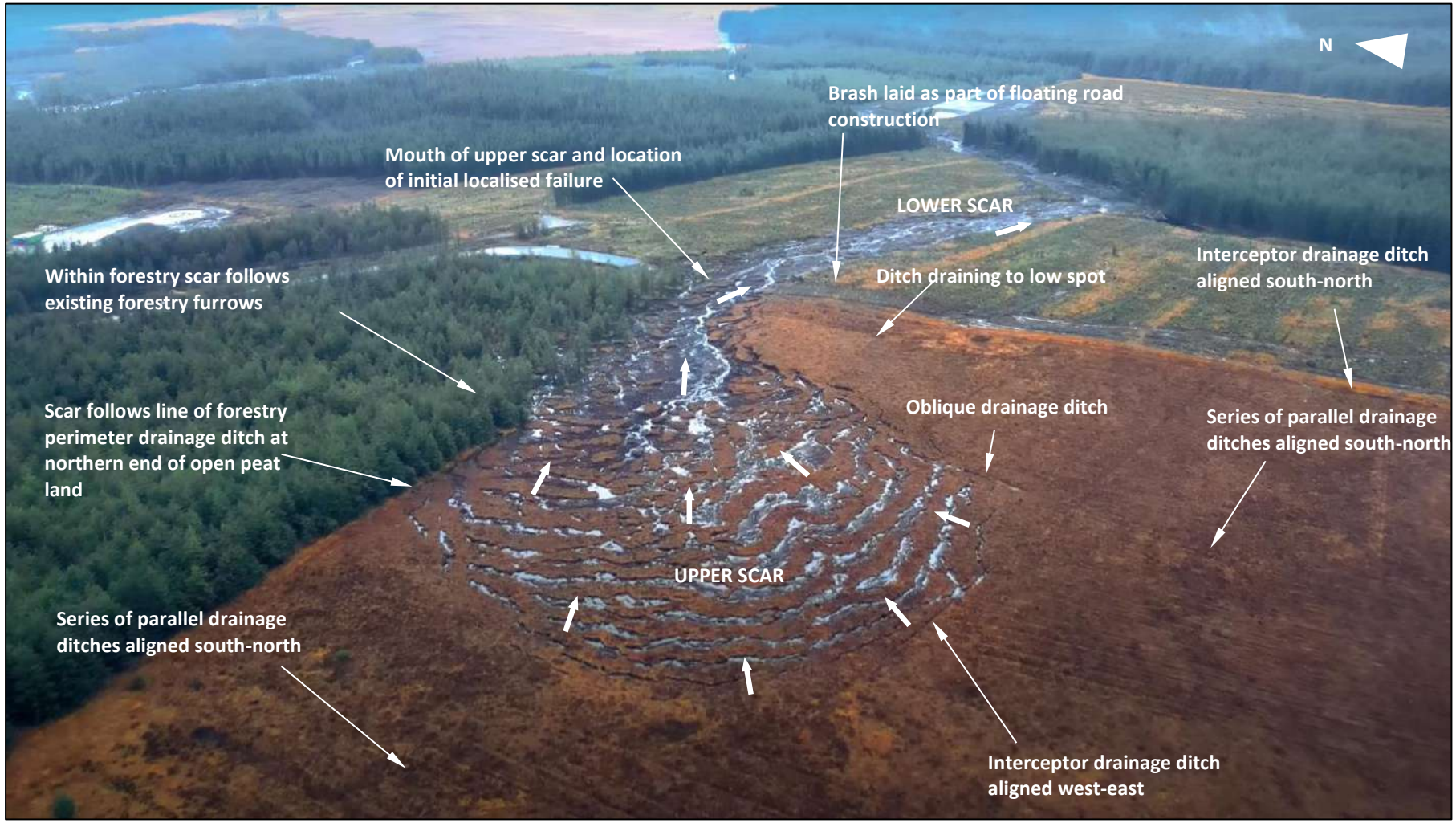


**Figure 4.2: Meeenbog Peat Depths**



### 4.1.2 Hydrological/Hydrogeological

A site visit was undertaken to identify both the natural and artificial drainage present around the area of the 2020 peat failure.

The upper failure scar extends into an area of flat, open blanket bog. A review of aerial photography combined with ground truthing from on-site inspection indicates some existing drains within the open blanket bog and these generally drained to perimeter interceptor drains relating to the surrounding forestry. The area of the failure scar appears to have been previously undrained, suggesting that the blanket bog may have been too soft and wet to support forestry machinery.

The extent of existing (pre-failure) forestry drainage and local natural watercourses are shown on Figure 3.9 and 3.10. The artificial forestry drainage design relies on a dense pattern of rill drains to carry water to interceptor drains and then from the interceptor drains to downstream natural watercourses. The observed rill drainage in the area of forestry surrounding the failure scar runs either north-south or east-west, which generally follows the local slope of the ground.

The area surrounding the upper failure scar comprises standing forestry on blanket bog to the north and west, felled forestry on blanket bog to the east and northeast, and open blanket bog and higher ground to the south, which is a mixture of open ground and forestry.

The forestry to the north of the open blanket bog/upper failure scar has rill drains running in a north-south direction, and there is an interceptor drain running west-east along the southern edge of the forestry. These rill drains are typically spaced 10-15m apart and are up to 0.5m deep. A drain is noted to emerge from the interceptor drain approx. 40m from the eastern end of the forestry and its orientation is in a south-westerly direction. The main interceptor and the offshoot drain have been partially severed by the upper failure scar, as the scar encroaches into the forestry over a linear distance of approx. 125m (along what was the alignment of the interceptor drain). The interceptor drain ran along the southern edge of the forestry and its eastern end coincides with the probable inception point of the failure. Drone footage of the site on the morning of the failure shows this interceptor drain with water in it, with minor ponding upstream and downstream of the head of the windfarm road construction works.

The available LiDAR data of the open blanket bog (pre-failure) shows that the low point and drainage outfall occurs approximately 80m south of the edge of the forestry drain where the interceptor drain crossed the ‘floating’ road. Some advance drainage works appeared to have been completed at that low point prior to the 12 November 2020 failure. Evidence from historic aerial photography also indicates that the forestry extraction route used for the clearing of the felled forestry block to the east of the failure point used a path parallel to the north-south boundary of the open blanket bog, and then veered northeast at the approximate location of the failure. All of this forestry extraction route occurs just off the edge of the open blanket bog and along a convex break in slope.

The forestry to the west of the open blanket bog/upper failure scar has rill drains running in a north-south direction, and within the forestry, there is a natural watercourse that flows to the northwest. This watercourse is shown on EPA Surface Water features. The western edge of the open blanket bog drains towards this western forestry and the natural watercourse.

There is an area of felled forestry on blanket bog to the west and northwest of the upper failure scar. The lower failure scar runs through this area. There is an interceptor drain along the eastern edge of the open blanket bog, but it appears to have drained to the east at several points and also the low point as described

above, with only some of the flow draining from the north (towards the natural low point) where the failure occurred. Rill drains within this felled forestry area run west-east and drain to the east into an interceptor drain, and then to a natural watercourse. This watercourse is the upper reaches of the Shruhangarve stream. Some of these west-east rill drains were removed by the lower failure scar, but water is flowing down the lower failure scar in a newly formed channel.

Lough Carrickaduff, a small lake located approx. 600m to the southeast of the failure scar is situated on higher ground, and it drains to the southwest, and does not interact with the open blanket bog within which the upper failure occurred.

The site visit has identified three zones of drainage (Figure 4.5) at the site that have direct relevance to the peat failure event:

- **Zone A:** Relatively intact open blanket bog characterised by diffuse overland flow across flat vegetated ground towards the north-eastern corner of the open blanket bog area. Not all the open blanket bog drained to this outfall, as some areas drain east and west.
- **Zone B:** Forestry drainage from the north, with linear flow along the bounding interceptor drain, directing flow to the east towards the likely inception point of the failure.
- **Zone C:** Runoff from the blanket bog forestry and the open blanket bog drained to the east down a steeper slope in the forestry drainage associated with the felled area, which had rill drains and collection drains. The head of this transition zone appears to be a critical area for the peat failure. Downstream of this area, the forestry drainage flows into the Shruhangarve stream.

### 4.1.3 Ecological

Ecological surveys were completed on 17 and 18 August 2022. The survey sought to characterise the habitats to Fossit classes (Fossitt, 2000) and vegetation characteristics of the area around the peat failure, and to check for any features, plant species or assemblages which could potentially indicate conditions conducive to the peat failure.

Vegetation was recorded from a series of 2m x 2m plots (Relevés). All species within each Relevé were identified and a percentage cover value for each species was assigned. Relevés were targeted to capture the transition from forestry to open bog, and to compare areas with and without drains. A total of 13 plots were surveyed (see Figure 4.3).

Full botanical survey results are included in Appendix B, which provides species lists and percentage cover for each survey location.

Two habitat types are present in the immediate area: upland blanket bog (Fossitt class PB2) surrounding the failure and conifer plantation (Fossitt class WD4) to the west and north surrounding the open bog. The forestry was planted on blanket bog. Transitional vegetation characterised by higher grass cover and lower heather cover forms an ecotone between the areas of open upland blanket bog and conifer plantation. The upland blanket bog habitat was surveyed in detail.

*Upland blanket bog PB2 (Fossitt)*

This is the dominant habitat in the area. This habitat type encompasses both intact blanket bog, and areas with drains.

Ling heather *Calluna vulgaris* is the dominant species in areas of open bog. Purple moorgrass *Molinia caerulea* is also prominent in some areas. Deergrass *Trichophorum caespitosum* and Common bog cotton *Eriophorum angustifolium* were frequently recorded. Cross-leaved heath *Erica tetralix*, Bog asphodel *Narthecium ossifragum*, Tormentil *Potentilla erecta* and Heath milkwort *Polygala serpyllifolia* were present. A notable record was White beak-sedge *Rhynchospora alba,* which was only recorded on an isolated island of peat within the failure.

Red bog-moss *Sphagnum capillifolium* was abundant in parts. Other *Sphagnum* species present included Papillose bog-moss *Sphagnum papillosum*, Lustrous bog-moss *Sphagnum subnitens*, Soft bog-moss *Sphagnum tenellum* and Feathery bog-moss *Sphagnum cuspidatum.* Woolly fringe-moss *Racomitrium lanuginosum* and Reindeer lichen *Cladonia portentosa* were common.

In open areas abutting conifer plantation, the vegetation was grassier, being dominated by Purple moorgrass. Wavy hairgrass *Deschampsia flexuosa* was also present in these zones, and Ling heather was present in varying amounts. Cover of *Sphagnum* and other mosses was good in these areas. Magellanic bogmoss *Sphagnum magellanicum* was recorded at plots M6 and M11 beside conifer plantation, but not in more open areas. *Sphagnum* mosses were recorded at all 13 locations. *Sphagnum* cover was greater than 50% in five quadrats (M2, M3, M4, M5 and M12).

The vegetation in areas with drains does not differ markedly to those without drains. Parts of the intact bog are extremely wet, quaking bog.

As noted in the data review, White beak-sedge can be indicative of the presence of quaking bogs (occurring in the Annex 1 habitat *Rhynchosporion* depressions [7150] and also as part of the sub-community *Rhynchospora alba* quaking bogs within 'Transition mires and quaking bogs [7140]).



**Plate 4-1: Upland blanket bog at Meenbog. Failure visible in top left.**

*IVC Classification/ ERICA Analysis*

Relevé data was analysed using ERICA, the online statistical software tool used to assign habitat types to IVC (Irish Vegetation Classification) communities (Perrin et al. 2018). This allows a more detailed exploration of vegetation communities, albeit with the qualification that peat depth, a key factor in differentiating wet heath from blanket bog is not considered in the analysis. As such, based on vegetation composition only, the analysis indicates the presence of both heath and blanket bog at Meenbog, despite the peat depths recorded in this area (ranging from 0.9m to 4.5m) placing the habitat classification firmly in the blanket bog category. This would indicate that some drying/degradation of the blanket bog has occurred to allow the alteration of the vegetation to wet heath.

The most frequently assigned community was BG2C peatland, which can occur in either blanket bog or wet heath. This community was recorded in areas of open bog closer to the failure point. Most plots classified as heath were located along the conifer plantation/bog ecotone, with the exception being M1 which was in open bog near the failure inception. It is also noted that the most frequently assigned heath community (HE4D, assigned to M6, M8, M11 and M13) can also occur on disturbed blanket bog.

**Table 4-1: IVC communities assigned by ERICA analysis (Meenbog)**

| Plot | Code |
|---|---|
| M1 | HE4E |
| M2 | BG2C |
| M3 | BG2C |
| M4 | BG2C |
| M5 | BG2C |
| M6 | HE4D |
| M7 | HE2D |
| M8 | HE4D |
| M9 | BG2C |
| M10 | BG2C |
| M11 | HE4D |
| M12 | HE4E |
| M13 | HE4D |

BG2C: *Erica tetralix – Molinia caerulea – Cladonia portentosa* peatland

This community is dominated by a mixture of *Calluna vulgaris* and *Molinia caerulea*. *Erica tetralix* and *Trichophorum cespitosum/germanicum* are also plentiful constants while *Potentilla erecta* and *Eriophorum angustifolium* complete the usual plants of the field layer. Frequent companions to these species are *Eriophorum vaginatum*, *Narthecium ossifragum*, *Polygala serpyllifolia* and *Drosera rotundifolia*. *Sphagnum capillifolium* is usually found in the bryophyte layer together with *Hypnum jutlandicum* and *Odontoschisma sphagnii*. *Sphagnum tenellum* and *Sphagnum subnitens* are frequent. Conspicuous white patches of *Cladonia portentosa* are a common.

This is predominantly a community of lower mountain slopes and boglands, occasionally higher up (mean altitude = 214 m, *n* = 57; mean slope = 9.2°, *n* = 51), occurring on wet, acidic and infertile peats (mean extent of bare peat = 2.3%, *n* = 87). It may form part of blanket bog or wet heath vegetation.

HE4E: *Molinia caerulea – Calluna vulgaris – Erica tetralix* heath

*Molinia caerulea* dominates this community but is accompanied by a reasonably well-developed dwarf shrub layer composed of *Calluna vulgaris* and *Erica tetralix*. *Potentilla erecta*, a plant common to most upland heaths and bogs, is again to be found here, and indeed is the only other constant vascular species. Often, there are some patches of *Trichophorum cespitosum/germanicum* or *Eriophorum angustifolium* amongst the *Molinia* tussocks, and the blue flowers of *Polygala serpyllifolia* may be spotted. Occasionally there is some *Eriophorum vaginatum* or *Carex panicea*. The bryophyte layer is not very abundant with *Hypnum jutlandicum* the most frequent component, often joined by *Sphagnum capillifolium*, *Sphagnum subnitens* or *Odontoschisma sphagnii*.

This community occurs on the lower to middle slopes of hills and mountains (mean altitude = 215 m, *n* = 49; mean slope = 15.0°, *n* = 42) on wet, acidic and infertile peaty soils (mean extent of bare peat = 3.3%, *n* = 77).

HE4D: *Molinia caerulea – Potentilla erecta – Erica tetralix* heath

Dense *Molinia caerulea* dominates this community, often forming large tussocks and a thick litter layer. The only other constant species is *Potentilla erecta*. Occasionally, there is some spindly growth of *Erica tetralix*, *Calluna vulgaris* or *Myrica gale*, but dwarf shrub cover is typically very low. Other occasional plants are *Succisa pratensis*, *Juncus effusus*, *Agrostis canina/vinealis* and *Anthoxanthum odoratum*. The bryophyte layer is very sparse or absent; some hunting amongst the leaf litter may reveal some patches of *Sphagnum capillifolium*, *Hypnum jutlandicum* or *Hylocomium splendens*.

This is mostly a community of lowland peatlands (mean altitude = 140 m, *n* = 52; mean slope = 4.0°, *n* = 41), usually occurring as a part of wet heaths or disturbed blanket bog. Soils are wet, acidic and infertile (mean extent of bare peat = 2.9%, *n* = 46). There may be some degree of flushing but it is not pronounced.

HE2D: *Calluna vulgaris – Molinia caerulea – Erica cinerea* heath

This community is typically dominated by bushes of *Calluna vulgaris* but tufts or small tussocks of *Molinia caerulea* are also plentiful. These are accompanied by *Potentilla erecta* and both *Erica cinerea* and *Erica tetralix*. There are few other vascular plants, with the sedges *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Trichophorum cespitosum/germanicum* being only occasional. The bryophyte layer is largely pleurocarpous in character, with *Hylocomium splendens*, *Rhytidiadelphus loreus*, *Hypnum jutlandicum* and *Pleurozium schreberi* occurring, but crimson patches of *Sphagnum capillifolium* are also frequently encountered here.

This is a community of the lower to middle slopes of hills and mountains (mean altitude = 221 m, n = 55; mean slope = 12.7°, n = 16), primarily wet heathland where soils are rather poorly drained, acidic and infertile (mean extent of bare rock = 0.0%, n = 16).

**Figure 4.3: Meenbog Botanical Survey Points**

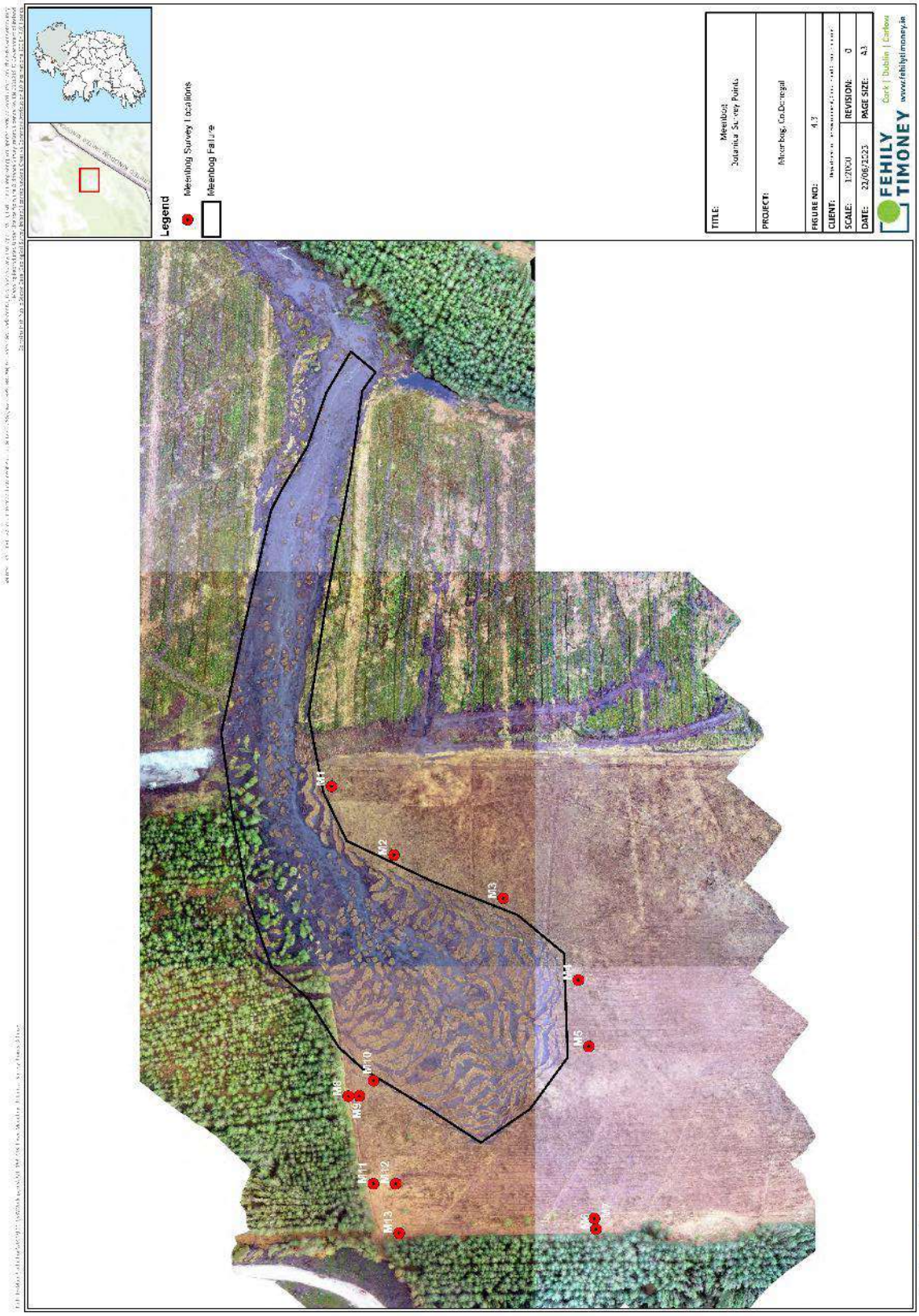


**Figure 4.4: Meenbog Habitats**

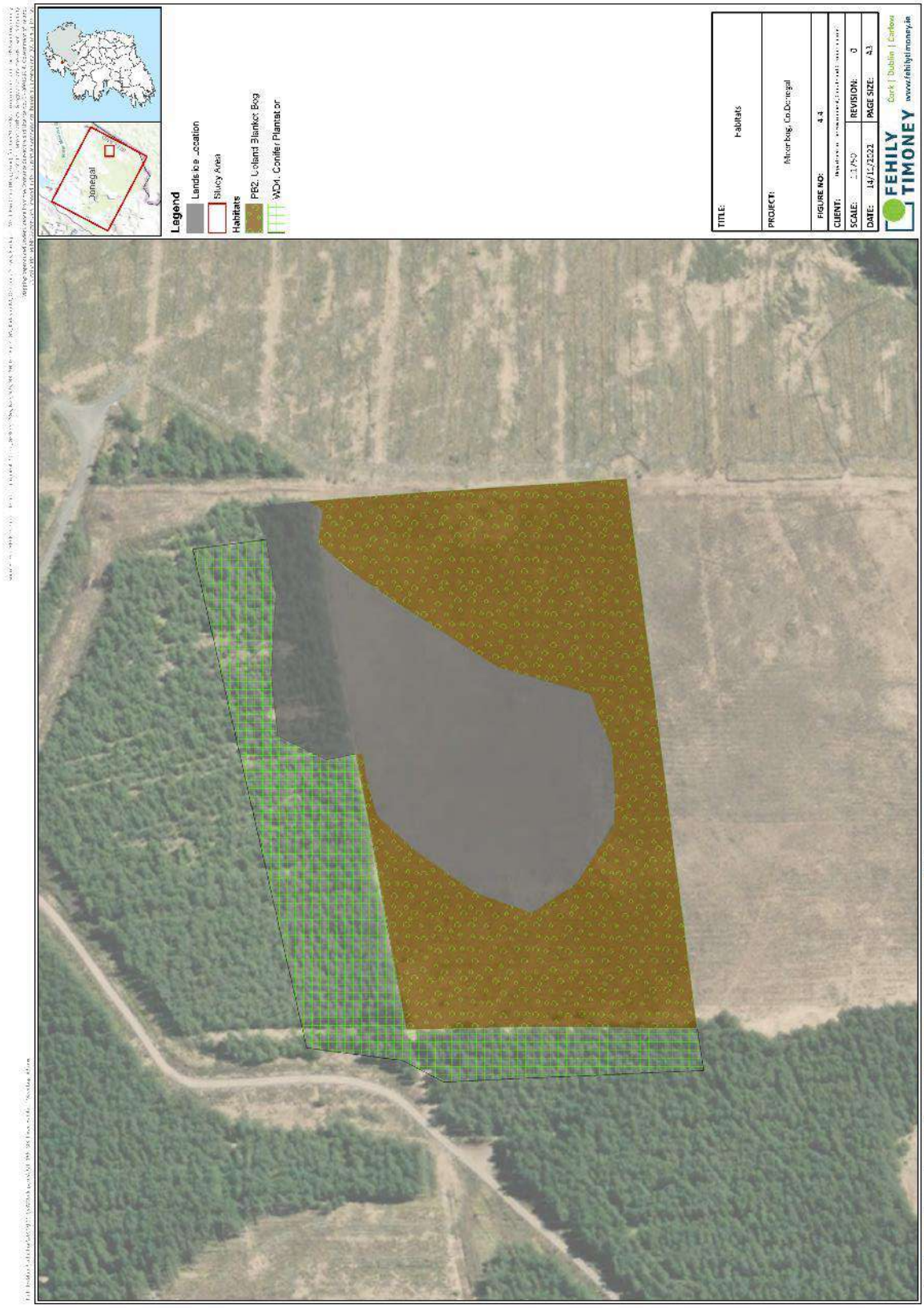
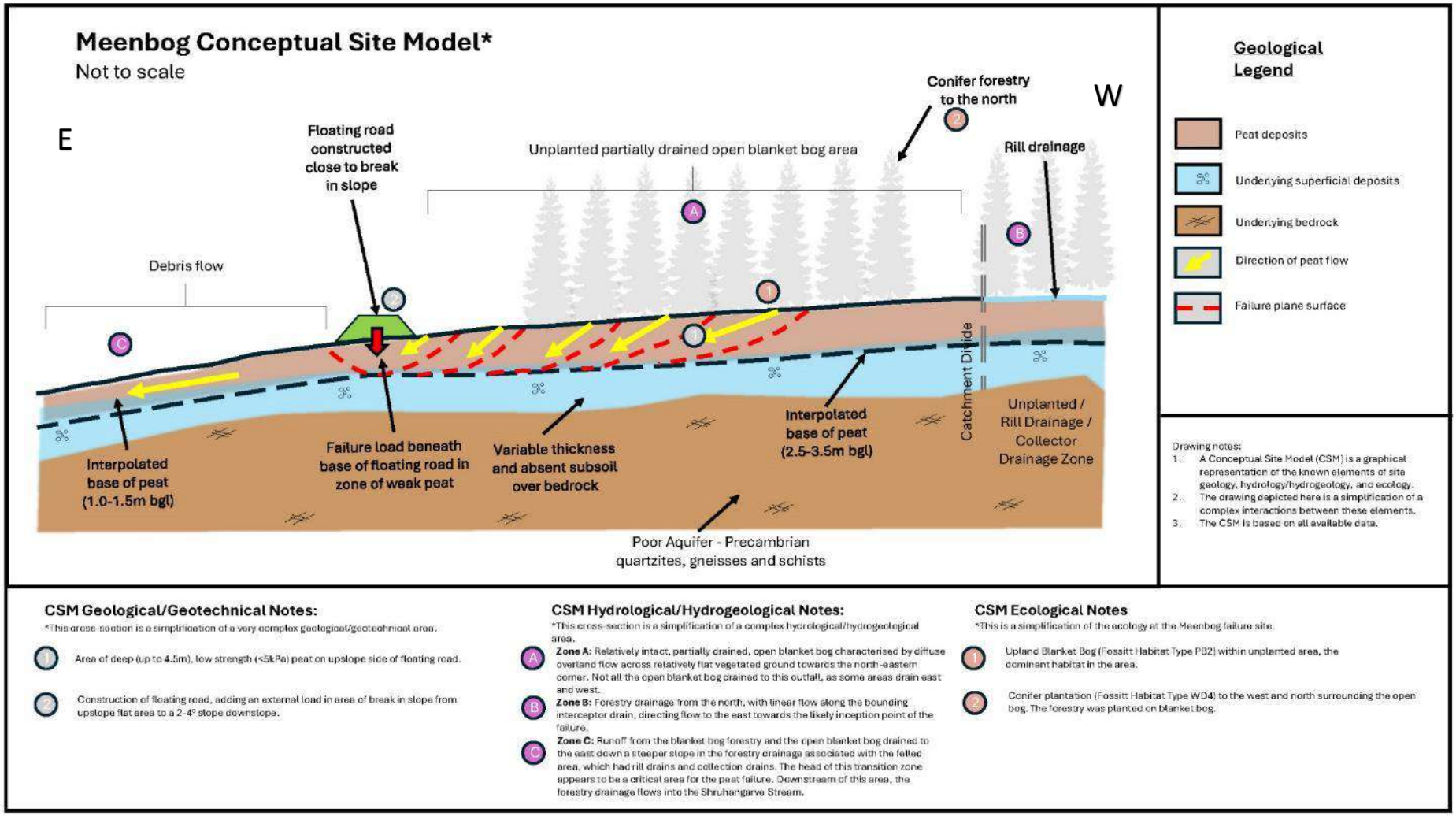


**Figure 4.5: Meenbog Conceptual Site Model**



## 4.2 Shass Mountain

### 4.2.1 Geotechnical

This peat failure occurred on a southerly facing slope supporting open blanket bog with a forestry plantation on blanket bog at the head of the failure. The failure occurred on 28 June 2020 during/following a period of heavy rain.

The failure scar is defined in 2 parts (Figure 4.6), namely:

- Upper scar. This comprised the main source area of the failed blanket peat. The upper scar was about 450m long by about 200m wide. The head of the failure scar was within the forestry plantation, where 2 no. notable head features are readily apparent, which follow topographical low areas. The estimated total area of the upper scar is 8ha.

- Lower scar. The lower part of the failure scar followed an existing incised stream channel where there appeared to be scouring of material, and a net removal of material. Based on inspection this is assumed not to extend as far as the Dawn of Hope bridge. Below this scar there was a net accumulation of the failed peat material. The lower scar along the incised channel was 700m long by 20m wide. The estimated total area of the lower scar is 2ha.

The total area of the upper and lower scars is about 10ha. A report into this peat failure (RPS, 2020) records the total affected area above the Dawn of Hope bridge as 11.9ha.

**Peat Depth / Slopes / Strength**
Peat depth data recorded during the site walkover was used to provide an indication of the peat depth around the area of the failure.

Slope angles recorded on site ranged from 2 to 6 degrees, with a slight steepening of the slope downslope of the head of the failure.

Shear strength data from these visits was also reviewed. Peat strengths were recorded using a hand-held shear vane. This indicated that the peat in the area around the edge of the failure had a shear strength of typically 6-30kPa with an average of 18kPa. Some 20% of the readings recorded a shear strength of 10kPa or lower, with a slight increase in peat strength with depth. There was no indication of the presence of a zone of very weak peat towards the base of the peat layer. Unfortunately, the peat strength in the central part of the failure is not known. Peat depths range from 1.7m to 5.0m (Figure 4.7) with an average of 3.0m. These depths signify blanket bog.

Based on peat probe results from around the perimeter of the upper scar, the average depth of peat is 3.0m. Based on a failure area of 8ha, then the failure volume is 240,000m$^3$, of which a notable proportion has remained within the upper scar.

The lower scar followed an existing incised stream channel where there would have been only minimal failure of material due to mainly scouring caused by the movement of the upper failed material. Assuming 0.5m of material failed (was scoured) within the lower scar then with an area of 2ha, the failure volume is 10,000m$^3$.

Based on the above, the estimated failure volume is about 250,000m$^3$, of which a notable proportion has remained within the upper scar. The RPS report has estimated that approximately 160,000m$^3$ of material was deposited in the townlands of Corcormick, Corcuhill Lower and Derindangan.

Below the lower scar, the peat debris followed the incised stream channel passing through the Dawn of Hope bridge. The incised stream channel is a tributary stream of the Diffagher River, which flows into Lough Allen about 8.5km downstream of the failure.

Given the shape of the upper scar, the likely mode of failure was a bog flow slide followed by lateral and downslope movement of intact peat rafts (acrotelm) into the upper scar. Downslope the failed peat debris degraded and became channelised as a flow within the incised stream before eventually becoming fully suspended within the water in the stream. In this manner, peat debris can be carried many kilometres downstream.

The peat failure is considered to be a bog flow due to the upper scar forming a "bottleneck" morphology as material locally and retrogressively failed by localised sliding of the blanket bog from the side and the upslope margins of the scar into the centre of the scar to leave saucer shape terrain. The initiation point of the failure was likely at the lower end of the upper scar given the morphology of the failed material. The concentric pattern of intact acrotelm rafts is indicative of a retrogressive flow slide failure and of an initiation point downslope (Figure 4.6).

Within the upper scar the weaker and more mobile catotelm layer (more humified peat) flowed out from below the more resistance acrotelm layer (less humified peat). The acrotelm layer in places was carried downslope by the underlying flowing catotelm layer.

The above suggests that saturation by rainfall and focused surface water runoff from the forestry drainage were likely trigger factors in the failure.

**Figure 4.6: Aerial image of failure, Shass Mountain**

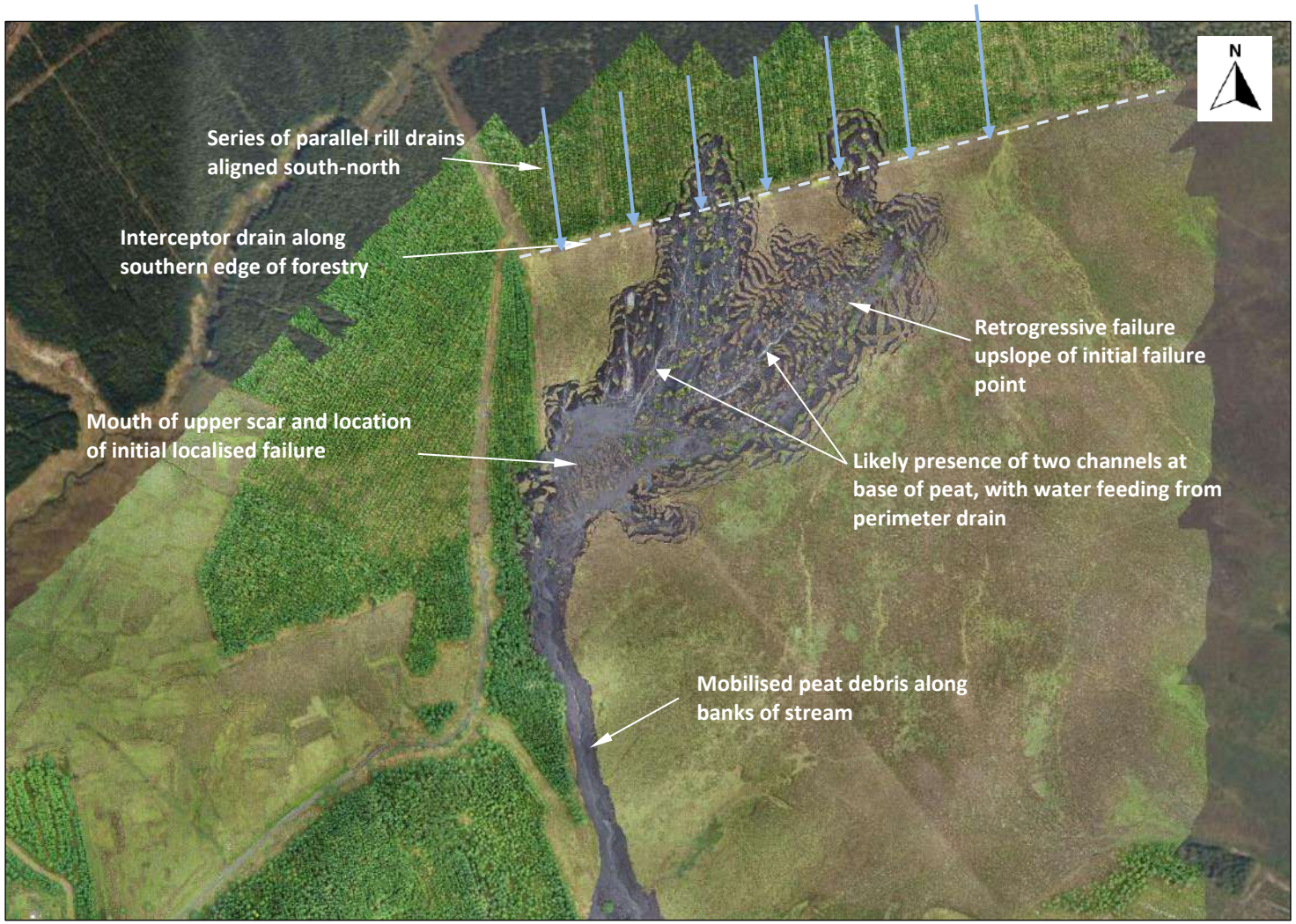
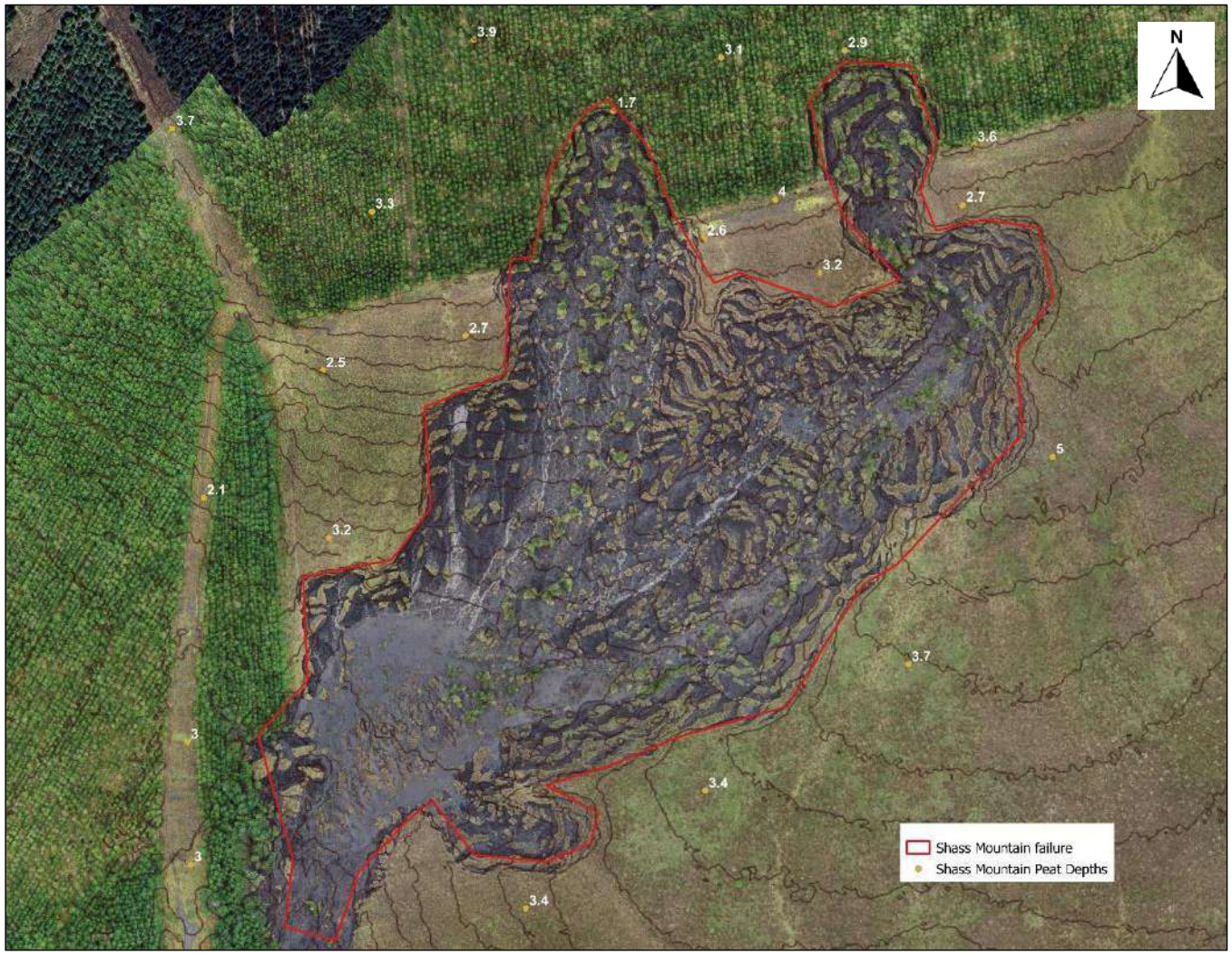


**Figure 4.7: Shass Mountain Peat Depths**



4.2.2 Hydrological/Hydrogeological

A site visit was undertaken to identify both the natural and artificial drainage present around the area of the Shass 2020 peat failure.

The extent of existing (pre-failure) forestry drainage and local natural watercourses are shown on Figure 3.18 and 3.19. The tract of planted forestry upslope of the failure is large in spatial area (109,110m$^2$). The forestry drainage comprises north-south aligned rill drainage at approx. 5m centres that transfers runoff downslope to an east-west heavily overgrown narrow (0.2-0.3m wide) interceptor drain. Prior to the failure the interceptor drain over-spilled to the downstream open blanket bog through gaps in a vegetated soil berm that occurs to the south of the forestry and the interceptor drain. There was a post and wire fence to the south of the spoil berm prior to the failure, but some of this fence has been pulled downhill with the failure.

During the field visit void space or cracking was identified at the base of the interceptor drain, and also along the alignment of rill drains within the forestry where the two lobes of the peat failure extend up into the forestry block.

It is not clear whether this cracking was present below the interceptor drain prior to the failure, or whether the failure caused the cracking considering the considerable movement of peat downhill of the interceptor drain. If the cracking in the interceptor drain existed prior to the failure, there were potential vertical pathways for water flow to the peat subsoil interface.

Prior to the failure, available aerial photography clearly illustrates runoff areas for drainage water from the forestry that correspond with overspill pathways emerging from low points and gaps in the spoil berm.

While this can't be confirmed as those areas are now removed by the peat failure, downhill of the forestry there were also large areas that appeared to be flushed, as described in the desk study (Section 3.3.6) and may have been receiving mineralised groundwater from below the peat.

The shape of the failure scar, specifically the two separate failure arms extending towards the forestry, indicate that a topographic drainage channel along the mineral substrate surface may have been present in these locations. The large rainwater inputs from the forestry drains can be expected to have exerted very high and possibly artesian water pressures around this channel (as observed elsewhere: Dykes and Warburton 2008), promoting the very localised flow and its own lateral retrogressive margins.

The site visit has identified three zones of drainage (Figure 4.10) at the site that have direct relevance to the peat failure event:

- **Zone A:** Forestry drainage via linear rill drains to an interceptor drain from the forestry block north of the failure. Water from the interceptor drain overspilled at discreet outfall locations onto the open bogland to the south.
- **Zone B:** This is the transition zone between Zones A and C. Flow from Zone A was transferred as overland flow and collected into an emerging stream head to the southwest. There was flushed vegetation evident in this area prior to the failure. This area has been significantly modified by the failure.
- **Zone C:** Runoff from Zone B collected into the unnamed tributary of the Diffagher River that flows to the southwest of the failure, and this stream carries water downstream to Lough Allen. Runoff emerging from the failure scar still flows into the stream.

### 4.2.3 Ecological

Surveys of the Shass failure site were completed on 16 and 17 August 2022. The survey sought to characterise the habitats and vegetation characteristics of the area around the peat failure, and to check for any features, plant species or assemblages which could potentially indicate conditions conducive to the peat failure.

Vegetation was recorded using 2 x 2m squares (Relevé). All species within each Relevé were identified and a percentage cover value for each species was assigned. Relevés were targeted to capture the transition from forestry to open bog (including the excavated firebreak), and on flushes and a historical peat failure south-east of the peat failure. Two survey plots (S24 and S25) were also positioned to sample inside and outside the fence on open bog to the south of the peat failure. A total of 25 plots were surveyed (Figure 4.8).

Full botanical survey results are included in Appendix B which provides species lists and percentage cover for each survey location.

Four main habitat types (Fossitt, 2000 classification used) are present in the area: upland blanket bog (PB2) surrounding the peat failure; conifer plantation (WD4) on blanket bog to the west and north of the open bog; poor fen and flush (PF2) in the western and eastern parts of the habitat survey study area, and wet heath (HH3) occurring on the firebreak peat spoil bank and within the historical failure at the south-eastern corner of the habitat survey study area. The upland blanket bog, flush and wet heath habitats were surveyed in detail.

*Upland blanket bog PB2 (Fossitt, 2000)*

This is the dominant habitat in the area, covering the open hillside and occurring as remnant strips running through the surrounding conifer plantations. This habitat type encompasses both intact blanket bogs, and an excavated firebreak running around the plantation margins which has been recolonised by vegetation.

The most immediately visible dominant species on the intact open bog were Ling *Calluna vulgaris* and Wavy hairgrass *Deschampsia flexuosa,* which frequently had the highest cover within plots. A high proportion (ranging from 50% to 95%) of Ling stems were dead in the majority of plots; only two plots, S19 and S23 contained more living than dead Ling stems. Ling was noted to be more dominant and grass cover reduced in the eastern part of the site, with particularly high Ling cover between S19 and S20.

The prevalence of Wavy hairgrass, which is more typically associated with heath (rather than *Molinia* which is associated with both heath/bog, and usually wetter conditions) indicates that peat drying and vegetation change are likely to have been chronic processes at the site, since such fundamental changes in vegetation composition do not occur rapidly in the absence of complete vegetation clearance.

Cross-leaved heath *Erica tetralix* was frequently recorded but had lower cover than Ling. Rowan *Sorbus aucuparia* was recorded at one plot.

Hare's tail cottongrass *Eriophorum vaginatum* and Common bog cotton *Eriophorum angustifolium* were frequently recorded; both species typically had low cover within plots. Graminoids present included Sweet vernal-grass *Anthoxanthum odoratum,* Deergrass *Trichophorum caespitosum,* Heath rush Juncus squarrosus, Field woodrush *Luzula campestris,* Star sedge *Carex echinata*, and Carnation sedge *Carex panicea.* Bilberry *Vaccinium myrtillus* was recorded frequently and had relatively high cover. Tormentil *Potentilla erecta* and Cranberry *Vaccinium oxycoccos* were also present. Heath bedstraw *Galium saxatile* was recorded in one location only.

*Sphagnum* mosses were present in most plots, with red bogmoss *Sphagnum capillifolium* being the most frequently recorded species. Cover of this species was generally around 5-25% but covered 100% of one plot (S10) and 70% of another (S24). Plot S10 is located in the firebreak and as such is representative of disturbed conditions. Lustrous bog-moss *Sphagnum subnitens*, feathery bog-moss *Sphagnum cuspidatum*, papillose bog-moss *Sphagnum papillosum* and magellanic bog-moss *Sphagnum magellanicum* were also recorded. Total Sphagnum cover ranged from 0 – 70%.

Other frequently recorded mosses included little shaggy moss *Rhytidiadelphus loreus,* mountain fern moss *Hylocomium splendens* and heath plait moss *Hypnum jutlandicum*. Common haircap moss *Polytrichum commune* and bog bead-moss *Aulacomnoium palustre* were recorded at single locations only.

Within the upland blanket bog PB2 habitat, a subtype resulting from disturbance is also present. This occurs along the revegetating firebreak. The ground is lower lying with a flat surface, and is typically wetter than the adjacent bog. Ling and Wavy hairgrass were present in some plots but had lower cover than on the intact open bog. Feathery bog-moss occurred more frequently and had higher cover in this sub-type. Hare's tail cottongrass was another species which had notably higher cover in some plots within this sub-type.

High cover of bog asphodel *Narthecium ossifragum* within the firebreak is a notable contrast with most plots located on intact bog and indicates wetter conditions in the firebreak. This species covered 20% of plot S10 but had lower cover in most plots in the firebreak. It is noted that Bog asphodel dominated large areas of the firebreak, and this is not fully reflected in the sampling results.

In contrast, this species was absent from most open areas of bog sampled, apart from two plots to the east of the failure (S16 and S19). These had high cover (75% and 35% respectively), with S16 being representative of transitional conditions between a grassy flush and adjacent drier ling-dominated bog.

Plots S1, S8, S9, S14, S18, S19, S23, S24 and S25 were located on intact blanket bog. Plots S2, S4, S10 and S14 were located on the revegetated firebreak. Plots S7 and S16 were located in transitional zones and had affinities with both blanket bog and flush. Plot S19 could also be considered to include flushed areas due to high cover of Bog asphodel.



**Plate 4-2: Shass Mountain Upland Blanket bog. Failure visible in top of frame.**

*Poor Fen and Flush PF2 (Fossitt, 2000)*

A total of three flushed areas were surveyed. Two broad types were observed; rush dominated, and grass/sphagnum dominated.

A small rush-dominated flush is present near the north-west corner of the bog. There is erosion here where water runs down off the bog to enter the firebreak. The dominant species is Soft *rush Juncus effusus.* The next most common species are common haircap moss, feathery bog-moss and blunt-leaved bogmoss *Sphagnum palustre,* the latter of which was recorded only at this location. Heath bedstraw *Galium saxatile*, Fescue *Festuca* sp. and Velvet bent-grass *Agrostis canina* are also present. The flush grades into blanket bog, with species including Tormentil, Velvet bent-grass, Mountain fern moss, Bilberry and Field woodrush growing in adjacent areas.

An area of rush-dominated flush is also present in a historical peat failure to the south-east of the 2020 peat failure. This is dominated by Sharp-flowered rush *Juncus acutiflorus*, with Tormentil and Heath bedstraw being common. Purple moorgrass and Common sorrel *Rumex acetosa* are present in small amounts.

A large flushed area on a gentle slope to the east of the peat failure was surveyed. Distinct zones within this flush were observed. The upper part where the water is concentrated into a narrow area is dominated by feathery bogmoss (75% cover) and wavy hairgrass (50% cover), with noticeably wet ground underfoot. Deergrass, red bog-moss, Bilberry and Tormentil are present here in small amounts. Further downslope, the vegetation is dominated by grasses, with Wavy hairgrass and Purple moorgrass making up the bulk of cover. Bilberry is relatively abundant, and Ling is also present. Sphagnum cover is lower (40%, comprised of lustrous bog-moss and papillose bog-moss) but still relatively high compared with surrounding areas.

A lateral transition zone running uphill from the edge of the flush grades into drier Ling-dominated bog. Closer to the flush, Bog asphodel dominates, followed by Deergrass, feathery bogmoss and Ling. Further upslope, Ling increases and Bog asphodel reduces, although cover of the latter remains high compared to other surveyed areas of intact bog. Deergrass is also present in the upper part of the transition zone.

No evidence of calcareous influence on plant communities was recorded in any of the flushed areas.

Survey locations S6, S22 (rush-dominated), S15 (grassy flush) and S17 (*Sphagnum*-dominated) are within this habitat. Plots S7 and S16 were located in transitional zones and had affinities with both blanket bog and flush. Plot S19 could also be considered to include flushed areas due to high cover of bog asphodel.



**Plate 4-3: Shass Mountain Poor Fen and Flush PF2**

*Wet Heath HH3 Fossitt, 2000)*

This habitat occurs on the bank of excavated peat cast aside during excavation of the firebreak, and within the historical failure. Both are atypical representations of this habitat which have established on disturbed peat.

The cast-aside peat bank is dominated by Ling, Bilberry, Wavy hairgrass, Heath plait moss, little shaggy moss and mountain fern moss, in varying combinations, and is visibly desiccated.

The wet heath occurring at the historical failure is dominated by Purple moorgrass and Wavy hairgrass, with Ling being common. Mountain fern moss, feathery bogmoss and Tormentil are also present.

Survey locations S3, S5, S11, S12, S20 and S21 are within this habitat.



**Plate 4-4: Shass Mountain Wet heath on peat spoil bank**

*IVC Classification/ ERICA Analysis*

Relevé data was analysed using ERICA, the online statistical software tool used to assign habitat types to IVC (Irish Vegetation Classification) communities (Perrin et al. 2018). This allows a more nuanced exploration of vegetation communities, albeit with the qualification that peat depth, a key factor in differentiating wet heath from blanket bog is not considered in the analysis. Based on vegetation composition only, the analysis indicates the presence of heath, blanket bog, and wet grassland.

Peat depths recorded in areas of open blanket bog ranged from 2.5m to 5m, which is indicative of blanket bog rather than the shallower peat depths typically associated with wet heath (15-50cm). As such, the peat depths recorded in this area place the habitat classification for vegetated intact/semi-intact peat substrates firmly in the blanket bog category. The excavated peat spoil bank is formed from desiccated peat and as such is a severely disturbed habitat, which best fits within the wet heath category, based on vegetation composition.

Due to the prevalence of dead Ling stems, an alternative dataset with reduced Ling cover based on survey notes for each plot was analysed using ERICA (Ling cover was reduced for most plots). The classification of just two plots (S10 and S19) was affected by the alternative dataset (S10 classification changed from BG2B to BG1A; S19 classification changed from HE2B to BG2B). The vegetation communities assigned to all other plots remained the same.

Descriptions of IVC vegetation communities assigned to plots are included in Appendix B. Where discussion of IVC communities is at a high level, generic codes are used (i.e. BGxx = bog, and GLxx = grassland). Full IVC codes are used when discussing results at plot level. Full IVC community codes and associated names are listed below. The relevant IVC codes for each plot area detailed in in Table 4-2. The Fossitt habitat type and notes on habitat subtype are also included for each plot to facilitate exploration of the interrelationships between IVC and Fossitt types, and to present relevant information on habitat subtypes or disturbance.

The names of vegetation communities assigned to the Shass mountain survey plots listed below in Table 4-2 are as follows:

- HE3A: *Calluna vulgaris – Hylocomium splendens* heath
- HE4E: *Molinia caerulea – Calluna vulgaris – Erica tetralix* heath
- HE2B: *Calluna vulgaris – Hypnum jutlandicum* heath
- HE3F: *Calluna vulgaris – Eriophorum vaginatum* bog
- BG2E: *Calluna vulgaris – Eriophorum* spp. bog
- BG2B: *Erica tetralix – Andromeda polifolia* bog
- BG2F: *Trichophorum cespitosum/germanicum – Eriophorum angustifolium* peatland
- BG1A: *Sphagnum cuspidatum – Sphagnum subsecundum* agg. hollow
- GL2D: *Juncus effusus – Rumex acetosa* grassland
- GL4B: *Nardus stricta – Potentilla erecta* grassland
- GL1A: *Juncus acutiflorus – Holcus lanatus* grassland

**Table 4-2: IVC communities assigned by ERICA analysis (Shass)**

| Plot | IVC Code | Fossitt Classification | Subtype/Notes |
|---|---|---|---|
| S1 | HE3A | PB2 | Intact Blanket Bog |
| S2 | BG2E | PB2 | Revegetating Firebreak |
| S3 | HE3A | HH3 | Peat Spoil Bank |
| S4 | BG2B | PB2 | Revegetating Firebreak |
| S5 | HE3A | HH3 | Peat Spoil Bank |
| S6 | GL2D | PF2 | Rushy Flush |
| S7 | GL4B | PB2/PB2 | Transitional |
| S8 | HE3A | PB2 | Intact Blanket Bog |
| S9 | HE3A | PB2 | Intact Blanket Bog |
| S10 | **BG2B/BG1A** | PB2 | Revegetating Firebreak |
| S11 | HE3A | HH3 | Peat Spoil Bank |
| S12 | HE3A | HH3 | Peat Spoil Bank |
| S13 | BG2E | PB2 | Revegetating Firebreak |
| S14 | HE3A | PB2 | Intact Blanket Bog |
| S15 | HE4E | PF2 | Grassy Flush |
| S16 | BG2F | PF2/PB2 | Transitional |
| S17 | BG1A | PF2 | Grassy/Sphagnum Flush |
| S18 | BG2E | PB2 | Intact Blanket Bog |
| S19 | **HE2B/BG2B** | PB2 | Intact Blanket Bog |
| S20 | HE4E | HH3 | Grassy Heath in Historical Failure |
| S21 | HE3A | HH3 | Grassy Heath in Historical Failure |
| S22 | GL1A | PF2 | Rushy Flush |
| S23 | HE3A | PB2 | Intact Blanket Bog |
| S24 | HE3F | PB2 | Intact Blanket Bog |
| S25 | HE3A | PB2 | Intact Blanket Bog |

A notable result of the analysis was that the majority of plots on intact upland blanket bog (PB2) were classified as HE3A heath (S1, S8, S9, S14, S23 and S25). The prevalence of heathy species such as Bilberry, Wavy hairgrass and the mosses *Rhytidiadelphus loreus* and *Hylocomium splendens* in combination with relatively low *Sphagnum* cover (0-27%) in these plots influenced their assignment to this community.

Plots S18 and S24 were the only plots on intact bog assigned to bog communities (BG2E and HE3F respectively) by both datasets, while S19 was assigned to heath (HE2B) or bog (BG2B) based respectively on 75% or 50% Ling cover. Plots S18 and S24 had 35% and 70% *Sphagnum* cover respectively. Plot S19 only had 2% *Sphagnum* cover, but higher cover (35%) of Bog asphodel (a species associated with wet conditions) and very low cover of heathy species.

The revegetating firebreak was consistently assigned to bog communities (BG2B and BG2E) or a wet community which occurs within bog (BG1A) (plot S10 was assigned to BG2B or BG1A based respectively on 15% or 7% Ling cover). Sphagnum cover at plots in the firebreak was generally higher (19 – 90%) than plots on intact bog which were assigned to HE3A.

The assignment of the firebreak to BGxx and assignment of most intact blanket bog plots to HE3A is indicative of wetter conditions along the firebreak and drying out of the intact blanket bog. The contrast between the deep peat present onsite which should support bog vegetation communities and the heath communities assigned by ERICA analysis indicates the underlying peat is unnaturally dry. The description for HE3A notes that underlying soils are 'relatively well-drained'; this condition would not occur naturally in 2.5m – 5m deep peat. Considering the above, it is considered probable that the high cover of dead Ling stems has resulted from peat drying and further acute desiccation during dry periods. The dead stems showed no signs of having been burned.

Other plots assigned to BGxx were S16 and S17, both of which were in flushed areas (classified as PF2/PB2 and PF2 respectively). S16 was assigned to BG2F peatland, which is noted as occurring on wet, acidic and infertile peats (mainly as deep, ombrogenous peats of upland blanket bog, but also occurring on shallower soils as wet heath). S17 was assigned to BG1A, which typically occurs as a *Sphagnum*-dominated community of peat hollows and is also noted as encompassing *Sphagnum*-dominated springheads from upland slopes. The surface water-flushed habitat in this area can be considered similar to a springhead as it occurs in an area where surface flows from upslope are focused through a narrow area. In this case, however, there are no springs present.

The grassy flush (PF2) at S15 was classified by ERICA analysis as HE4E heath. The assignment of S15 to HE4E is influenced by the prevalence *Molinia caerulea* in that area.

The peat spoil bank was consistently assigned to HE3A heath. The well-drained substrate formed by the desiccated peat spoil, and prevalence of species such as Bilberry and the heathy mosses *Rhytidiadelphus loreus*, *Hylocomium splendens* and *Hypnum jutandicum*.

The three plots assigned to GLxx were associated with rushy flushes and adjacent transitional areas. Plot S6 which was classified as a flush (PF2) under the Fossitt system based on the abundance of Soft rush in combination with *Sphagnum palustre,* which is associated with flushes, was assigned to the IVC community GL2D grassland. This community is noted as species poor and sometimes occurring on peaty soils but has no specific association with flushes. Plot S7 (categorised as transitional between flush PF2 and upland blanket bog PB2) was assigned to GL4B grassland, which is noted as occurring on thin, peaty, very infertile soils restricted largely to unenclosed, sheep-grazed, steep slopes in the high uplands (mean altitude = 238m). It is possible that grazing and desiccation have resulted in conditions conducive to this community establishing in this area.

Plot S22 which was classified as a flush (PF2) based on the abundance of Sharp-flowered rush, was assigned to GL1A grassland, which is noted as being a wet grassland community of marginal farmland that is typically found in the lowlands (mean altitude = 84 m). This species-poor plot is likely to have been assigned to GL1A solely on the basis of Sharp-flowered rush dominance, which is likely to have established following disturbance. GL1A has no specific association with flushes.

It is noted that the IVC does not include a specific category for flushes, but rather describes communities in which they can occur, such as BG1A discussed above.

The rushy flushes noted at S6 and S22 are considered to be generic enough to escape classification as flushes. Their categorisation as flushes (PF2) is based on the vegetation present, their position, and alignment with flush patterns visible in orthophotography. It is also noted that historical disturbance in these areas could have contributed to the dominance of rushes. Both areas may have been eroded historically, and the recolonisation of bare peat arising from the peat failure by rushes (primarily bulbous rush *Juncus bulbosus*) is conspicuous.

**Figure 4.8: Shass Mountain Botanical Survey Points**

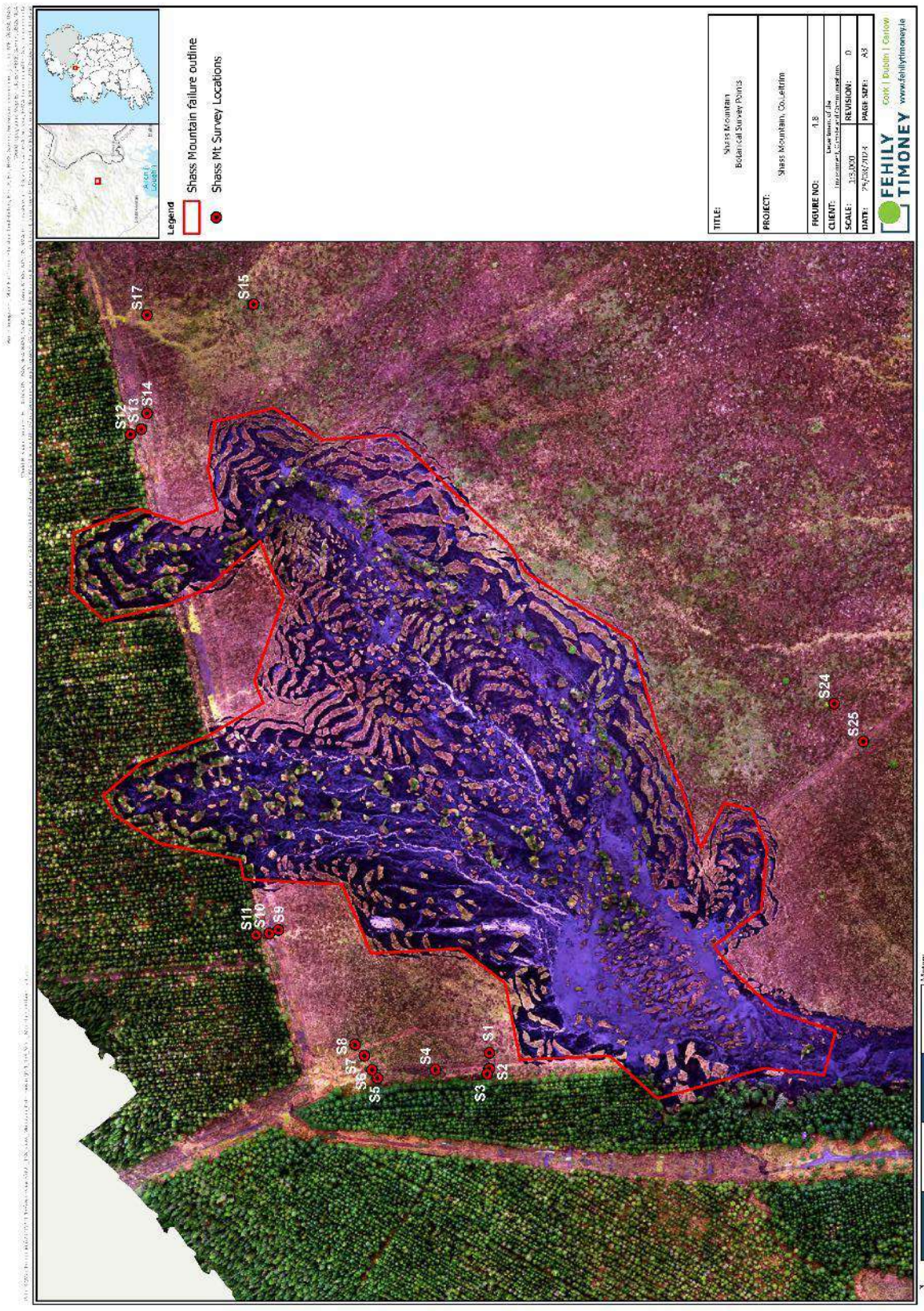
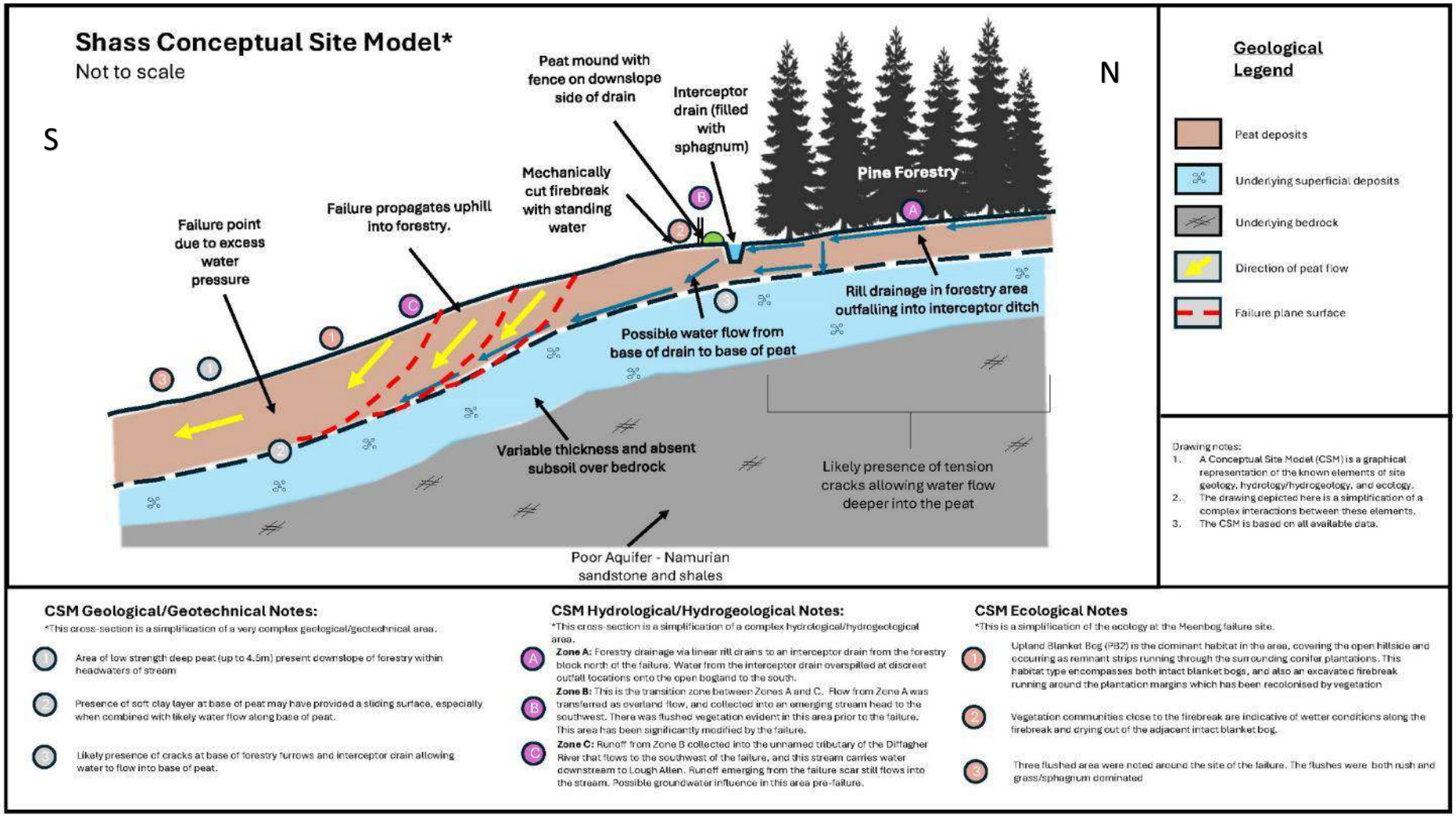


**Figure 4.9: Shass Mountain Habitats**



**Figure 4.10: Shass Conceptual Site Model**



## 4.3 Mount Eagle

### 4.3.1 Geotechnical

The peat failure occurred on a slope covered in blanket peat located within and adjacent to a forestry plantation. It is not known exactly when it occurred however, based on public reports, it is assumed that it occurred on 15 November 2020 (three days after the Meenbog event).

The failure scar is estimated to be 650m long by about 30 to 50m in width. The lower part of the failure scar within the tree plantation is narrower, which suggests that this represents material running out from the scar and is likely not part of the failure scar. This lower part of the scar, which is 200m long by 20m wide, has not been included as part of the failure scar. Based on the above the estimated plan area of the failure scar covers 2.6ha. Assuming average failed peat depth is 2m, then failure volume is 52,000$m^3$, of which a notable proportion has remained within the area of the failure scar. The underlying material is visible within the failure scar, indicating that the failure was a peat slide, where the failure surface is at the interface between the peat and the underlying material.

Based on aerial imagery from 2018 it is clear that the Mount Eagle site has been affected by a previous failure (Figure 4.12). The year of the previous failure is not known however it is visible on the 2018 aerial imagery but not present on the 2012 imagery. The presence of this earlier failure is likely to be a causal factor in the 2020 failure, as it would have removed some lateral support from the peat at the edge of the 2020 failure, increasing the likelihood of another failure.

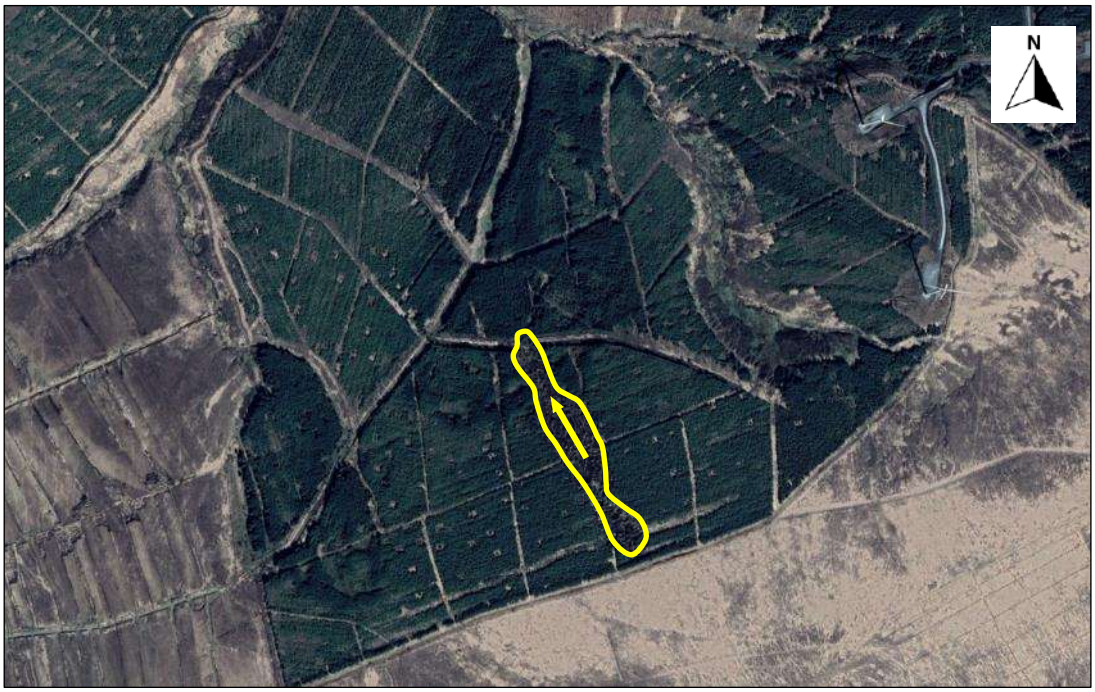
The November 2020 event occurred at a similar topographic location, and almost adjacent to, the previous failure, see Figure 4.13: Mount Eagle peat failure (annotated). One difference is that the head of the 2020 failure extends into the open peatland upslope of the forestry plantation, which did not happen in the earlier failure. Slope angles around the failure ranged from 3 to 8 degrees, with a slight steepening of the ground slope around 250m to the south of the head of the failure. This represents a convex break in slope which is not particularly evident on topographic mapping of the failure site.

Given the shape of the 2020 peat failure scar, the likely mode of failure was a progressive peat slide which downslope degraded into a debris slide before being channelised as a flow, which in many cases results in a long run-out. It is understood that peat debris from the failure entered a nearby tributary stream of the River Clydagh, which originates from this area. Some retrogression of the failure upslope also occurred, extending the peat failure scar into the open blanket bog upslope of the forestry.

The peat depth around the failure ranged from 1.30m to 3.0m, with an average of 2.3m, indicating blanket bog (Figure 4.14).

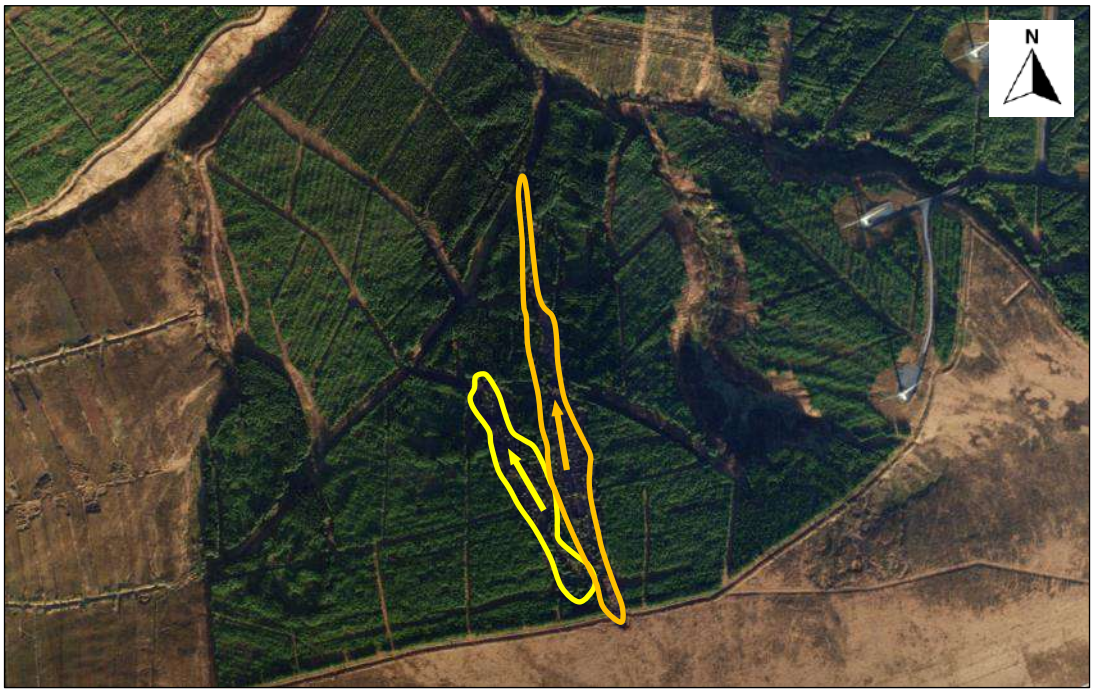
Hand-held shear vane strength testing was carried out at selected locations around the head of the failure within the forestry and in the open blanket bog during the site visit. The shear vane results indicated undrained shear strengths in the range of 12 to 44kPa, with an average value of 22kPa. These values would be considered typical of a reasonably well drained upland blanket bog. The peat strength in the central part of the failure is not known.

**Figure 4.11: Mount Eagle historical peat failure, image March 2019**




Source: Google Earth Pro CNES/Airbus image from 29 March 2019. Copyright CNES/Airbus image

**Figure 4.12: Mount Eagle peat failure, image 25 November 2020**




Source: Planet Labs SkySat image from 25 November 2020. Copyright Planet Labs

**Figure 4.13: Mount Eagle peat failure (annotated)**

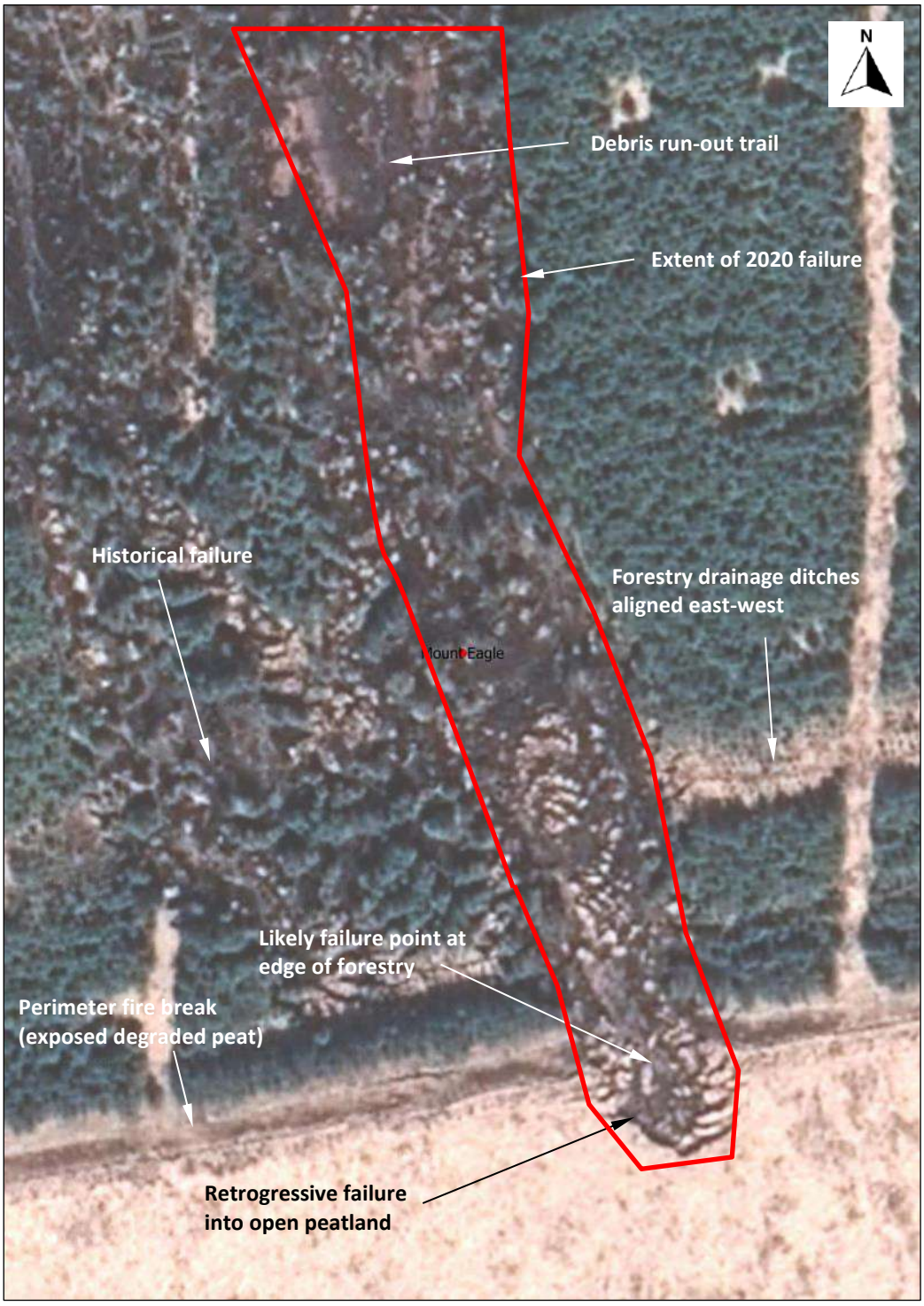
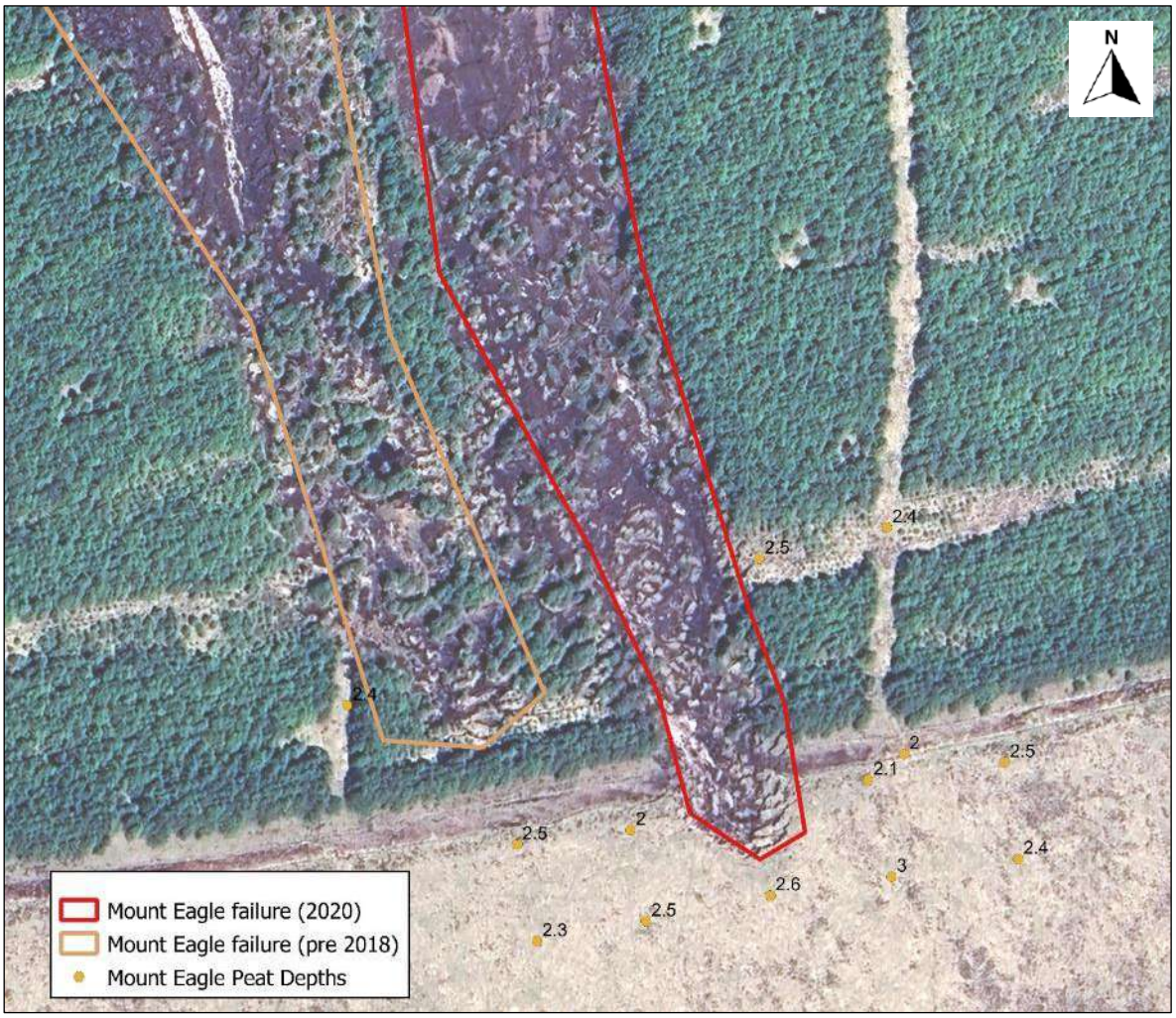


**Figure 4.14: Mount Eagle Peat Depths**



### 4.3.2 Hydrological/Hydrogeological

A site visit was undertaken to identify both the natural and artificial drainage present around the area of the 2020 peat failure.

There is an east-west aligned ridge running to the south of the failure scar. The peak of the ridge is approximately 280m south of the top of the failure scar. The natural drainage from the northern flank of this ridge consists of diffuse overland sheet flow, which typically drains to either natural watercourses with narrow incised channels, or the runoff is intercepted by the firebreak present along the southern side of the forestry plantation.

The extent of existing (pre-failure) forestry drainage and local natural watercourses are shown on Figure 3.27 and 3.28. The tract of planted commercial forestry downslope of the failure site is large in areas with internal interceptor drains operating typically along firebreaks, running east-west, and ultimately draining to the north. There is a rill drainage network within the forestry, and these generally run east-west, which is parallel to the ground slope. Rill drains are typically spaced 10m to 15m apart and are approx. 0.2m-0.3m deep. Several of the interceptor drains along the edge of the firebreak were observed to be deep (approx. 1.5m) and incised.

Runoff water from the open blanket bog flows towards the firebreak. Along the firebreak flow follows topography and depending on gradient, flows east or west along the firebreak. At various locations, flow then overspills or discharges to the next available interceptor drain and flows downhill to the north. Flow along the firebreak is concentrated in peat erosion channels, and the erosion channels indicate that high flows have occurred in the past. There were local areas of ponding observed in the blanket peat along the firebreak. These were <5m$^2$.

During the site walkover, some cracking and void space was noted in the peat within the interceptor drain that runs east-west in the first firebreak in the forestry on the eastern side of the head of the 2020 peat failure. The interceptor drain appears to have opened (widened), slightly closer to the failure site, but movement was noted at least 50m-80m from the failure site. This opening could have occurred as a result of the failure event, but it may also indicate a pre-existing weakness in the peat along that interceptor drain, either in the form of a break and weakness in the acrotelm or by causing desiccation and cracking in the catotelm peat along that alignment. This firebreak and the area around it also appears to either have not been planted, or there may have been stunted forestry growth locally (evident from historic aerial photographs), which also could suggest some pre-existing wetness or hydrological anomaly.

The site visit has identified three zones of drainage (Figure 4.17) at the site that have direct relevance to the peat failure event:

- **Zone A:** Relatively intact blanket bog characterised by diffuse overland sheet flow as the primary flow regime.
- **Zone B:** This is the transition zone between Zones A and C. Flow from Zone A is intercepted by the firebreak, and transfers runoff to the forestry drainage system (Zone C) via overspill outfalls to interceptor drains. The flow along the firebreak is linear and causes peat erosion depending on its velocity, and some local ponding of water occurs along the firebreak. This zone is the critical zone for the peat failure.
- **Zone C:** Drainage in this zone is via forestry rill drains and interceptor drains. The flow paths are modified, are linear, and flow is likely to be rapid. Rill drainage is parallel to slope and interceptor drains or perpendicular to slope. The interceptor drains, within the forestry, transfer runoff downslope to the natural incised watercourse channels described above.

Water on site is currently flowing into the failure site and washing down through the failure scar in a northerly direction. Water is also flowing along the firebreak where topography allows, and over spilling into interceptor drains as described above.

On the wider mountain, there are areas of peat cutting, and also natural undisturbed flushed areas which have some hydrological significance, but those are remote from the failure.

### 4.3.3 Ecological

Ecological surveys were completed on 30 June 2022. The survey sought to characterise the habitats and vegetation characteristics of the area around the peat failure, and to check for any features, plant species or assemblages which could potentially indicate conditions conducive to the peat failure.

The survey targeted the blanket bog uphill of the failure and the conifer plantation/blanket bog ecotone including the excavated firebreak between the conifer plantation and blanket bog. Target notes were recorded at each location. All species visible at the survey locations were identified. Species cover was not quantified; however, the dominant species and relevant characteristics of the floral assemblage were noted at each location. Additional details, such as the presence of bare peat and standing water, degree of grazing and disturbance were also noted. A total of 33 points were surveyed (see Figure 4.15).

Full botanical survey results are included in Appendix B which provides species lists, notes and overall vegetation cover estimates (%) for each survey location. The data collected were analysed to classify and indicate the condition of vegetation at each survey location and combined to provide a site-scale assessment.

Three main habitat types are present in the area around the head of the peat failure: upland blanket bog (PB2); cutover bog/upland blanket bog mosaic (PB5/PB2) and wet heath (HH3). The head of the second peat failure extends southwards into these habitats. Conifer plantation WD4 planted on blanket bog is present to the north, with the majority of the peat failure having occurred in this hydrologically and ecologically much altered, former blanket bog habitat. Remnant strips of upland blanket bog/wet heath in the form of firebreaks run though the conifer plantation. The upland blanket bog, cutover bog/upland blanket bog mosaic and wet heath habitats were surveyed in detail.

*Upland Blanket Bog PB2*

This is the dominant habitat south of the conifer plantation. No drains or cut areas were present in the areas surveyed, and vegetation cover was 100%. The dominant species is Purple moor-grass *Molinia caerulea.* Ling heather *Calluna vulgaris* was present at most survey locations and is more abundant on the eastern side of the failure as is evident in aerial imagery. Bilberry *Vaccinium myrtillus*, Tormentil *Potentilla erecta,* Hare's tail cottongrass *Eriophorum vaginatum*, Cross-leaved heath *Erica tetralix* and Devil's bit scabious *Succisa pratensis* were frequently recorded. Deergrass *Trichophorum caespitosum* and Bog asphodel *Narthecium ossifragum* were recorded infrequently. It is noted the latter was recorded primarily at locations closer to the firebreak and the edge of the failure site (recorded at only one other location in the intact heath/bog; approx. 20m from the failure edge) and is potentially an indicator of flushed conditions[2] where the surrounding habitat is not uniformly saturated.

Heath plait moss *Hypnum jutlandicum* was the most frequently recorded moss, followed by Hoary rock moss *Racomitrium lanuginosum.* Sphagnum mosses were not abundant, with red bogmoss *Sphagnum capillifolium* accounting for most records, with one record of lustrous bog moss *Sphagnum subnitens.* The moss assemblage indicates a relatively dry type of blanket bog, and the low *Sphagnum* cover is likely to increase the rate of surface runoff.

It is likely that historical interventions such as grazing, and forestry drainage have altered the vegetation composition.

[2] Streeter et al. note this is a plant of wet heaths, bogs, flushes.

Survey locations 9 -26, and 33 are within this habitat.



**Plate 4-5: Mount Eagle Upland Blanket Bog**

*Cutover Bog PB5/ Upland Blanket Bog PB2 (Mosaic)*

The category of cutover bog has been utilised to aid in describing the excavated firebreak running between the open hillside and conifer plantation, in the absence of any more suitable habitat type to describe the strip of artificially exposed peat here. This strip contains bare areas interspersed with islands of vegetation signalling recolonisation has begun, and areas with higher vegetation cover more representative of blanket bog. Flows of surface water were present in parts of the firebreak.

Purple moor-grass, Hare's tail cotton-grass and Common bog cotton were recorded frequently. Deergrass was recorded at one location only. Ling was recorded frequently; Cross-leaved heath was recorded at two locations only.

Bog asphodel was the most frequently recorded forb; Heath milkwort and tormentil were also common. Bilberry was recorded at one location only. Round-leaved sundew *Drosera rotundifolia* was recorded at two locations. Single occurrences of Bramble *Rubus fruticosus agg.,* and Eared willow *Salix aurita* were recorded. The Bramble was observed establishing on a drier vertical bank face created by the excavated firebreak.

Compact bog moss *Sphagnum compactum* and red bog moss were the most frequently recorded Sphagnum mosses. Single occurrences of feathery bog moss *Sphagnum cuspidatum* and papillose bogmoss *Sphagnum papillosum* were recorded. Sphagnum cover was low, tending to occur as isolated hummocks along the edges of the firebreak or as small prostrate patches in flat open areas.

Other mosses present included Hoary rock moss, Heath plait moss, Common haircap moss *Polytrichum commune* and Broom fork-moss *Dicranum scoparium,* none of which were common. The non-native invasive species heath star moss *Campylopus introflexus* was frequently recorded colonising areas of bare peat.

Purple spoonwort *Pleurozia purpurea* was recorded at two locations. One occurrence of frillwort *Fossombriona* sp. was recorded. Two lichen species, devil's matchsticks *Cladonia floerkeana* and reindeer lichen *Cladonia portentosa* were observed, with single occurrences of each recorded.

Survey locations 1, 6, 7, 8, 29, 31 and 32 are within this habitat mosaic.



**Plate 4-6: Mount Eagle Cutover Bog / Upland Blanket Bog Mosaic**

*Wet Heath HH3*

This habitat occurs on the bank of excavated peat cast aside during excavation of the firebreak.

The dominant species is Purple moor-grass. Hare's tail cotton-grass was also recorded. Ling was frequently recorded; Cross-leaved heath was recorded at one location only.

Bilberry, Tormentil and Hay-scented buckler-fern *Dryopteris aemula* were frequently recorded; Devil's bit scabious was recorded at one location only. Rowan *Sorbus aucuparia* was frequently recorded.

Broom fork-moss and Heath plait moss were frequently recorded; little shaggy moss *Rhytidiadelphus loreus* and hoary rock moss were recorded at single locations only. The non-native invasive species heath star moss was frequently recorded.

The liverwort water earwort *Scapania undulata* was recorded at two locations. A number of lichens including reindeer lichen, devil's Matchsticks and *Cladonia chlorophaea* agg. were present.

The presence of Bilberry, Hay-scented buckler-fern and Rowan, and absence of *Sphagnum* mosses are indicative of the desiccated and disturbed nature of the peat this assemblage has colonised.

Survey locations 2, 3, 4, 5 and 30 are within this habitat.



**Plate 4-7: Mount Eagle Wet Heath**

*Analysis*

The low *Sphagnum* cover in the blanket bog uphill of the failures could result in a higher rate of runoff towards the firebreak and conifer plantation drains, as *Sphagnum* acts like a sponge retaining water.

The reduced rate of revegetation along the firebreak above the failures observed during field surveys and examination of orthophotography could indicate that heavy flows of water regularly travel along these sections of the firebreak and inhibit revegetation.

Due to the relatively steep slope, the firebreak is an excavation on the upslope side, with the attendant effect of drainage and peat drying on the blanket bog upslope. Drains within the conifer plantation are also likely to contribute to drying of the blanket bog upslope of the failure. These drainage features are likely to be the primary drivers of peat drying in the area. It is possible that grazing has also altered the vegetation composition of the blanket bog, with resultant reduction in water retention capacity; however, there was no direct evidence of grazing at the time of surveys.

**Figure 4.15: Mount Eagle Botanical Survey Points**

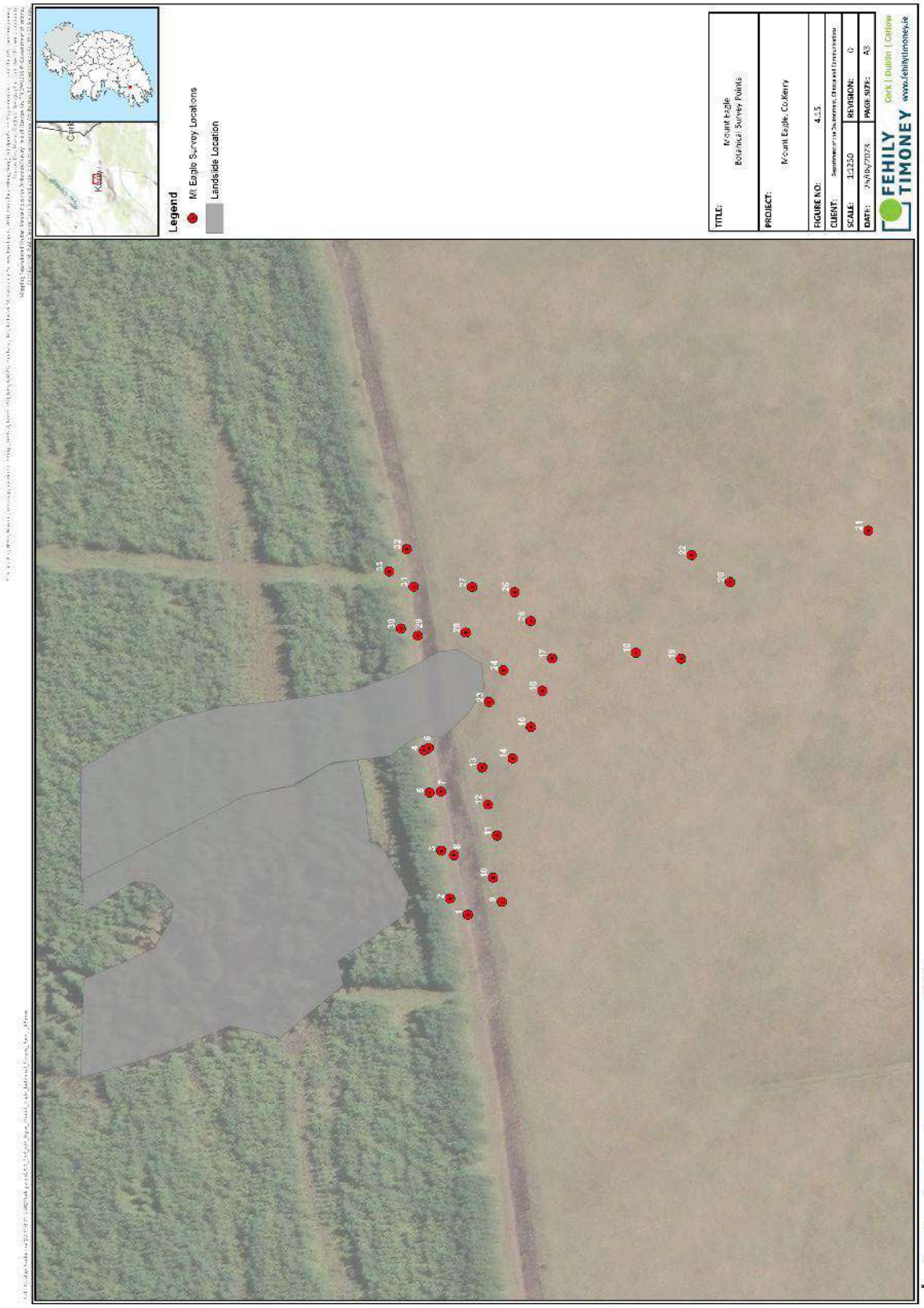
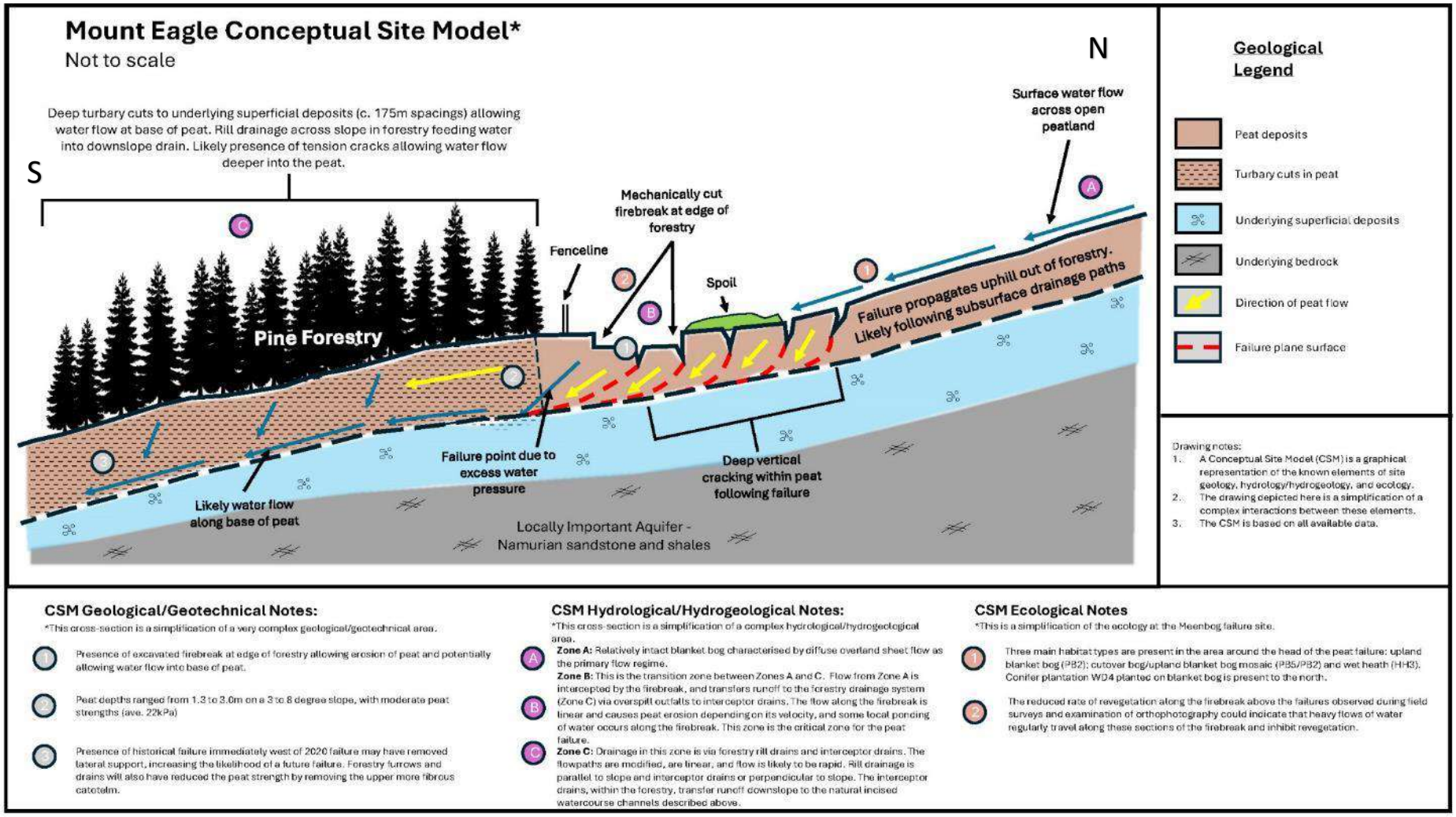


**Figure 4.16: Mount Eagle Habitats**



**Figure 4.17: Mount Eagle Conceptual Site Model**



# 5. Conditioning and Triggering Factors for Failures

The following section covers the key conditioning and triggering factors in each of the three peat failures visited as part of the Project.

## 5.1 Meenbog

The following are considered to be the key conditioning and triggering factors of the bog flow/peat failure of 12 November 2020.

One or a few of these factors in combination are highly unlikely to cause the scale of the peat failure that occurred. It is likely that the combination of all of the identified factors created the conditions for the peat failure.

FT visited the failure site and carried out testing and observations, the following is based on the site visits and aerial imagery.

A review of rainfall records at the nearest weather stations is described in Section 3.2.7.

- **Construction of floating road (Triggering factor).** The unauthorised construction works for the floating road triggered a localised initial peat failure within the underlying *in situ* peat. It would not be uncommon for discrete sections of floating road to undergo excessive movement due to localised weakening within the underlying peat, however at this location a number of other contributory factors caused an escalation of the initial localised failure.

- **Low Peat Shear Strength (Conditioning factor).** It is considered that a zone of unforeseen weaker peat was present below the floating road that resulted in localised bearing failure within the underlying peat. Where there were drains passing below the floating road, which occurred at about the location of the failure, the drains would have severed the acrotelm layer (upper fibrous layer) of the peat where most of the intrinsic strength of the peat lies.

- **Interceptor Drain (Conditioning Factor).** A forestry interceptor drain is noted to flow towards the failure area, but the main drainage outfall from the open blanket bog area occurs approx. 80m south of the failure inception point.

- **Area of deep, wet, blanket bog comprising weak peat immediately upslope (Conditioning factor).** Upslope of the location where the floating road was being constructed was a flat plateau that was a blanket bog area formed of a large body of notably saturated and very weak peat. For lateral stability, this body of saturated and very weak peat relied on the peat slope upon which the floating road was being constructed. Hand vane results indicated undrained shear strengths in the range 2 to 9kPa, with an average value of slightly less than about 5kPa. These low recorded peat strengths represent a body of very weak peat.

- **Rainfall pattern (Conditioning and triggering factor).** A combination of preceding heavy rainfall and the pattern of weather recorded over the preceding months likely contributed to the failure. However, the failure was not triggered by an intense rainfall event. There was, however, a 28mm

rainfall event recorded at Lough Mourne ASC on 11 November 2020, so the site was likely to be wet, but likely no wetter than normal. Several similar daily totals were recorded at Lough Mourne ASC in the weeks and months preceding the failure. There was no clear significant peak rainfall duration period immediately prior to the peat failure. There was a significant dry spell (April and May 2020) followed by relatively high daily rainfall amounts (from June 2020 onwards).

- **Cracks in the peat under the forestry plantations (Conditioning Factor).** The significant and sustained dry spell may have caused drying of the already altered peat within the forestry, leading to cracking of the near surface peat particularly along forestry furrows and drainage lines, or widening/deepening of existing cracking within the forestry. Subsequent run-off from rainfall may then have gained ingress to the peat at depth via these cracks, potentially eroding the base of peat or increasing the porewater pressure at the peat/overburden interface.

- **Drainage and surface water ingress into peat (Conditioning factor).** Pre-failure topography indicates that drainage from the open blanket bog occurred to a low point approx. 80m south of the failure inception point. The west-east forestry interceptor drain present along the southern edge of the forestry block to the north of the open bogland directed drainage towards the failure area. However, not all of this forestry block (approx. 4Ha) drained to the failure point as there is an offshoot drain noted roughly 40m from the eastern end of the forestry that likely directed some of the forestry drainage to the southwest towards the natural low point (as shown in Figure 3.9).

  Drone footage from the area on the morning of the failure indicates some water in the west-east interceptor drain, and some minor ponding upstream and downstream of the floating road. Such ponding is not uncommon when constructing floating roads, but this is noteworthy considering the location of the failure. However, the open blanket bog did not drain via the forestry interceptor, and it is possible that not all the forestry drained via this interceptor either, given the location of the offshoot drain.

- **Topography/ Convex break in slope (Conditioning factor).** The initiation of the failure occurred at a convex break in the peat slope. A convex break in slope is commonly cited as the location for peat failures for a number of reasons. In this particular case, the convex break in slope marks the transition from an upgradient plateau area containing deeper and very weak and saturated peat compared to downslope where the peat is not as deep and has relatively greater strength. At the convex break in slope, it is likely that in many cases there is a zone of relatively higher strength peat, due to a greater degree of drainage, that acts to support the very weak and saturated peak present in the plateau area upslope. If this zone is removed or damaged it can lead to the type of retrogressive failure noted at Meenbog.

- **Forestry related activities (Conditioning factor).** The area downslope of the floating road comprised a forestry plantation that had been felled a few years in advance of the wind farm construction. The extraction route from this forestry block appears to follow an alignment consistent with the route of the floating road, with a slight skew to the northeast close to where the failure inception occurred. Previous forestry extraction routes may have weakened the underlying peat especially at a turning point. This area comprised forestry furrows and drains aligned downslope on peat slopes with a peat depth of about 1.8m and a slope angle of 4-6 degrees. This area is not unique, nor would it represent an increased stability risk. However, the presence of furrows and drains aligned downslope on peat slopes, which have severed the acrotelm layer and the likely blockage of drainage following felling operations allowed the slope to readily fail once localised failure was initiated upslope. The failure through this area exploited the existing forestry furrows which are lines of weakness.

## 5.2 Shass Mountain

The following are considered to be the key conditioning and triggering factors of the peat failure of 28 June 2020. For the peat failure to occur these key factors are required to be present. One or a few of these factors in combination are unlikely to cause the scale of the peat failure that occurred but the combination of all of the factors was sufficient to cause the failure.

It is considered that preceding heavy rainfall and the pattern of weather recorded over the preceding months contributed significantly to the failure. FT visited the failure site and carried out testing and observations, the following is based on the site visit and aerial imagery. A review of rainfall records at the nearest weather stations is described in Section 3.7.

- There is no evidence to suggest there were mechanical works (drainage or forestry related) ongoing at the site at the time of the failure.

- Rainfall intensity and pattern (Triggering factor). The trigger for the failure is related to run-off/water flow from preceding heavy rainfall following a prolonged dry spell (see Section 3.3.8).

Site-specific Conditioning Factors

- **Potentially Low Peat Shear Strength (Conditioning Factor).** Hand-held shear vane strength testing was carried out at selected locations around the head of the failure within the forestry and in the open peat land during the site visit. The hand vane results indicated undrained shear strengths ($c_u$) in the range 6 to 29kPa, with an average value of about 18kPa. The peat depth was on average about 2.5m (max. of 5m). In general, the recorded undrained shear strength of the peat was not significantly low at the test locations. Unfortunately, the peat strength in the central part of the failure is not known. Given the type of failure, it is conjectured that there must have been a significant body of saturated and weak peat ($c_u$<5kPa) within the upper scar area. The above suggests that saturation of an already weak peat area by rainfall and the additional volumes of surface water directed to the failure location by the forestry drains were likely significant contributory factors in the failure.

- **Forestry drains alignment with slope (Conditioning Factor).** The forestry drains are shallow rill drains and run north-south in general alignment with the slope and therefore direct water towards the location of the failure initiation point.

- **Forestry and associated subsurface peat cracks (Conditioning Factor).** The forestry drains will also have caused significant change to the natural in-situ hydrological conditions of the blanket bog.

  Additionally, the tree root systems will have altered the properties of the catotelm and acrotelm peat. In some cases, this may provide additional strength, but where there is weaker peat or groundwater influence (such as upwelling groundwater pressures), or where cracking of the peat occurs (tree growth is known to cause cracking and fissuring of the peat), the addition of extreme rainfall onto such weaker conditions could cause the initiation of a failure.

  Some cracking was observed in existing drainage along the edge of the forestry, but it was not clear whether this occurred during/after the failure, or whether it was present before the failure. While there is no direct evidence that the forestry drainage contributed to the failure, it is likely to have played a significant role. For example, all the rill drains run north-south, and these transfer water to the east-west interceptor, and then to the south via overspills where gaps in the perimeter soil berms occurred. This drainage system thereby focused runoff to specific locations rather than diffusely,

which would have been the natural condition. Given that there was no maintenance of the interceptor drain (it was observed to be heavily vegetated and closed in), nor was there likely any maintenance at the overspills, it is possible that during an extreme rainfall event the overspills were flooded and likely overloaded. There is also evidence from the drone footage of the failure event at Shass that forestry run-off water was ponding on the firebreak downslope of the interceptor drain (Fig. 3- 7(a)).

The proximity of the head of the failure to the upslope margin of the open blanket bog and forestry plantation would strongly suggest that run-off from the forestry which had drainage furrows directed downslope towards the failure, possibly in combination with run-off flowing within the downslope perimeter interceptor drain of the forestry plantation, was directed towards the site of the head of the failure.

Considering the likely volume of water that would have been concentrated in this area, and at ponding and overspill areas, where the water penetrated into the base of the peat through cracks in the peat surface under existing drains or in combination with natural processes, this is considered likely to be sufficient to initiate localised failure within the weaker more decomposed peat (catotelm peat) at depth. The localised failure would then have destabilised the adjacent intact peat causing the larger peat failure. Following the initial failure, the head of the failure retrogressed upslope into the forestry plantation following the lines of weakness in the blanket peat created by the forestry drainage furrows.

- **Role of Flush Zones (Conditioning Factor).** Prior to afforestation, there was a large funnelling collection flush zone at this site. This flush zone encompasses the majority of the study area and the failure footprint (outlined above and based on 1995 OSI Aerial Photograph). Remnants of this flush zone and potential new flushes created by discharge from the boundary interceptor drain were mapped by FT in 2022 (Figure 4.8). The spatial extent of these recently mapped flush zones is limited by the destructive impact of the peat failure.

  The pre-afforestation original collector flush zone is considered to be an important indicator of the volume of surface water that collected and funnelled through this area before it reached the stream in the eastern boundary of the site. The fact that this area coincides with the failure inception zone supports the interpretation that changes to the flow regime arising from the forestry plantation and associated drainage impact (direct and indirect), is likely a primary conditioning factor to slope instability in this area. The only issue here is that the flush zone existed in this form for many years alongside the forestry drainage, and as such it is not clear why, when there were previous similar rainfall events, it contributed to the 2020 failure.

### 5.3 Mount Eagle

The following are considered to be the key conditioning and triggering factors of the peat failure of November 2020.

It is considered likely that the combination of all of the identified factors created the conditions for the peat failure as one or a few of these factors in combination are highly unlikely to cause the scale of the peat failure that occurred.

There is no evidence to suggest there were mechanical works (drainage related or forestry related) ongoing at the site at the time of the failure.

- **Rainfall (Triggering Factor).** The trigger for the failure is likely related to run-off/water flow from preceding rainfall following a prolonged dry spell. The proximity of the head of the failure to the upslope margin of the forestry plantation and the open blanket bog would strongly suggest that run-off from the open peatland, possibly in combination with run-off flowing along the firebreak, was concentrated at the head of the failure.

Site Conditioning Factors (November 2020 failure)

- **Previous failure (conditioning factor).** There is a previous adjacent failure that likely occurred for the same reasons as the 2020 failure. The presence of this previous failure is, however, considered to be a conditioning factor in the 2020 failure, as it is likely to have removed some lateral support of the peat on the edge of the 2020 failure, increasing the likelihood of a future failure.

- **Drainage (Conditioning Factor).** The forestry plantation that is located downslope within the failure catchment has caused significant changes to the natural drainage conditions, both along the firebreaks and also within the forested area. Drains within the conifer plantation and in open bog to the south-west of the failure are also likely to contribute to some drying of the blanket bog upslope of the failure. The east-west orientated interceptor drains within the forestry may also have held water on the slope if they were not properly maintained, leading to saturation of the peat.

  Considering the volume of water that would have been concentrated in this area, where the water penetrated into the base of the peat through cracks in the peat surface under existing drains or through natural processes this would likely be sufficient to initiate localised failure within any weaker peat at depth. The localised failure would then destabilise the adjacent intact peat causing the larger peat failure. Following initial failure, the head of the failure retrogressed upslope out of the forestry.

  It is also noteworthy that the pre-2018 and the November 2020 failures both occurred in the headwaters of a tributary stream, which is one of a number of headwaters in the area. Such areas may be areas of more focused flow than other areas. This is similar to the conditions at the Shass Mountain failure.

- **Topography (Conditioning Factor).** A slight convex break in slope has been noted at the assumed failure point within the forestry. This type of feature has been found at a significant number of peat failures across Ireland and the UK and is considered to be a key conditioning factors in peat slides.

- **Forestry Firebreak (Conditioning Factor).** The firebreak is an excavation on the upslope side of the forestry, with the attendant effect of draining and potentially peat drying the blanket bog upslope. Drains within the conifer plantation and in open bog to the south-west of the failure are also likely to contribute to some drying of the blanket bog upslope of the failure. The proximity of the head of the failure to the upslope margin of the forestry plantation and the blanket bog would strongly suggest that run-off from the blanket bog, possibly in combination with run-off flowing along the firebreak, was concentrated, and potentially ponding, both within the firebreak and possible further down the slope at the initiation point of the failure.

  This perimeter firebreak has, over time, been eroded, denuded, desiccated and cracking has developed due to oxidation of the peat surface. Over time, these cracks have widened and propagated vertically into the peat substrate. Water coming off as sheet flow from the open blanket bog, will therefore also have infiltrated as subsurface flow into these linear cracks which ultimately can cause instability by lubrication and buoyancy of the weaker catotelm peat at the base of the peat profile. The slip layer is considered to be at the base of peat contact with underlying mineral subsoils / bedrock.

- **Peat Strength (Conditioning Factor).** Shear vane strength testing (hand-held) was carried out at selected locations around the head of the failure within the forestry and in the open blanket bog during the site visit. The hand vane results indicated undrained shear strengths in the range 12 to 44kPa, with an average value of about 22kPa. The peat depth was on average about 2.3m. In general, the recorded undrained shear strength of the peat was not significantly low at the test locations. The peat strength in the central part of the failure is not known.

# 6. Summary

This report summarises the findings of the assessment of the three major peatland landslides (peat failures) that occurred during 2020 at Meenbog, Shass (Boleybrack Mountain) and Mount Eagle.

An assessment was undertaken of available data such as topography, aerial photography, historical mapping and publicly available reports. In addition, site visits were undertaken by geotechnical, hydrological and ecological specialists to gather additional data on the likely conditioning factors for the three failures.

A summary of the triggering factors and the site-specific conditioning factors for each of the failures is presented in Table 6-1.

## 6.1 Meenbog

The bog flow failure at Meenbog occurred on 12 November 2020, during the unauthorised construction of a wind farm access road (a floating road) across blanket bog. The planning history for the site at Meenbog is outlined in Section 2.1.

Peat depth probes around the perimeter of the upper scar showed an average peat depth of 2.7m, though locally depths of 4.5m were recorded. The total estimated volume of failed peat is 86,240m$^3$.

The failure scar morphology comprises 3 distinct parts, namely an upper scar and lower scar which provided the source area for the failed peat, and a run-out trail along which the failed peat was deposited. The upper scar is 260m long measured from the furthest upslope point to the approximate downslope limit at the mouth of the upper scar, at the location of the ‘‘floating’’ wind farm access road that was being constructed at the time of the peat failure. The maximum width of the upper scar is 120m. The estimated total area of the upper scar is 2.4ha.

**Triggering Factors**
The key trigger activity for the failure was the construction of a floating access road across blanket bog close to a convex break in slope, and directly downslope of an area of deep blanket bog with peat of very low shear strength. The presence of a drain along the forestry boundary may also have acted as a potential line of weakness, with the failure starting at this point and extending progressively into the area of open peatland.

**Site Specific Conditioning Factors**

- Deep (up to 4.5m), open blanket bog immediately upslope of the location where the wind farm road was being constructed and which contained peat of very low shear strength;
- Forestry drainage and forestry plantation on blanket bog with a dense complex of parallel drains aligned with the slope and feeding water towards the road that was under construction. The presence of a drain along the forestry boundary may also have acted as a potential line of weakness, with the failure starting at this point and extending progressively into the area of deep open blanket bog;
- Over time the forestry drains and growing trees would also cause peat oxidation and drying of the bog, leading to cracking of the near surface acrotelm layer, particularly along forestry furrows and

drainage lines. Once this occurs surface water run off can gain ingress via drains and cracks to the more decomposed, less fibrous and weaker, catotelm peat at depth.

- The previous use of the area close to the failure point as a forestry extraction route may also have weakened the underlying peat.

**Rainfall Patterns**
There was no clear significant peak rainfall duration period immediately prior to the peat failure.

The combination of a significant dry spell (April and May 2020) followed by relatively high daily rainfall amounts (from June 2020 onwards) may have been a predisposing factor in the hydrologically modified areas of the site which would be more sensitive to perturbations that hydrologically intact areas of blanket bog. However, the same weather conditions affected similar sites in this vicinity yet did not trigger other peat failures which points to the construction activity at that location in tandem with site specific drainage factors being the predominant cause of the 2020 failure at Meenbog.

## 6.2 Shass Townland (Boleybrack Mountain)

This bog flow failure occurred within an area of moderately sloping blanket bog in Shass townland on Boleybrack Mountain, north-east of Drumkeeran, Co Leitrim on the 28 June 2020, approximately 1.2km to 1.4km upstream of the Dawn of Hope bridge.

The evacuated peat initially entered existing watercourses and deposited large volumes of peat for example (c. 25,000 cubic metres upstream of Dawn of Hope bridge and 15,000 cubic metres at Courcuill Upper). The peak flow height of the peat above Dawn of Hope bridge was up to 4.5m. Based on a failure area of 10ha combining the upper and lower scars, the total estimated volume of failed peat is estimated as 260,000$m^3$.

The majority of the peat carried downstream of the Dawn of Hope bridge was deposited on flood plains, mainly within the townlands of Corcormick and Derrindangan. The Diffagher River carried some peat sediment and other debris to Lough Allen, approximately 8.45km from the starting point, where it has been observed washed up on the shoreline, e.g. at Corry Strand (RPS, 2020).

**Triggering Factor**
The trigger for the failure was heavy rainfall over a short period of time (60mm over a 24-hour period from the closest weather station). The runoff from this rainfall was concentrated by the existing drainage network within the forestry plantation to the north of the failure into the headwaters of a small stream. This was also an area of deep peat, and there is evidence to suggest that flushing and potential groundwater emergence contributed to the initial failure. It is likely that some of the runoff penetrated into the base of the peat through cracks in the peat surface under existing drains or through natural processes, initiating a failure at the base of the peat. This localised failure would then destabilise the adjacent intact peat causing the larger peat failure.

**Site-specific Conditioning Factors**
The site-specific conditioning factors include the man-made drainage network aligned with the upland slope within the forestry plantation planted on blanket bog to the north of the failure site. This has the effect of directing surface water runoff into a localised catchment area, which also appears to have been a pre-existing flush zone.

- The forestry drains are shallow rill drains and run north-south in general alignment with the slope and therefore also direct water towards the location of the failure initiation point. The drains will also

have caused significant change to the natural in-situ hydrological conditions of the blanket bog and to the properties of the peat.
- The forestry drains may also allow water into the base of peat, through cracks, where the weaker, non-fibrous, catotelm peat and the soft clay layer is located initiating a failure at the base of the peat.
- The presence of a forestry interceptor drain that is locally Sphagnum-filled and therefore not fully effective meaning that ponding of water can occur around this drain. Additionally, there is a wide peat soil bank (c. 0.4m high, NPWS ecological report) alongside the downslope side of the forestry drainage interceptor drain that impedes surface water flows from the forestry drains which means that ponding can occur upslope of this spoil bank.
- The presence of a slight convex break in slope below the peat failure initiation area.
- A relatively deep peat layer, with peat depths ranging from 1.7 to 5.0m.
- The presence of a soft clay layer below the peat may have been a condition factor, providing a slip plane for the peat to fail along.
- The location of the failure in a flush drainage zone may also have been a conditioning factor.

**Rainfall Pattern**
As there was heavy rainfall over a short period of time on the day of the peat failure it is considered that this was a trigger factor that combined with the above site-specific conditioning factors lead to the peat failure at Shass.

## 6.3 Mount Eagle

This peat slide failure was recorded on 15 November 2020 in afforested blanket bog on Mount Eagle, County Kerry.

The failure scar is estimated to be about 650m long by about 30 to 50m average width. The lower part of the failure scar within the forestry plantation is narrower, which suggests that this represents material running out from the scar and is likely not part of the failure scar. Based on the above the estimated plan area of the failure scar covers about 2.6ha. The run-out distance for the failed material is estimated at 2.5km.

Assuming that the average failed peat depth is 2m, then failure volume is 52,000m$^3$, of which a notable proportion has remained within the area of the failure scar.

**Triggering Factor**
The trigger for the failure is likely related to run-off/water flow from preceding rainfall following a prolonged dry spell.

**Site-specific Conditioning Factors**
The site-specific conditioning factors include the man-made drainage network aligned with the upland slope within the forestry plantation planted on blanket bog.

- The presence of the firebreak and modified drainage system associated with the forestry, has contributed to local desiccation and erosion, and cracking and fissuring of the peat.
- Another factor in this failure is likely to have been the hydrological and structural impact of the previous peat failure on the afforested bog directly alongside the 2020 failure site, which removed the peat which would have provided structural support to the western flank of the afforested peat within the failure site.
- The presence of a slight convex break in slope at or close to the assumed failure initiation point.

- The failure appears to have initiated close to the zone where diffuse overland flow from the open blanket bog upslope of the forestry plantation reached the perimeter firebreak at the edge of the forest.
- The combination of the effects of forestry drainage allowing water ingress to the base of the peat; loading from ponding of run-off water from the open blanket bog upslope of the plantation; and cracks or fissures in the peat that would also have allowed vertical infiltration and lubrication and increased buoyancy at the base of the peat profile are considered to have been significant factors in the initiation of this peat failure.

**Rainfall Pattern**

There was no clear significant peak rainfall duration period (storm event) immediately prior to the peat failure. However, the combination of a significant dry spell (April and May 2020) followed by relatively high daily rainfall amounts (from June 2020 onwards) may have been the triggering factor in the failure in association with the conditioning factors listed above.

## 6.4 Summary of Conditioning and Triggering Factors

The following is a summary of the Conditioning and Triggering factors for the three peat failures.

**Table 6-1: Conditioning and Triggering Factors for Three 2020 Peat Failures**

| Site | Triggering Factors | Conditioning Factors (site-specific characteristics) |
|---|---|---|
| **Meenbog<br>County Donegal<br>(12 November 2020)** | Unauthorised construction activity causing excess loading on blanket bog (during construction of floating road across blanket bog) | Convex break in slope at site of construction activity.<br><br>Area of poorly drained, deep, weak peat (blanket bog) directly upslope of route of access road.<br><br>Presence of forestry drainage altering the ecohydrological functioning of the blanket bog and focussing water flow. |
| **Shass (Boleybrack Mountain)<br>County Leitrim<br>(28 June 2020)** | Localised very heavy rainfall event on June 28 2020. | Blanket bog with altered ecohydrological functioning.<br><br>Forestry drainage upslope of the failure location is diverting additional volumes of run-off water into localised areas of the deep open blanket bog.<br><br>Pre-existing flush zones that converge on the failure points and that may facilitate surface run-off water access to the weaker peat base peat.<br><br>Convex break in slope close to the point of the failure.<br><br>Presence of soft clay layer at the base of the peat. |
| **Mount Eagle<br>County Kerry<br>(15 November 2020)** | Rainfall pattern during the earlier year (dry Spring and wet Summer) combined with run-off from the | Drained and afforested blanket bog hence with severely altered ecohydrological functioning:<br><br>Forestry drainage focusing surface run-off water into localised area of afforested blanket bog; erosion of |

| | | |
|---|---|---|
| | open blanket bog being focussed within forestry drains | blanket bog along a firebreak at upper edge of the forestry; and peat drying/cracking due to lack of vegetation cover along the firebreak.<br><br>Convex break in slope close to the point of the failure.<br><br>Presence of older failure adjacent to 2020 failure has removed lateral support to the area that failed in 2020. |

These Conditioning and Triggering factors are similar to those found in other historical peat failures across Ireland and the UK, involving rainfall, head loading of peat during construction activity (both triggering factors), convex breaks in slope and the impact of forestry drainage on surface water flow and the ecohydrological functioning of blanket bog (conditioning factors). Each of these factors is important when considering the potential susceptibility of a site to peat failure.

# 7. Opportunities for Further Study

This Section has been included to address the fact that while some background data is available for the three failure sites, specific information such as pre failure water level, water flow, specific drainage patterns following storm events, etc. is not known for the three sites.

It is suggested, for example, that for the failures at Shass Mountain and Mount Eagle, hydrological and hydrogeological monitoring is undertaken on peatland immediately adjacent to the failure locations. This would allow data to be gathered on the response of the drainage network to storm events. This could involve flow gauges, push-in piezometers with data loggers, and/or remotely trigger camera to record the water flow through a study location and effect of extreme rainfall event on drainage.

Ecological surveys would also be undertaken within any study areas and should be repeated at multi-year intervals to determine if there is any ongoing change in habitat occurring due to the presence of the failures or the artificial drainage within the forestry.

Further study of the peat could include recording additional peat depths, peat sampling and logging (van Post) to determine the degree of humification within the peat body. The use of satellite information to monitoring ground movements (as per Islam et al, 2022) could also be considered.

Creighton (2006) reports that the Irish Landslides Working Group recommends that a large body of research be completed with regard to landslide susceptibility assessment in Ireland. The National Landslide Susceptibility map was published in 2016. The growing pressure for development in more marginal land areas, and the potential impacts of climate change, make such work an important imperative in the context of the sustainable development of the Irish landscape, and also on health and safety grounds. In the 2006 publication, a need for multidisciplinary studies on landslide phenomena involving geologists, geomorphologists, engineers, peatland ecologists, climatologists, planners and those with GIS expertise was identified. The collaborators would include university researchers, local authorities, government departments and agencies, and consulting geologists and engineers. With progress in these specific themes, more informed approaches can be undertaken on the methodology of landslide susceptibility mapping.

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# APPENDIX A

Rainfall Data

**Figure B.1 Daily rainfall preceding 2020 Meenbog peat failure from Lough Mourne ASC**

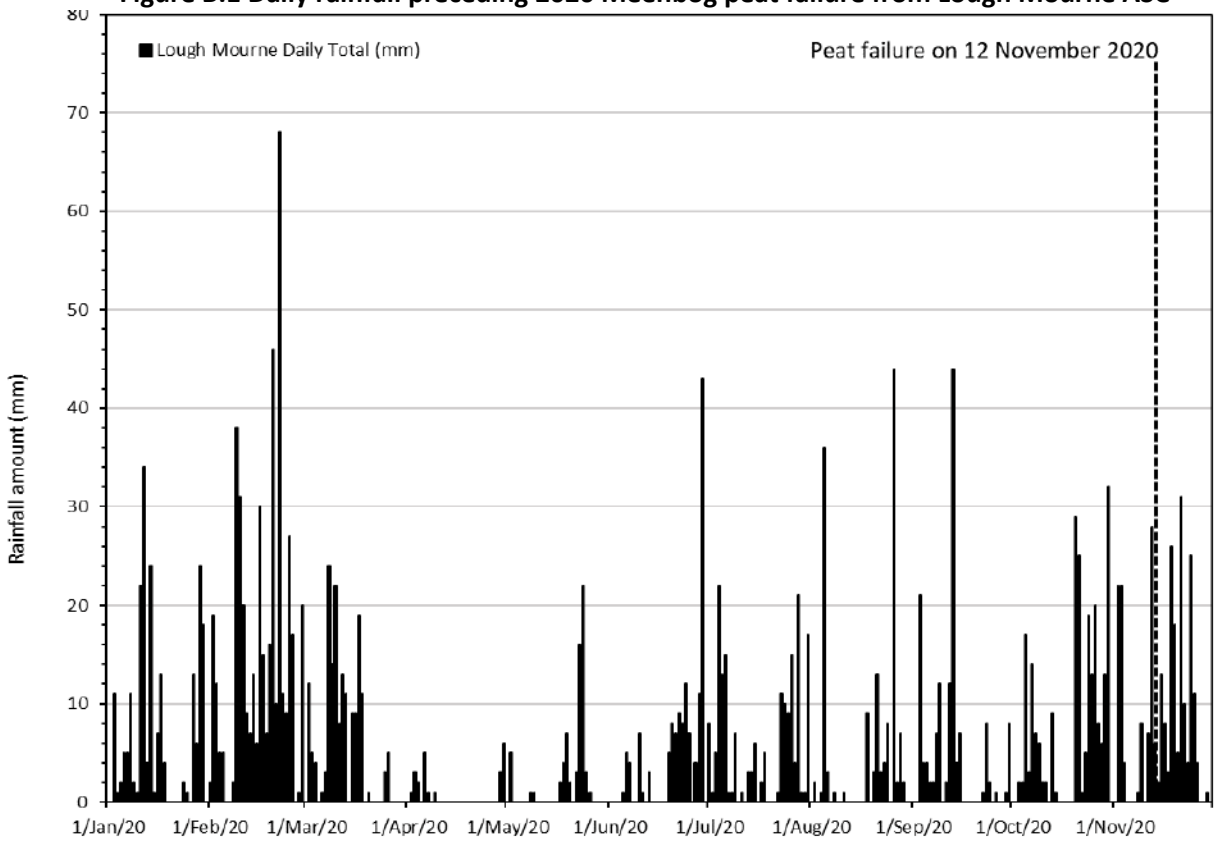



**Table B.2 Daily rainfall at Finner WS, preceding 2020 Meenbog peat failure,**

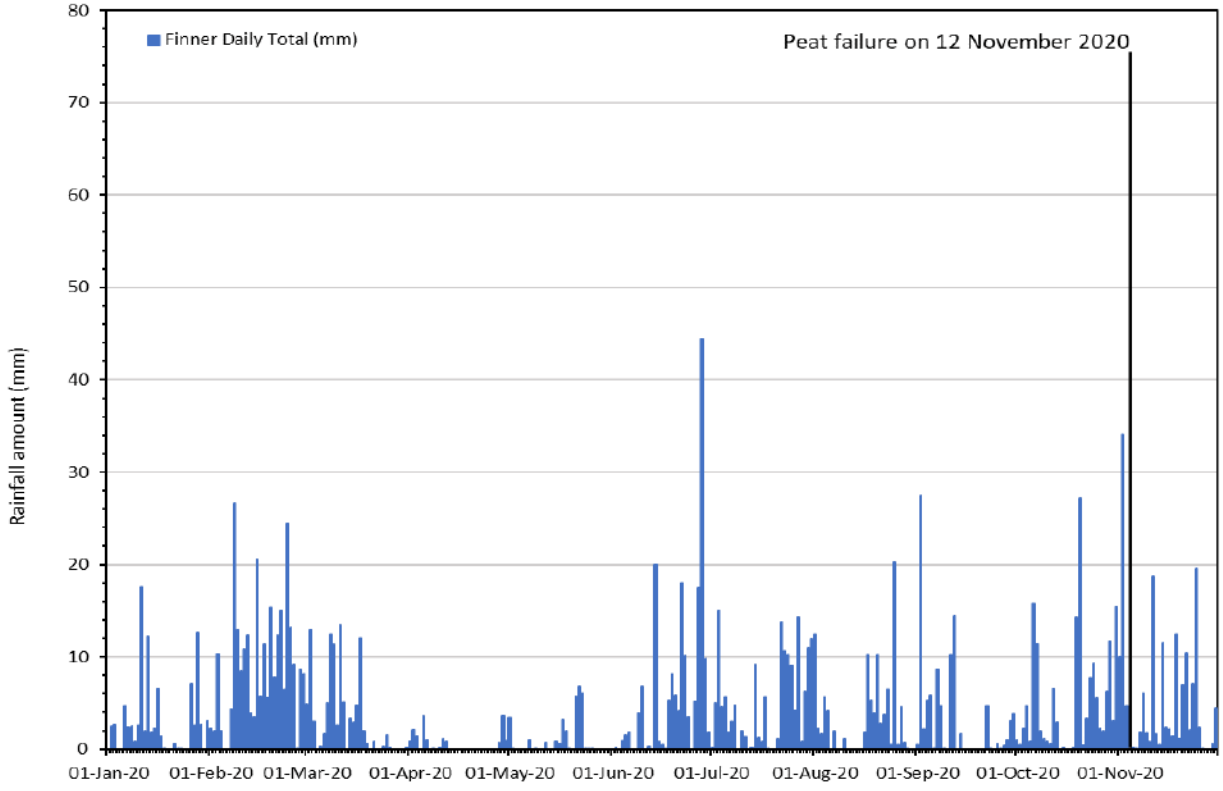


**Figure B.3 Daily rainfall preceding 2020 Shass Mountain peat failure from Manorhamilton**

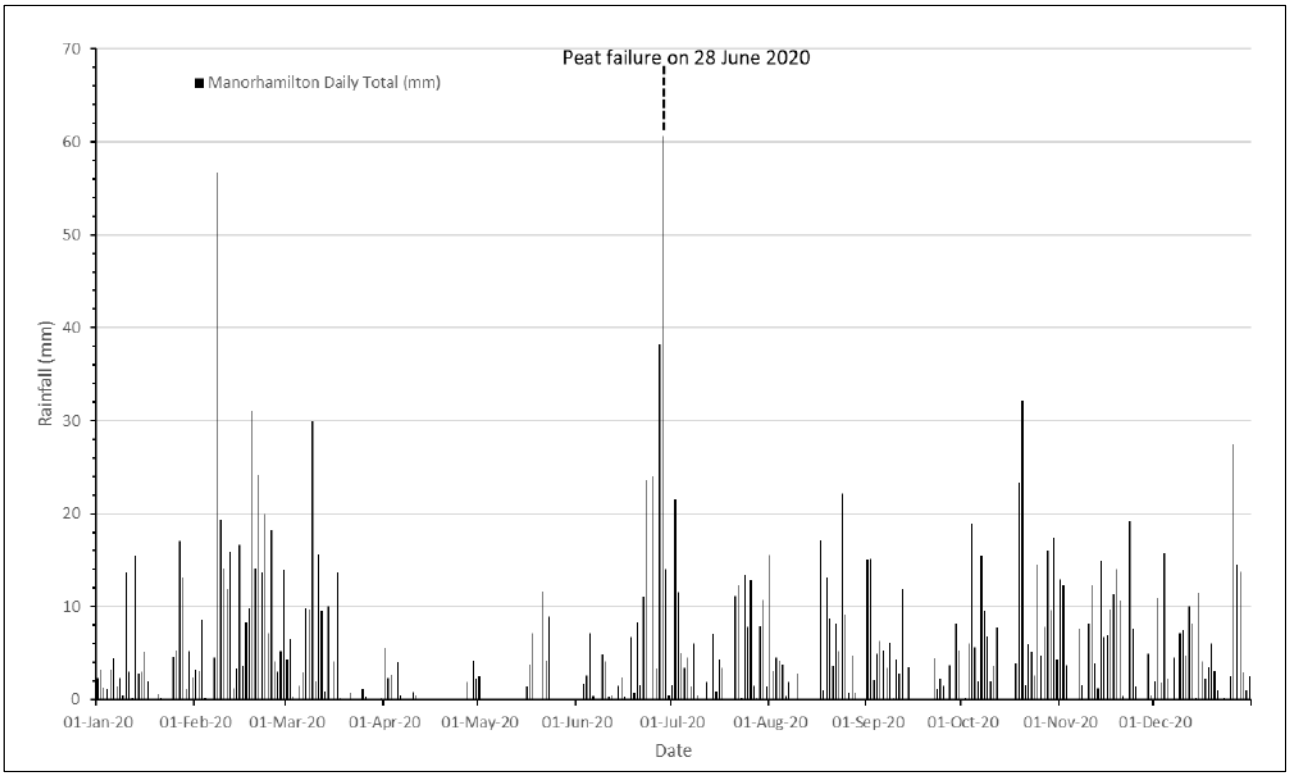



**Figure B.4 Daily rainfall preceding 2020 Mount Eagle peat failure from Castleisland (Coom)**

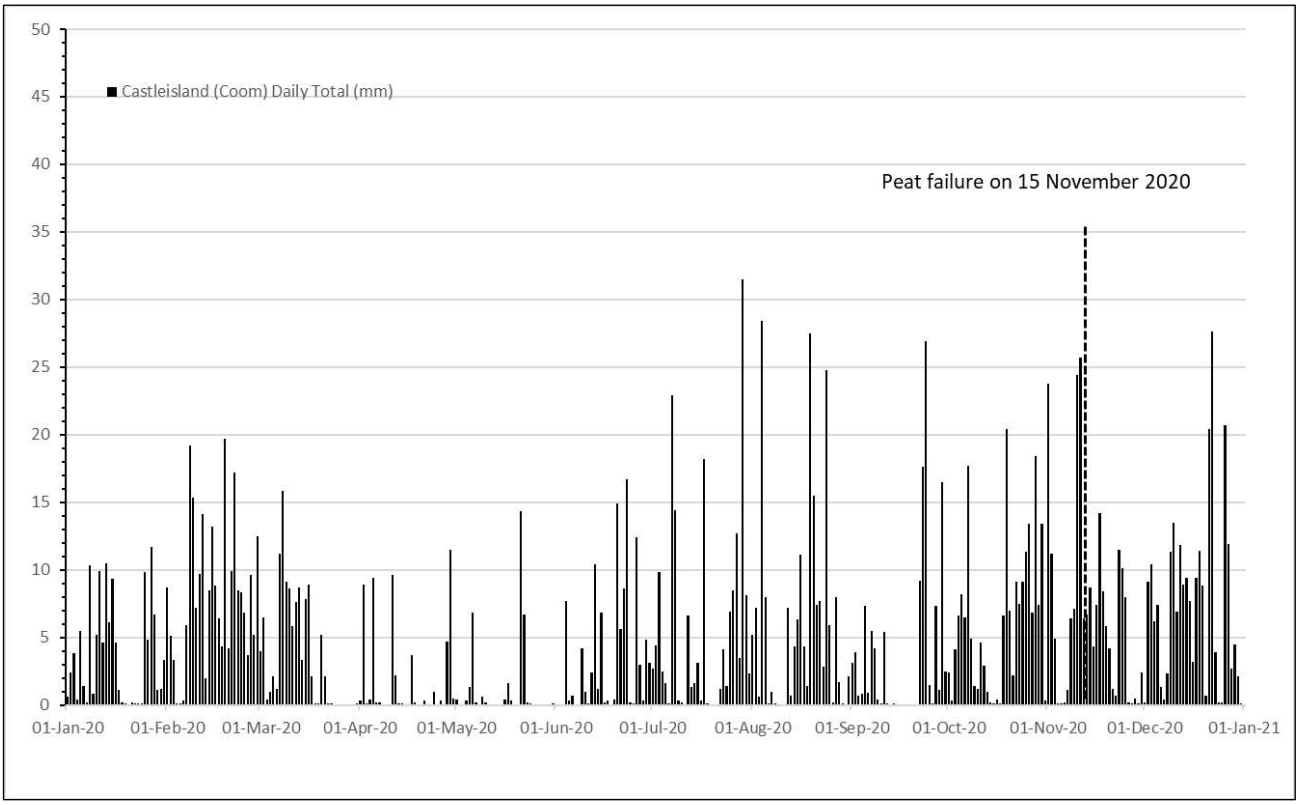


**Figure B.5 Daily rainfall preceding 2020 Mount Eagle peat failure from Castleisland (Kilmurry)**

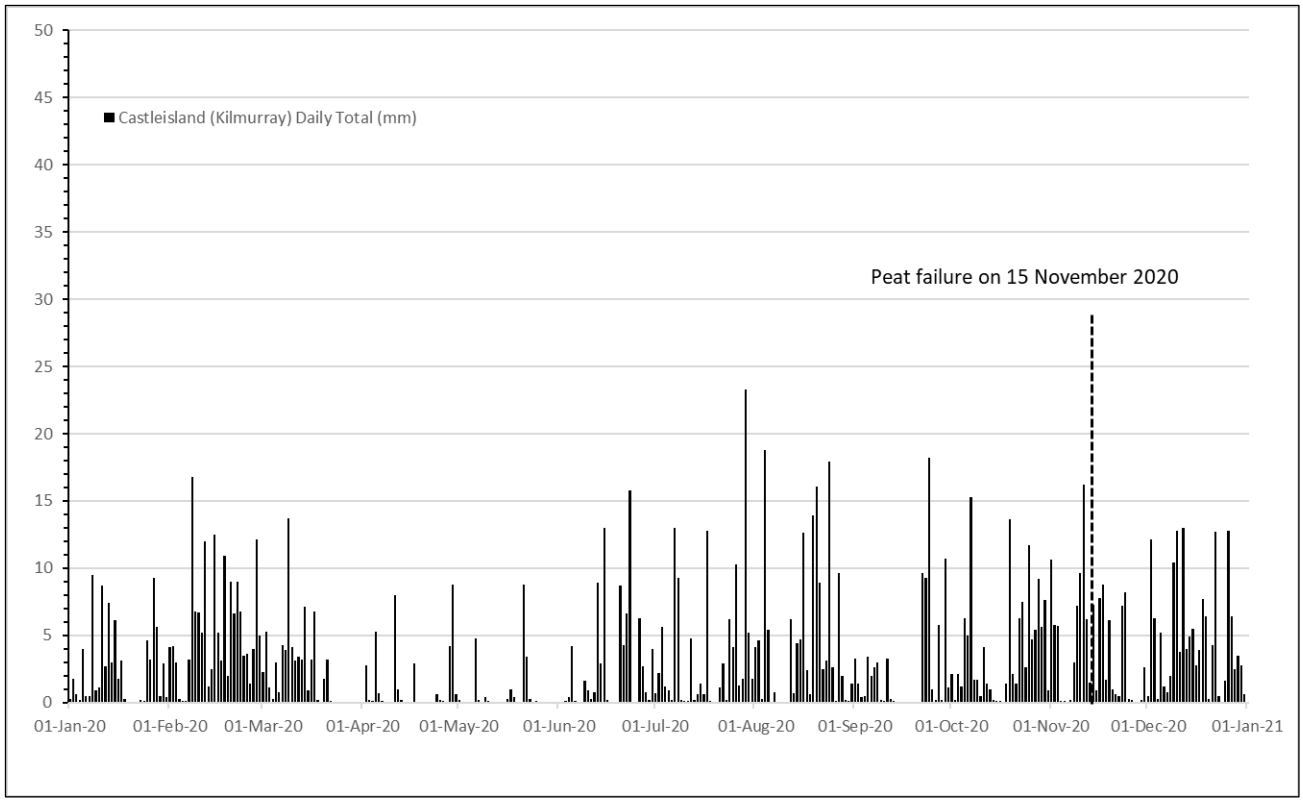
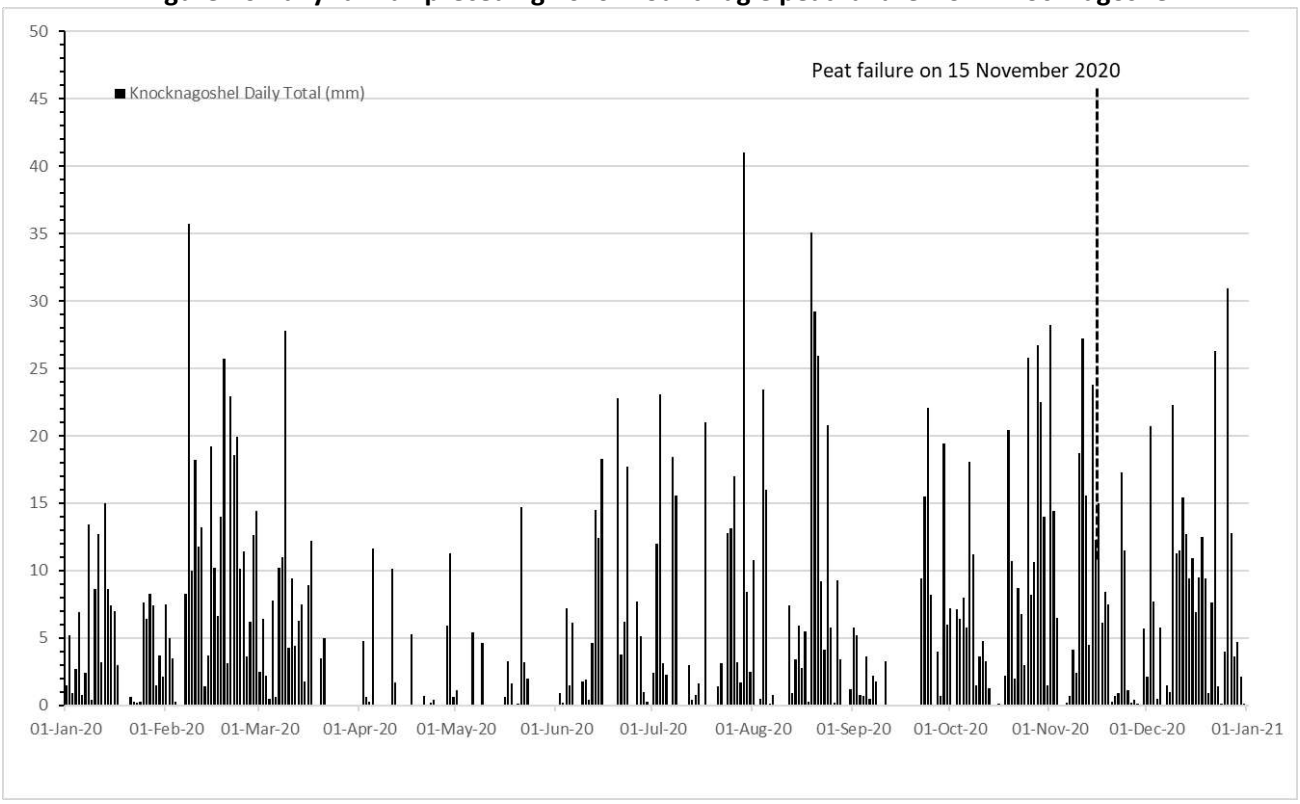



**Figure B6 Daily rainfall preceding 2020 Mount Eagle peat failure from Knocknagoshel**



# APPENDIX B

Ecological Survey Records

Meenbog Botanical Survey Results

| Survey Dat | Relevé | Species | Species % | Median Vegetation H | | Standing w | Bare peat | Total spha | Shrub cove | No. of pla | Grazing | Habitat Notes | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M1 | | | 30 | 70 | 0 | 30 | 7 | 22 | 12 | None evident | Bog beside failure | No drains visible | | |
| | | *Molinia caerulea* | 60 | | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 30 | | | | | | | | | | | | |
| | | *Calluna vulgaris* | 20 | | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 5 | | | | | | | | | | | | |
| | | *Erica tetralix* | 2 | | | | | | | | | | | | |
| | | *Potentilla erecta* | 2 | | | | | | | | | | | | |
| | | *Narthecium ossifragu* | 1 | | | | | | | | | | | | |
| | | *Sphagnum subnitens* | 1 | | | | | | | | | | | | |
| | | *Sphagnum papillosur* | <1 | | | | | | | | | | | | |
| | | *Polygala serpyllifolia* | <1 | | | | | | | | | | | | |
| | | *Sphagnum tenellum* | <1 | | | | | | | | | | | | |
| | | *Odontoschisma spha* | <1 | | | | | | | | | | | | |
| | M2 | | | 18 | 100 | 0 | 0 | 60 | 58 | 7 | None evident | Bog beside failure | No drains visible | | |
| | | *Sphagnum capillifoliu* | 60 | | | | | | | | | | | | |
| | | *Calluna vulgaris* | 55 | | | | | | | | | | | | |
| | | *Molinia caerulea* | 45 | | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 15 | | | | | | | | | | | | |
| | | *Narthecium ossifragu* | 3 | | | | | | | | | | | | |
| | | *Erica tetralix* | 3 | | | | | | | | | | | | |
| | | *Potentilla erecta* | 3 | | | | | | | | | | | | |
| | M3 | | | 15 | 100 | 0 | 0 | 90 | 85 | 8 | None evident | Bog beside failure | No drains visible | | |
| | | *Sphagnum capillifoliu* | 90 | | | | | | | | | | | | |
| | | *Calluna vulgaris* | 80 | | | | | | | | | | | | |
| | | *Molinia caerulea* | 60 | | | | | | | | | | | | |
| | | *Trichophorum caespi* | 20 | | | | | | | | | | | | |
| | | *Cladonia portentosa* | 5 | | | | | | | | | | | | |
| | | *Erica tetralix* | 5 | | | | | | | | | | | | |
| | | *Narthecium ossifragu* | 1 | | | | | | | | | | | | |
| | | *Potentilla erecta* | 1 | | | | | | | | | | | | |
| | M4 | | | 45 | 100 | 0 | 0 | 51 | 68 | 11 | None evident | Bog beside failure | Drain beside Relevé | | |
| | | *Calluna vulgaris* | 60 | | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 50 | | | | | | | | | | | | |
| | | *Molinia caerulea* | 40 | | | | | | | | | | | | |
| | | *Trichophorum caespi* | 20 | | | | | | | | | | | | |
| | | *Eriophorum angustif* | 10 | | | | | | | | | | | | |
| | | *Potentilla erecta* | 10 | | | | | | | | | | | | |
| | | *Cladonia portentosa* | 10 | | | | | | | | | | | | |
| | | *Erica tetralix* | 8 | | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 2 | | | | | | | | | | | | |
| | | *Sphagnum papillosur* | <1 | | | | | | | | | | | | |
| | | *Sphagnum tenellum* | <1 | | | | | | | | | | | | |

Meenbog Botanical Survey Results

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M5 | | | 30 | 100 | 0 | 0 | 57 | 53 | 9 | None evident | Bog beside failure | Drain overlapped by Relevé | |
| | | *Calluna vulgaris* | 50 | | | | | | | | | | | |
| | | *Molinia caerulea* | 50 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 50 | | | | | | | | | | | |
| | | *Cladonia portentosa* | 15 | | | | | | | | | | | |
| | | *Sphagnum papillosur* | 7 | | | | | | | | | | | |
| | | *Erica tetralix* | 3 | | | | | | | | | | | |
| | | *Potentilla erecta* | 2 | | | | | | | | | | | |
| | | *Hypnum jutlandicum* | <1 | | | | | | | | | | | |
| | | *Lophocolea bidenta* | <1 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M6 | | | 25 | 100 | 0 | 0 | 20 | 3 | 10 | None evident | Conifer plantation/bog ecotone | | |
| | | *Molinia caerulea* | 80 | | | | | | | | | | | |
| | | *Sphagnum palustre* | 10 | | | | | | | | | | | |
| | | *Sphagnum magellan* | 10 | | | | | | | | | | | |
| | | *Calluna vulgaris* | 2 | | | | | | | | | | | |
| | | *Potentilla erecta* | 2 | | | | | | | | | | | |
| | | *Drosera rotundifolia* | 2 | | | | | | | | | | | |
| | | *Narthecium ossifragu* | 1 | | | | | | | | | | | |
| | | *Erica tetralix* | 1 | | | | | | | | | | | |
| | | *Trichophorum caespi* | <1 | | | | | | | | | | | |
| | | *Odontoschisma spha* | <1 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M7 | | | 50 | 100 | 0 | 0 | 15 | 60 | 8 | None evident | Grassy vegetation near western edge of bog | | |
| | | *Molinia caerulea* | 75 | | | | | | | | | | | |
| | | *Calluna vulgaris* | 60 | | | | | | | | | | | |
| | | *Trichophorum caespi* | 10 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 10 | | | | | | | | | | | |
| | | *Rhytidiadelphus lore* | 5 | | | | | | | | | | | |
| | | *Sphagnum cuspidatu* | 5 | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 5 | | | | | | | | | | | |
| | | *Hylocomium splende* | 5 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M8 | | | 50 | 100 | 0 | 0 | 23 | 5 | 8 | None evident | Conifer plantation/bog ecotone | | |
| | | *Molinia caerulea* | 90 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 20 | | | | | | | | | | | |
| | | *Hypnum jutlandicum* | 10 | | | | | | | | | | | |
| | | *Calluna vulgaris* | 3 | | | | | | | | | | | |
| | | *Sphagnum cuspidatu* | 3 | | | | | | | | | | | |
| | | *Erica tetralix* | 2 | | | | | | | | | | | |
| | | *Narthecium ossifragu* | <1 | | | | | | | | | | | |
| | | *Cortinarius mucifluus* | <1 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M9 | | | 35 | 95 | 0 | 5 | 32 | 38 | 14 | None evident | Quaking bog | | |
| | | *Calluna vulgaris* | 35 | | | | | | | | | | | |
| | | *Molinia caerulea* | 30 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 30 | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 10 | | | | | | | | | | | |

Meenbog Botanical Survey Results

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Erica tetralix* | 3 | | | | | | | | | | | |
| | | *Pleurozia purpurea* | 3 | | | | | | | | | | | |
| | | *Potentilla erecta* | 2 | | | | | | | | | | | |
| | | *Pedicularis sylvatica* | 1 | | | | | | | | | | | |
| | | *Cladonia portentosa* | 1 | | | | | | | | | | | |
| | | *Sphagnum cuspidatu* | 1 | | | | | | | | | | | |
| | | *Eriophorum angustif* | <1 | | | | | | | | | | | |
| | | *Sphagnum tenellum* | <1 | | | | | | | | | | | |
| | | *Sphagnum papillosur* | <1 | | | | | | | | | | | |
| | | *Odontoschisma spha* | <1 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M10 | | | 60 | 95 | 0 | 5 | 15 | 44 | 12 | None evident | Quaking bog inside failure near edge | | |
| | | *Calluna vulgaris* | 40 | | | | | | | | | | | |
| | | *Molinia caerulea* | 35 | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 20 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 15 | | | | | | | | | | | |
| | | *Rhynchospora alba* | 5 | | | | | | | | | | | |
| | | *Erica tetralix* | 4 | | | | | | | | | | | |
| | | *Cladonia portentosa* | 2 | | | | | | | | | | | |
| | | *Pleurozia purpurea* | 2 | | | | | | | | | | | |
| | | *Narthecium ossifragu* | 1 | | | | | | | | | | | |
| | | *Pedicularis sylvatica* | 1 | | | | | | | | | | | |
| | | *Potentilla erecta* | 1 | | | | | | | | | | | |
| | | *Drosera rotundifolia* | <1 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M11 | | | 40 | 100 | 0 | 0 | 24 | 5 | 12 | None evident | Conifer plantation/bog ecotone | | |
| | | *Molinia caerulea* | 85 | | | | | | | | | | | |
| | | *Sphagnum magellani* | 20 | | | | | | | | | | | |
| | | *Deschampsia flexuos* | 15 | | | | | | | | | | | |
| | | *Hylocomium splende* | 12 | | | | | | | | | | | |
| | | *Potentilla erecta* | 8 | | | | | | | | | | | |
| | | *Calluna vulgaris* | 5 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 3 | | | | | | | | | | | |
| | | *Rhytidiadelphus lore* | 2 | | | | | | | | | | | |
| | | *Sphagnum cuspidatu* | 2 | | | | | | | | | | | |
| | | *Sphagnum subnitens* | 2 | | | | | | | | | | | |
| | | *Polytrichum commur* | 1 | | | | | | | | | | | |
| | | *Rhytidiadelphus squa* | 1 | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | M12 | | | 40 | 100 | 0 | 0 | 55 | 36 | 8 | None evident | Ecotone between Molinia/Ca | Quaking but not as wet as M9/M10 | |
| | | *Molinia caerulea* | 50 | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 50 | | | | | | | | | | | |
| | | *Calluna vulgaris* | 35 | | | | | | | | | | | |
| | | *Sphagnum subnitens* | 5 | | | | | | | | | | | |
| | | *Hypnum jutlandicum* | 2 | | | | | | | | | | | |
| | | *Potentilla erecta* | 1 | | | | | | | | | | | |
| | | *Erica tetralix* | 1 | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 1 | | | | | | | | | | | |

Meenbog Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| | M13 | | | 55 | 100 | 0 | 0 | 15 | 2 | 14 | None evident | Grassy vegetation near western edge of bog | | | |
| | | *Molinia caerulea* | 95 | | | | | | | | | | | | |
| | | *Sphagnum palustre* | 10 | | | | | | | | | | | | |
| | | *Sphagnum capillifoliu* | 5 | | | | | | | | | | | | |
| | | *Potentilla erecta* | 3 | | | | | | | | | | | | |
| | | *Erica tetralix* | 2 | | | | | | | | | | | | |
| | | *Deschampsia flexuos* | 2 | | | | | | | | | | | | |
| | | *Drosera rotundifolia* | 1 | | | | | | | | | | | | |
| | | *Racomitrium lanugin* | 1 | | | | | | | | | | | | |
| | | *Hypnum jutlandicum* | 1 | | | | | | | | | | | | |
| | | *Carex echinata* | 1 | | | | | | | | | | | | |
| | | *Calluna vulgaris* | <1 | | | | | | | | | | | | |
| | | *Polytrichum commur* | <1 | | | | | | | | | | | | |
| | | *Narthecium ossifragu* | <1 | | | | | | | | | | | | |
| | | *Agrostis canina* | <1 | | | | | | | | | | | | |

Shass Mountain Botanical Survey
Results

| Relevé | Species | | Species co | Median Vegeta | Vegetation | Standing w | Bare peat c | Total Spha | Shrub cove | No. of spe | Grazing | Habitat Notes | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 | | | | 30 | 100 | 0 | 0 | 12 | 40 | 14 | | Open bog near faliure | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 80 | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 25 | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 20 | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | 10 | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 10 | | | | | | | | | | Half of ling stems dead |
| | Tormentil | *Potentilla erecta* | 8 | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 5 | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 5 | | | | | | | | | | |
| | Cranberry | *Vaccinium oxycoccos* | 2 | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 2 | | | | | | | | | | |
| | Common haircap mos | *Polytrichum commune* | 1 | | | | | | | | | | |
| | Lustrous bog-moss | *Sphagnum subnitens* | 1 | | | | | | | | | | |
| | Feathery bog-moss | *Sphagnum cuspidatum* | 1 | | | | | | | | | | |
| | Bog bead-moss | *Aulacomnium palustre* | <1 | | | | | | | | | | |
| S2 | | | | 10 | 100 | 0 | 0 | 19 | 22 | 14 | | Revegetated firebre | Excavated to lower level & wetter than adjacent bog |
| | Wavy hairgrass | *Deschampsia flexuosa* | 38 | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 15 | | | | | | | | | | |
| | Lustrous bog-moss | *Sphagnum subnitens* | 8 | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | 7 | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 5 | | | | | | | | | | Most ling stems dead |
| | Heath plait moss | *Hypnum jutlandicum* | 4 | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | 4 | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | 3 | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 2 | | | | | | | | | | |
| | Cranberry | *Vaccinium oxycoccos* | 2 | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 2 | | | | | | | | | | |
| | Feathery bog-moss | *Sphagnum cuspidatum* | 1 | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 1 | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | <1 | | | | | | | | | | |
| S3 | | | | 20 | 100 | 0 | 0 | 4 | 70 | 7 | | Peat spoil bank | Peat from firebreak excavation cast aside & forms bank. Obviously drier veg |
| | Mountain fern moss | *Hylocomium splendens* | 75 | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 45 | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 40 | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 25 | | | | | | | | | | Most ling stems dead |
| | Wavy hairgrass | *Deschampsia flexuosa* | 15 | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | 4 | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | <1 | | | | | | | | | | |
| S4 | | | | 20 | 95 | 0 | 5 | 46 | 17 | 10 | | Revegetated firebreak | |
| | Red bog-moss | *Sphagnum capillifolium* | 25 | | | | | | | | | | |
| | Reindeer lichen | *Cladonia portentosa* | 20 | | | | | | | | | | |
| | Feathery bog-moss | *Sphagnum cuspidatum* | 20 | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 15 | | | | | | | | | | Only 5% ling stems living |
| | Wavy hairgrass | *Deschampsia flexuosa* | 10 | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 5 | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 2 | | | | | | | | | | |
| | Rusty swan-neck moss | *Campylopus flexuosus* | 1 | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | 1 | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | <1 | | | | | | | | | | |
| S5 | | | | 15 | 95 | 0 | 0 | <1 | 30 | 11 | | Peat spoil bank | |

Shass Mountain Botanical Survey
Results

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heath plait moss | *Hypnum jutlandicum* | 35 | | | | | | | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 30 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 20 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 20 | | | | | | | | | | Only 5% ling stems living | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 10 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 2 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 2 | | | | | | | | | | | | | | | | |
| | Common haircap mos | *Polytrichum commune* | 1 | | | | | | | | | | | | | | | | |
| | Sitka spruce | *Picea sitchensis* | <1 | | | | | | | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | <1 | | | | | | | | | | | | | | | | |
| | Compact bogmoss | *Sphagnum compactum* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S6 | | | | 50 | 100 | 0 | 0 | 45 | 0 | 7 | | Rushy patch - flushe | No standing water but ground notably softer, muddy | | | | | | |
| | Soft rush | *Juncus effusus* | 85 | | | | | | | | | | | | | | | | |
| | Common haircap mos | *Polytrichum commune* | 25 | | | | | | | | | | | | | | | | |
| | Feathery bog-moss | *Sphagnum cuspidatum* | 25 | | | | | | | | | | | | | | | | |
| | Blunt-leaved bogmoss | *Sphagnum palustre* | 20 | | | | | | | | | | | | | | | | |
| | Heath bedstraw | *Galium saxatile* | 15 | | | | | | | | | | | | | | | | |
| | Fescue | *Festuca Sp.* | 5 | | | | | | | | | | | | | | | | |
| | Velvet bent-grass | *Agrostis canina* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S7 | | | | 50 | 100 | 0 | 0 | 0 | 2 | 11 | | Edge of rushy depre | No standing water but soft ground | | | | | | |
| | Soft rush | *Juncus effusus* | 50 | | | | | | | | | | | | | | | | |
| | Velvet bent-grass | *Agrostis canina* | 35 | | | | | | | | | | | | | | | | |
| | Hay-scented buckler-f | *Dryopteris aemula* | 20 | | | | | | | | | | | | | | | | |
| | Fescue | *Festuca Sp.* | 15 | | | | | | | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 10 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 5 | | | | | | | | | | | | | | | | |
| | Heath bedstraw | *Galium saxatile* | 5 | | | | | | | | | | | | | | | | |
| | Field woodrush | *Luzula campestris susp. c* | 5 | | | | | | | | | | | | | | | | |
| | Sweet vernal-grass | *Anthoxanthum odoratum* | 5 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 2 | | | | | | | | | | | | | | | | |
| | Common haircap mos | *Polytrichum commune* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S8 | | | | 40 | 100 | 0 | 0 | 0 | 75 | 11 | | Open bog | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 85 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 70 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 50 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 35 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Tormentil | *Potentilla erecta* | 5 | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 5 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 2 | | | | | | | | | | | | | | | | |
| | Star sedge | *Carex echinata* | 2 | | | | | | | | | | | | | | | | |
| | Heath rush | *Juncus squarrosus* | 1 | | | | | | | | | | | | | | | | |
| | Carnation sedge | *Carex panicea* | 1 | | | | | | | | | | | | | | | | |
| | Heath bedstraw | *Galium saxatile* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S9 | | | | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 95 | 20 | 100 | 0 | 0 | 21 | 31 | 14 | | Open bog | | | | | | | |
| | Ling | *Calluna vulgaris* | 30 | | | | | | | | | | | | | | | | |
| | Sweet vernal-grass | *Anthoxanthum odoratum* | 15 | | | | | | | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 10 | | | | | | | | | | | | | | | | |
| | Lustrous bog-moss | *Sphagnum subnitens* | 7 | | | | | | | | | | | | | | | | |
| | Feathery bog-moss | *Sphagnum cuspidatum* | 7 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 5 | | | | | | | | | | | | | | | | |
| | Carnation sedge | *Carex panicea* | 5 | | | | | | | | | | | | | | | | |

Shass Mountain Botanical Survey
Results

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 5 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 5 | | | | | | | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | 2 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 1 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 1 | | | | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S10 | | | | 15 | 93 | 0 | 7 | 100 | 15 | 6 | | Revegetated firebreak | | | | | | | |
| | Feathery bogmoss | *Sphagnum cuspidatum* | 70 | | | | | | | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | 25 | | | | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | 20 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 15 | | | | | | | | | | Roughly half of ling stems dead | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 10 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 5 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S11 | | | | 40 | 100 | 0 | 0 | 0 | 90 | 13 | | Peat spoil bank | | | | | | | |
| | Ling | *Calluna vulgaris* | 80 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 70 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 50 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 15 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 15 | | | | | | | | | | | | | | | | |
| | Common haircap moss | *Polytrichum commune* | 2 | | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | 1 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 1 | | | | | | | | | | | | | | | | |
| | Velvet bent-grass | *Agrostis canina* | 1 | | | | | | | | | | | | | | | | |
| | Foliose lichen | *Hypotrachnea sp.* | <1 | Nothing from this genus in ERICA species list | | | | | | | | | On dead twigs | | | | | | |
| | Fruticose lichen | *Usnea cornuta* | <1 | | | | | | | | | | On dead twigs | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | <1 | | | | | | | | | | | | | | | | |
| | Broom fork-moss | *Dicranum scoparium* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S12 | | | | 25 | 100 | 0 | 0 | 0 | 90 | 11 | | Peat spoil bank | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 70 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 60 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 25 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 25 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 10 | | | | | | | | | | | | | | | | |
| | Hay-scented buckler-f | *Dryopteris aemula* | 3 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 2 | | | | | | | | | | | | | | | | |
| | Golden-head Moss | *Breutelia chrysocoma* | 2 | | | | | | | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 2 | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 1 | | | | | | | | | | | | | | | | |
| | Reindeer lichen | *Cladonia portentosa* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S13 | | | | 30 | 85 | 0 | 15 | 53 | 17 | 15 | | Revegetated firebreak | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 40 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 35 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 15 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 10 | | | | | | | | | | | | | | | | |
| | Feathery bogmoss | *Sphagnum cuspidatum* | 10 | | | | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophoroum angustifoliu* | 5 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 5 | | | | | | | | | | | | | | | | |
| | Carnation sedge | *Carex panicea* | 4 | | | | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | 3 | | | | | | | | | | | | | | | | |
| | Soft bog-moss | *Sphagnum tenellum* | 3 | | | | | | | | | | | | | | | | |
| | Lustrous bog-moss | *Sphagnum subnitens* | 3 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 2 | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bog-moss flapwort | *Odontoschisma sphagni* | 2 | | | | | | | | | | | | | | | | |
| | Magellanic bog-moss | *Sphagnum magellanicum* | 2 | | | | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S14 | | | | 50 | 100 | 0 | 0 | 27 | 87 | 13 | | Open bog | | | | | | | |
| | Ling | *Calluna vulgaris* | 50 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 45 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 35 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 30 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 25 | | | | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | 5 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 3 | | | | | | | | | | | | | | | | |
| | Lustrous bog-moss | *Sphagnum subnitens* | 2 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 2 | | | | | | | | | | | | | | | | |
| | Field woodrush | *Luzula campestris* subsp c | 1 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 1 | | | | | | | | | | | | | | | | |
| | Rowan | *Sorbus aucuparia* | 1 | | | | | | | | | | | | | | | | |
| | Cranberry | *Vaccinium oxycoccos* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S15 | | | | 50 | 100 | 0 | 0 | 35 | 81 | 11 | | Grassy flush | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 70 | | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | 60 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 50 | | | | | | | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | 30 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 30 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 10 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 5 | | | | | | | | | | | | | | | | |
| | Lustrous bog-moss | *Sphagnum subnitens* | 5 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 4 | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 3 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S16 | | | | 30 | 100 | 0 | 0 | 20 | 10 | 8 | | Transition zone from grassy flush to ling bog | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | 75 | | | | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | 30 | | | | | | | | | | | | | | | | |
| | Feathery bogmoss | *Sphagnum cuspidatum* | 15 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 10 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 5 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 5 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 3 | | | | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S17 | | | | 50 | 100 | 0 | 0 | 80 | 1 | 7 | | Top of flush - Sphagnum dominant | | | | | | | |
| | Feathery bogmoss | *Sphagnum cuspidatum* | 75 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 50 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 5 | | | | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | 2 | | | | | | | | | | | | | | | | |
| | Springy turf-moss | *Rhytidiadelphus squarrosu* | 1 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 1 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S18 | | | | 35 | 100 | 0 | 0 | 35 | 84 | 12 | | Drier ling-dominated bog | | | | | | | |
| | Ling | *Calluna vulgaris* | 75 | | | | | | | | | | Most ling stems dead | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 25 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 15 | | | | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | 15 | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bilberry | *Vaccinium myrtillus* | 8 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 5 | | | | | | | | | | | | | | | | |
| | Soft bog-moss | *Sphagnum tenellum* | 5 | | | | | | | | | | | | | | | | |
| | Magellanic bog-moss | *Sphagnum magellanicum* | 5 | | | | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | 1 | | | | | | | | | | | | | | | | |
| | Carnation sedge | *Carex panicea* | 1 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 1 | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S19 | | | | 30 | 100 | 0 | 0 | 2 | 76 | 6 | | Drier ling-dominated bog | | | | | | | |
| | Ling | *Calluna vulgaris* | 75 | | | | | | | | | | Most ling stems living | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | 35 | | | | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | 15 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 5 | | | | | | | | | | | | | | | | |
| | Papillose bog-moss | *Sphagnum papillosum* | 2 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S20 | | | | 30 | 100 | 0 | 0 | 5 | 35 | 10 | | Grassy vegetation inside old landslide | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | 75 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 20 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 15 | | | | | | | | | | All ling stems living | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 15 | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 10 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 5 | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | 1 | | | | | | | | | | | | | | | | |
| | Springy turf-moss | *Rhytidiadelphus squarrosus* | 1 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 1 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S21 | | | | 35 | 100 | 0 | 0 | 15 | 20 | 10 | | Grassy vegetation inside old landslide | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 70 | | | | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 20 | | | | | | | | | | All ling stems living | | | | | | |
| | Feathery bogmoss | *Sphagnum cuspidatum* | 15 | | | | | | | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 15 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 10 | | | | | | | | | | | | | | | | |
| | Devil's-bit scabious | *Succisa pratensis* | 2 | | | | | | | | | | | | | | | | |
| | Soft rush | *Juncus effusus* | 2 | | | | | | | | | | | | | | | | |
| | Common haircap moss | *Polytrichum commune* | 1 | | | | | | | | | | | | | | | | |
| | Heath milkwort | *Polygala serpyllifolia* | 1 | | | | | | | | | | | | | | | | |
| | Star sedge | *Carex echinata* | <1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S22 | | | | 70 | 100 | 0 | 0 | 0 | 0 | 5 | | Rush dominated vegetation inside old landslide | | | | | | | |
| | Sharp-flowered rush | *Juncus acutiflorus* | 95 | | | | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | 40 | | | | | | | | | | | | | | | | |
| | Heath bedstraw | *Galium saxatile* | 10 | | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | 5 | | | | | | | | | | | | | | | | |
| | Common sorrel | *Rumex acetosa* | 1 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| S23 | | | | 25 | 100 | 0 | 0 | 10 | 100 | 9 | | Open bog | | | | | | | |
| | Ling | *Calluna vulgaris* | 95 | | | | | | | | | | Most ling stems living | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 15 | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 10 | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | 10 | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 10 | | | | | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 5 | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mountain fern moss | *Hylocomium splendens* | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 3 | | | | | | | | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | <1 | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S24 | | | | | 20 | 100 | 0 | 0 | 70 | | | 6 | Open bog | Inside fence | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 95 | | | | | | | | | | | | | | | | | | | | | | | |
| | Red bog-moss | *Sphagnum capillifolium* | 70 | | | | | | | | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | <1 | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S25 | | | | | 30 | 100 | 0 | 0 | 0 | 98 | | 9 | Open bog | Outside fence | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | 75 | | | | | | | | | | | Approx. half of ling stems living | | | | | | | | | | | | |
| | Wavy hairgrass | *Deschampsia flexuosa* | 50 | | | | | | | | | | | | | | | | | | | | | | | |
| | Mountain fern moss | *Hylocomium splendens* | 45 | | | | | | | | | | | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | 25 | | | | | | | | | | | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | 3 | | | | | | | | | | | | | | | | | | | | | | | |
| | Hare's tail cottongrass | *Eriophorum vaginatum* | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| | Reindeer lichen | *Cladonia portentosa* | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | <1 | | | | | | | | | | | | | | | | | | | | | | | |

Mount Eagle Botanical Survey Results

| Plot | Species | | Species notes | Vegetation cover | | | Broad habitat type | Notes | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |
| 1 | | | | 25-30% | | | Excavated Firebreak | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | |
| | Compact bogmoss | *Sphagnum compactum* | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | |
| | Purple spoonwort | *Pleurozia purpurea* | | | | | | | | | | | | |
| | Heath milkwort | *Polygala serpyllifolia* | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | |
| | Deergrass | *Trichophorum cespitosum* | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 2 | | | | 100% | | | Heath edge along conifers | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Frequent | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | |
| | Hay-scented buckler- | *Dryopteris aemula* | | | | | | | | | | | | |
| | Reindeer lichen | *Cladonia portentosa* | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | |
| | Rowan | *Sorbus aucuparia* | | | | | | | | | | | | |
| | Lichen | *Cladonia Sp.* | To ID | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 3 | | | | 100% | | | Heath edge along conifers | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Abundant | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | |
| | Hay-scented buckler- | *Dryopteris aemula* | | | | | | | | | | | | |
| | Broom fork-moss | *Dicranum scoparium* | | | | | | | | | | | | |
| | Rowan | *Sorbus aucuparia* | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | |
| | Water earwort | *Scapania undulata* | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 4 | | | | 100% | | | Heath edge along conifers | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Frequent | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | |
| | Broom fork-moss | *Dicranum scoparium* | | | | | | | | | | | | |
| | Rowan | *Sorbus aucuparia* | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | |
| | Water earwort | *Scapania undulata* | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | |
| | Devil's Matchsticks | *Cladonia floerkeana* | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Mount Eagle Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | | 100% | | | Heath edge along conifers | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Frequent | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Broom fork-moss | *Dicranum scoparium* | | | | | | | | | | | | | |
| | Hay-scented buckler- | *Dryopteris aemula* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Cladonia | *Cladonia chlorophaea* agg. | | | | | | | | | | | | | |
| | Rowan | *Sorbus aucuparia* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 6 | | | | 35-40% | | | Excavated Firebreak | Noticeably drier & less diverse than plot 1 | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Isolated tufts | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Isolated bushes | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | large clumps | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | Abundant in wet patch | | | | | | | | | | | | |
| | Heath milkwort | *Polygala serpyllifolia* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 7 | | | | | | | Excavated Firebreak | Dry, bare peat band uphill + wetter vegetated part downhil | | | | | | | |
| Dry sec | Purple moorgrass | *Molinia caerulea* | small isolated tufts | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | small isolated bushes | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Common haircap mo | *Polytrichum commune* | | | | | | | | | | | | | |
| Wet sec | Purple moorgrass | *Molinia caerulea* | More abundant | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Round-leaved sundev | *Drosera rotundifolia* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Compact bogmoss | *Sphagnum compactum* | Hummocks + also small patches on bare peat | | | | | | | | | | | | |
| | Broom fork-moss | *Dicranum scoparium* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 8 | | | | 60% | | | Excavated Firebreak | Dry, more vegetation cover, deep fissures/shears in peat. Above 1st landslide | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Heath milkwort | *Polygala serpyllifolia* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's Matchsticks | *Cladonia floerkeana* | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | | | | | | | | | | | | | |
| | Bramble | *Rubus fruticosus* | In dry bank at uphill side | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 9 | | | | 100% | | | Heath/bog uphill | Fairly uniform & less diverse, covers most of hill above firebreak | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Occasional | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | Frequent | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | Occasional | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 10 | | | | 100% | | | Heath/bog uphill | | | | | | | | |

Mount Eagle Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Frequent | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | Frequent | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 11 | | | | 100% | | | Heath/bog uphill | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | Frequent | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 12 | | | | 100% | | | Heath/bog uphill | Depression - disturbed by peatslide further downhill? | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | Rare | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | Rare | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 13 | | | | 100% | | | Heath/bog uphill | Cracks in peat | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | 100% | | | Heath/bog uphill | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | 100% | | | Heath/bog uphill | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | 100% | | | Heath/bog uphill | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |

Mount Eagle Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | 100% | | | Heath/bog uphill | Directly above failure. Seems slightly wetter (audible underfoot) but not mudd | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | 100% | | | Heath/bog uphill | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Wavy hair-grass | *Deschampsia flexuosa* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 19 | | | | 100% | | | Heath/bog uphill | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | |
| | | | | 100% | | | Heath/bog uphill | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Wavy hair-grass | *Deschampsia flexuosa* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | | 100% | | | Heath/bog uphill | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | Dominant | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |

Mount Eagle Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | | | | 100% | | | Heath/bog uphill | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | |
| | | | | 100% | | | Edge of failure | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | |
| | | | | 100% | | | Edge of failure | | cracks present | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | Heath/bog uphill | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | More common than prev. stops - higher cover over this side | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |
| | Lustrous bog moss | *Sphagnum subnitens* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 26 | | | | | | | Heath/bog uphill | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | More common than prev. stops - higher cover over this side | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 27 | | | | | | | Heath/bog uphill | | | | | | | | |

Mount Eagle Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | More common than prev. stops - higher cover over this side | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | Hoary rock moss | *Racomitrium lanuginosum* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Deergrass | *Trichophorum caespitosum* | | | | | | | | | | | | | |
| | Fescue | *Festuca Sp.* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 28 | | | | | | | Edge of failure | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 29 | | | | Mostly bare peat | | | Excavated Firebreak | | | | | | | | |
| | Cross-leaved heath | *Erica tetralix* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Heath milkwort | *Polygala serpyllifolia* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Eared willow | *Salix aurita* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 30 | | | | 100% | | | Heath edge along conifers | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Broom fork-moss | *Dicranum scoparium* | | | | | | | | | | | | | |
| | Rowan | *Sorbus aucuparia* | | | | | | | | | | | | | |
| | Tormentil | *Potentilla erecta* | | | | | | | | | | | | | |
| | Water earwort | *Scapania undulata* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Little shaggy moss | *Rhytidiadelphus loreus* | | | | | | | | | | | | | |
| | Hay-scented buckler- | *Dryopteris aemula* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 31 | | | | 5% - Mostly bare peat | | | Excavated Firebreak | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Clumps | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Frillwort | *Fossombriona Sp.* | | | | | | | | | | | | | |
| | Feathery bogmoss | *Sphagnum cuspidatum* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Compact bogmoss | *Sphagnum compactum* | | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 32 | | | | 50% | | | Excavated Firebreak | | | | | | | | |

Mount Eagle Botanical Survey Results

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Purple moorgrass | *Molinia caerulea* | | | | | | | | | | | | | |
| | Ling | *Calluna vulgaris* | | | | | | | | | | | | | |
| | Bog asphodel | *Narthecium ossifragum* | | | | | | | | | | | | | |
| | Common cottongrass | *Eriophorum angustifolium* | | | | | | | | | | | | | |
| | Compact bogmoss | *Sphagnum compactum* | | | | | | | | | | | | | |
| | Heath star moss | *Campylopus introflexus* | | | | | | | | | | | | | |
| | Purple spoonwort | *Pleurozia purpurea* | | | | | | | | | | | | | |
| | Reindeer lichen | *Cladonia portentosa* | | | | | | | | | | | | | |
| | Red bogmoss | *Sphagnum capillifolium* | | | | | | | | | | | | | |
| | Round-leaved sundev | *Drosera rotundifolia* | | | | | | | | | | | | | |
| | Heath milkwort | *Polygala serpyllifolia* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Common haircap mo | *Polytrichum commune* | | | | | | | | | | | | | |
| | Papillose bogmoss | *Sphagnum papillosum* | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 33 | | | | 100% | | | Firebreak [between conifers - not excavated] | | | | | | | | |
| | Purple moorgrass | *Molinia caerulea* | Dominant | | | | | | | | | | | | |
| | Hay-scented buckler- | *Dryopteris aemula* | | | | | | | | | | | | | |
| | Heath plait moss | *Hypnum jutlandicum* | | | | | | | | | | | | | |
| | Little Shaggy-moss | *Rhytidiadelphus loreus* | | | | | | | | | | | | | |
| | Bilberry | *Vaccinium myrtillus* | | | | | | | | | | | | | |
| | Hare's tail cottongras | *Eriophorum vaginatum* | | | | | | | | | | | | | |
| | Devil's bit scabious | *Succisa pratensis* | | | | | | | | | | | | | |
| | White earwort | *Diplophyllum albicans* | | | | | | | | | | | | | |

An tSeirbhís Páirceanna Náisiúnta
agus Fiadhúlra
National Parks and Wildlife Service

# The 2022 National Survey of breeding Hen Harrier in Ireland

## Irish Wildlife Manuals 147





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**Keywords:** hen harrier, national survey, special protection areas, breeding, decline, population change, productivity, distribution, Ireland

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Front cover, small photographs from top row:

**A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Common Newt** *Lissotriton vulgaris,* Brian Nelson; **Limestone pavement**, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Garden Tiger** *Arctia caja,* Brian Nelson; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott

Bottom photograph: **Hen harrier** female in flight, Marc Ruddock

# The 2022 National Survey of breeding Hen Harrier in Ireland

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# Executive Summary

Capsule: The hen harrier is a rare bird of prey with a declining population in Ireland. The fifth national survey of the species in Ireland has documented further population declines and a diminished range, both in the wider countryside and within Special Protection Areas (SPAs).

Aim: To examine the abundance and distribution of hen harrier in Ireland, to estimate the change in the population size and distribution across their breeding range nationally and within the six Special Protection Areas (SPAs) designated for breeding hen harrier.

Methods: In 2022, field surveys were undertaken during the breeding season within 10 km squares across the known and/or likely range of breeding hen harrier, using standardised methods employed during previous national surveys (1998-2000; 2005; 2010 and 2015). The latest survey allows an assessment of changes to the population over time. The 2022 national survey achieved high levels of coverage, an estimated 93% of the breeding range, with a minimum of 7,700 survey hours completed by circa 250 surveyors.

Results: The hen harrier population in Ireland was estimated at 85 confirmed and 21 possible breeding pairs (85-106) in 2022. This is a decline of one third (33%) in the total population since the previous national survey in 2015 and a 27% contraction in their breeding range for the same period. A review of data for those squares covered in all surveys (long-term change), and squares covered consistently between consecutive surveys (*i.e.* a subset analyses), indicates that declines in both range and population have occurred in the short-term (2015); medium term (2010/2005) and long-term (1998-2000).

Estimated rates of breeding success and productivity remain low (0.7 fledged young per breeding pair) and are below the minimum recruitment rate (1.0 fledged young per breeding pair) typically required to maintain a stable population. The populations of five of the SPAs have declined by between 20% and 80% since 2007, when they were identified for designation. In the same period, the population for only one SPA has increased (12%). Overall, the SPA populations have declined by more than half (54 %) in the same period.

Conclusion: The hen harrier breeding distribution in Ireland has contracted further since the 2015 survey, and the total national population has also declined. The extent of declines varies locally, regionally and between SPA populations. These ongoing declines warrant continued conservation efforts, surveys (including targeted monitoring), the urgent implementation of the long-awaited national Hen Harrier Threat Response Plan (HHTRP), as well as appropriate resources and funding for the delivery of these actions.

Given the continued declines, and myriad of pressures and threats acting on hen harrier in Ireland, it is also likely the hen harrier will feature on the next Red-list of the Birds of Conservation Concern in Ireland (BoCCI) subject to a full assessment using the BoCCI Red-list criteria. This recommendation will also likely be informed by the specific subset analyses carried out which compared the 2022 results for squares also covered in each of preceding national surveys. These subset analyses have demonstrated a >50% decline since both the first national survey 1998-2000 and the second national survey in 2005.

It is imperative that conservation measures to increase the distribution and abundance of the species are urgently reviewed and all necessary actions to support recovery of the hen harrier in Ireland are implemented.

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# 1. Introduction

Raptors are indicators of ecosystem health (Donázar *et al.*, 2016) and provide important ecosystem services as scavengers and predators (O'Bryan *et al.,* 2018). Over half of the world's raptors are declining (McClure *et al.,* 2018). These declines are linked to the wider global biodiversity crisis (Elbert, 2002; Singh, 2002; Hoag, 2010; Marques *et al.,* 2019; Nature, 2021). This crisis has seen substantial losses in both distribution (and range) and populations of species including raptors (Cruz *et al.,* 2021) and is often interconnected with conservation policy (Bateman & Balmford, 2023). For raptor populations, such declines can have a destabilising effect in trophic chains and biological communities (Lees *et al.*, 2013; Terraube & Bretagnolle, 2018).

Raptor monitoring and surveying are key processes for tracking and measuring the performance of populations over time (Hardey *et al.,* 2013). The data collected can be used to inform conservation status and inform management and actions (McClure *et al.,* 2018). It is important that monitoring provides clear and concise information on what is happening and what changes are occurring and that methods are standardised to ensure the reduction of errors of estimation, improve estimation, and increase robustness of outputs (McClure *et al.*, 2022). Monitoring enables a review of risk and evaluation of the population, assessment of possible actions, and innovation towards shared solutions. Monitoring provides strategic oversight, trend analysis, and target or goal setting. Results derived from monitoring enhance understanding of external factors, context, and national or regional differences. The publication of monitoring information can help improve stakeholder relationships, advocacy, and strategic planning and facilitates feedback loops, population restoration and conservation management.

The hen harrier *Circus cyaneus* is a medium-sized raptor, typically found in upland areas in Ireland and the United Kingdom of Great Britain and Northern Ireland (UK) (Hardey *et al.*, 2013; Ruddock *et al.,* 2016; Wotton *et al.*, 2018). The hen harrier is red-listed in the UK due to historical and continued declines (Stanbury *et al.,* 2021) and is amber-listed in Ireland due to moderate long-term breeding population declines (Gilbert *et al.,* 2021).

The most recent European Red List (BirdLife International, 2021) categorised hen harrier as 'vulnerable' for the 28 European Union Member States (or EU28), including Ireland, and was informed by the best available population and distribution (or range) data. Declines across several European countries in both population size and distribution (or range) have been described previously (Keller *et al.*, 2020; Fernandez-Bellon *et al.,* 2021). Across Europe, the hen harrier is subject to a range of ongoing pressures and threats. The main drivers of its decline are the ongoing loss and degradation of suitable nesting, foraging, and wintering habitats (Amar & Redpath, 2005; Amar *et al. 2003; 2004; 2005; 2007; 2008; 2011*, Arroyo *et al.,* 2009; Redpath *et al.,* 2010; O'Donoghue *et al.*, 2011; Ruddock *et al.,* 2016; Thompson *et al.,* 2016; Wotton *et al.*, 2018; Caravaggi *et al.,* 2020; Fernandez-Bellon 2020; Newton, 2020; Ewing *et al.*, 2023), as well as on-going targeted persecution across its range (O' Donoghue *et al.,* 2011; O' Donoghue, 2019; Murgatroyd *et al.,* 2019).

Historically in Ireland, there was a rapid retraction in the distribution (or range) of the hen harrier from most occupied areas of Ireland between 1875 and 1900, so much so that by the turn of the 20th Century, breeding was confirmed only in south-west Munster and the mountains of Connaught (Thompson, 1849; Ussher & Warren, 1900). Losses were attributed to the destruction of breeding habitat, with localised extinctions first noted on lowland breeding sites, thereby isolating the species in the uplands where they subsequent also declined. In the early 20th century, the upsurge in raptor persecution, as interests in game shooting and game preservation grew, resulted in a significantly diminished hen harrier population in Ireland and Britain (Watson, 1977).

Protective legislation, a reduction in game-keeping activities and planting of young forest plantations in the uplands resulted in the recolonisation of the hen harrier to previously vacated

areas in the second half of the 20th century (O'Flynn, 1983). Between 1950 and 1970, population recovery of hen harriers in Britain likely aided recovery in Ireland, although localised losses continued due to habitat loss and other changes, including agricultural intensification, afforestation, and persecution (O'Flynn, 1983). Hen harriers now breed in sub-optimal forest plantations (Wilson *et al.,* 2012) that have been planted in former breeding habitats, when the trees are in pre-thicket stage (<15 years of age; more typically <12 years of age). However, maturing (>15 years old) plantations are unsuitable, for nesting or hunting (NPWS, 2015a). Nowadays, the hen harrier breeds mainly in the uplands in Ireland, in localised, but fragmented areas of suitable heath and blanket bog and afforested habitats where, in many areas, steep population declines have been evident.

There have been a series of strategic monitoring efforts of the hen harrier in the UK and Ireland, namely the various breeding (and wintering) Bird Atlas surveys which have described the distribution and abundance of the hen harrier (Sharrock, 1976; Gibbons *et al.*, 1993; Balmer *et al.,* 2013) and a number of targeted single-species national surveys, lastly in Ireland in 2015 (Ruddock *et al.*, 2016) and in the UK in 2016 (Wotton *et al.,* 2018). As set out in these aforementioned surveys, the Great Britain population has always been larger than that of Ireland and Northern Ireland given the larger extents there of appropriate open moorland, bog, and heathland habitats (ONS, 2022; CSO, 2021). The interchange *i.e.* movement and dispersal connections, between these island populations has been proven (Etheridge & Summers, 2006).

The UK populations have ranged from 570 ± 150 pairs in 1988-89 (Bibby & Etheridge, 1993); again 570 pairs in 1998 (Sim *et al.,* 2001); and then increasing to 806 pairs in 2004 (Sim *et al.*, 2007); before declining in both subsequent surveys to 662 pairs in 2010 (576-770; Hayhow *et al.,* 2013) and then 575 pairs in 2016 (477-694; Wotton *et al.*, 2018). The first Atlas of Breeding Birds in Britain and Ireland (Sharrock, 1976) broadly estimated 200 – 300 pairs of hen harrier during 1968-1972. Subsequently, Watson (1977) based on expert option (D. Scott) estimated the population at 250 – 300 pairs in Ireland by 1973-75. The second Atlas of Breeding Birds in Britain and Ireland (Gibbons *et al.,* 1993) reported around 180 pairs (All-Ireland).

The hen harrier population in Ireland was first strategically surveyed, via a national survey during the period 1998 – 2000 (Norriss *et al.*, 2002), and in subsequent national surveys of 2005 (Barton *et al.,* 2006), 2010 (Ruddock *et al.*, 2012) and 2015 (Ruddock *et al.,* 2016). The first national survey recorded 102 – 129 pairs (Norriss *et al.,* 2002). Apparent national increases were recorded in the two subsequent surveys in 2005 (132 – 152 pairs; Barton *et al.,* 2006) and 2010 (128 – 172 pairs; Ruddock *et al.,* 2012) although survey effort was also increased during those surveys. During the 2015 survey, there were 108 – 157 pairs of hen harrier recorded which was a decline from previous surveys. Sub-set analyses, which were comprised of an assessment of hen harrier breeding pairs in survey squares which were surveyed across two or more national surveys, further confirmed like-for-like comparative results, corroborating those declines (Ruddock *et al.*, 2016). The hen harrier population in Ireland increased during the period of the first two national surveys but has steadily declined since the 2010 national survey.

The Northern Ireland surveys are part of the UK national survey sampling regimen; there have been five published national surveys of the hen harrier in the UK and Isle of Man. In Northern Ireland, there were 10 pairs recorded in 1989/90. However, the coverage of that survey was thought to be incomplete (Bibby & Etheridge, 1993). The follow-up survey in 1998 recorded 38 territorial pairs (Sim *et al.*, 2001); 63 territorial pairs were recorded in 2004 (Sim *et al.*, 2007), 59 territorial pairs were recorded in 2010 (Hayhow *et al.*, 2013) and the fifth survey (2016) recorded 46 pairs (Wotton *et al.,* 2018). A sixth national UK survey (including Northern Ireland) got underway in 2023, with results expected in 2024. In an All-Ireland context there were 130 – 167 pairs (All-Ireland) reported based on the 28 – 38 pairs reported in Northern Ireland by Sim *et al*., 2001) combined with a national population estimate in Ireland of 102 – 129 pairs (Norriss *et al.,* 2002). This estimate was lower than the Gibbons *et al.,* (1993) estimated population of 180 pairs (All-Ireland).

The conservation status of the species on an all-Ireland basis was downgraded from Red to Amber on the Birds of Conservation Concern in Ireland list in the early 2000s (Newton *et al.,* 1999; Lynas *et al.*, 2007) due to the numbers recorded at the time (including the 1998-2000 national survey; Norriss *et al.*, 2002). In the intervening Red-list updates since then, it has been assessed as Amber, including in the fourth assessment of Birds of Conservation Concern in Ireland (Gilbert *et al.,* 2021). The species has remained Red-listed in the UK throughout these same decades, including the most recent assessment (Stanbury *et al.,* 2021). Regular surveys of rare or scarce species are necessary to establish their status, including spatial distribution and abundance and changes therein, in order to inform conservation assessment and prioritisation of actions required.

Article 12 of the EU Birds Directive requires that Ireland prepares a report on the implementation of the Directive, now every six years. This is to include information on the status and trends of all bird species occurring here. In part fulfilment of this obligation, Ireland undertakes a national survey of the hen harrier, typically every five years, including at the six Special Protection Areas (SPAs) (see www.npws.ie/protected-sites); namely (i) the Slieve Bloom Mountains SPA (Site code: 4160); (ii) the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 4161); (iii) the Mullaghanish to Musheramore Mountains SPA (Site code: 4162); (iv) the Slievefelim to Silvermines Mountains SPA (Site code: 4165); (v) Slieve Beagh SPA (Site code: 4167); and (vi) the Slieve Aughty Mountains SPA (Site code: 4168). Overall, the total SPA population declined by 18.1% between the 2005 and 2010 national surveys (Ruddock *et al.,* 2012) and by 28% between the 2010 and 2015 national surveys (Ruddock *et al.,* 2016).

This survey (2022) is the fifth national survey. The Golden Eagle Trust, Irish Raptor Study Group and BirdWatch Ireland formed a partnership to co-ordinate the 2022 Irish Hen Harrier Survey on behalf of the National Parks & Wildlife Service of the Department of Housing, Local Government and Heritage (DHLGH). The national survey has five key objectives:

- Obtain a reliable estimate of the size of the hen harrier breeding population in Ireland in 2022;
- Obtain a reliable estimate of the distribution of the hen harrier breeding population in the Ireland in 2022;
- Estimate the change in population size and distribution since the last surveys in 1998 – 2000; 2005; 2010; and 2015;
- Compare the distribution and size of the hen harrier populations within the six Special Protection Areas (SPAs) since the surveys in 2005, 2010 and 2015;
- Review and document ancillary data collected during 2022, including any details on breeding habitats, breeding success and productivity and pressures and threats.

# 2. Methods

## 2.1 Objectives

To establish population estimates, the primary objective of the hen harrier survey is to identify whether suitable habitat is present and occupied by breeding hen harrier. Secondary objectives are to establish whether a breeding attempt was initiated and to establish breeding outcome (*i.e.* success or failure of a nest and, if successful, establish the number of fledged young).

## 2.2 Survey design and implementation

The primary areas identified for survey within the breeding range of the hen harrier were defined as those 10 km national grid squares within which hen harrier were observed during the four national surveys completed thus far and which will be referenced using the titles below for the remainder of this report:

- 1998-2000 survey (Norriss *et al*., 2002)
- 2005 survey (Barton *et al.,* 2006)
- 2010 survey (Ruddock *et al.,* 2012)
- 2015 survey (Ruddock *et al.,* 2016)

Collectively, the above surveys are referred to as 'previous national surveys'.

Potentially suitable breeding areas for hen harrier were identified as mountain ranges/upland areas previously defined by Norriss *et al.,* (2002; Table 9). Hen Harriers nest across a range of elevations (36-385 m a.s.l.), but largely are confined to upland locations (>100 m to <600 m a.s.l.); O'Donoghue, 2010; Ruddock *et al.,* 2016). These areas were divided into individual survey units using the 10 km x 10 km national Irish grid squares and further defined within a series of mountain or upland ranges (see also previous national survey).

In addition to above sources, squares were included where recent occupation by hen harrier during the breeding season was known from other reliable sources. Such sources included supplemental records from 2006 to 2021 provided by the Irish Raptor Study Group (IRSG) annual monitoring scheme, the NPWS' species database, BirdWatch Ireland (BWI) raptor sightings database, ecological consultant data primarily from reports for wind energy developments and Environmental Impact Assessment Reports (EIAR) and a review of hen harrier records from the Breeding Bird Atlas data (2007 to 2011 inclusive; Balmer *et al.,* 2013). In addition, squares within the historical range of the species and/or known to contain suitable nesting habitat were also included.

This yielded a total of 327 10 km squares that were known to previously support breeding hen harrier and/or suitable breeding habitat in the Ireland during the period 1998 to 2021. The squares were prioritised, by prior known breeding status (see below; Appendix 6), for survey coverage and allocated amongst surveyors as follows:

(i) 105 'green' squares where breeding had been confirmed (see Barton *et al.,* 2006; Ruddock *et al.,* 2012; Balmer *et al.*, 2013; Ruddock *et al.*, 2016) in the period 1998–2021;

(ii) 28 'yellow' squares where breeding had been recorded as possible (see Barton *et al.,* 2006; Ruddock *et al.*, 2012; Ruddock *et al.,* 2016) in the period 1998–2021;

(iii) 129 'orange' squares in which hen harrier had been sighted in the period 1998–2021 and/or where suitable habitat was recorded; and

(iv) 65 'red' squares which had no historical hen harrier sightings, but which contained known or potentially suitable breeding habitat.

Geo-referenced OSI 1:50,000 maps and aerial photographs for each of the 10 km survey squares survey were digitised using ArcGIS 10.8 and provided to surveyors. The maps included the OSI 1:50,000 background showing habitat, contours, and a labelled 1 km grid layer to allow calculation of spatial references for sightings, nest locations *etc.* derived from the field maps. The aerial photographs (taken in 2018-2021) showed in further detail the extent of forest boundaries and allowed discrimination between improved grassland and unimproved grassland or moorland and afforested habitats.

The names and contact details of potential surveyors were derived from the contact databases of regional hen harrier researchers, the NPWS staff, the Irish Hen Harrier Winter Survey volunteers, Golden Eagle Trust staff and members, IRSG members and volunteers, BirdWatch Ireland staff, members, and volunteers, ecological consultants, and other independent raptor surveyors. Workshops were publicly advertised for people to join the mailing lists and participate, and all survey planning and storage of information was done in compliance with organisational data management procedures. Surveyors were invited to participate in the survey and also to attend training workshops via email and telephone contact. Online workshops and training events were undertaken to disseminate standardised fieldwork methods, distribute maps and aerial photographs and allocate survey squares and field-based training sessions were undertaken as required; group visits were also undertaken during the survey season.

## 2.3 Defining survey areas

The survey areas were defined by the Irish 10 km grid squares (see Figure 1) and included for selection based on previous records of breeding hen harrier and/or containing suitable breeding habitat. Prior to commencing the survey, surveyors used maps and aerial photographs of each 10 km grid square to exclude unsuitable habitat, identify areas of potentially suitable hen harrier breeding habitat and locate suitable vantage points for timed observations. The suitability of these areas was confirmed during the first visit by driving or walking through the square to "ground-truth" likely breeding habitats and vantage point locations.

As per the approach taken in previous surveys, suitable breeding habitat was defined as heather dominated and/or grass moorland, other open habitats with extensive scrub or bramble cover and developing pre-thicket forest (first and second rotation crops). The following areas were classified as unsuitable habitat and were excluded on maps and from further survey effort (see Hardey *et al.*, 2009; 2013):

- Ground above 600 m;
- built-up/urban areas or within 100 m of occupied farms and dwellings;
- improved pasture and arable farmland; the interior of unbroken, closed-canopy forest blocks;
- sheep-walk (*i.e.* enclosed or unenclosed areas of heavily grazed sheep pasture); extensive areas of bracken;
- degraded or overgrazed upland areas without any heather cover; and
- areas within close proximity to sea-cliffs, inland crags, rocky outcrops, boulder fields and scree slopes.

Particular attention was paid to:

- heather moorland which contains stands of deep (usually >0.4 m tall), well-drained heather with more than 50% cover;
- areas with good all-round visibility such as slopes and river valleys;

- deep heather areas within forest clearings;
- forest rides, and pre-thicket stage forest; and
- heather at the edges of forest plantations.

The latter category is usually found where livestock are excluded by fencing associated with afforestation and/or unplanted areas within the forest ownership boundary. Grass-dominated and degraded moorland that contained patches of deep heather or other shrub cover were also surveyed. Other shrub-dominated areas such as river valleys, abandoned fields and bogs with scrub cover were included as potentially suitable habitat for hen harrier in the survey. Pre-thicket coniferous forests were surveyed, and particular attention was paid to areas where forest compartments are characterised by prolific shrub layers. In Northern Ireland, tree-nesting hen harrier have been recorded (Scott, 1991). However, in Ireland mature coniferous forests were only surveyed as part of the 2022 survey where hen harrier observations were regularly associated with post-thicket stage plantations since harriers will often nest in rides or open lacunas within mature plantations. Tree-nesting hen harrier have not been recorded in Ireland and this behaviour appears limited to Co. Antrim only.

In addition, areas of scrub (*e.g.* willow and bramble), often on the edges of moorland or bog, were surveyed for occupancy by hen harrier. Suitable habitat within all survey squares (see Section 4.2) was preferably to be visited on four occasions between late March and the end of July, and three visits was the minimum required.

## 2.4 Hen harrier field surveys

Surveys in 2022 followed the same methods prescribed for previous national surveys. The surveys involved fixed vantage point methodology following prescribed visit schedules observing suitable habitats. Two visits to establish territorial occupancy were required, with the first visit to occur between late March and mid-April and the second between mid-April and mid-May.

These two visits were the most important as this helps identify where the hen harrier territories may occur. A third survey visit was recommended (but not essential) between late May and late June to establish evidence of breeding, with particular emphasis on locating active nests, where these were not already located. A fourth visit was required between late June and the end of July to confirm nest activity and whether fledged young had been observed to establish breeding outcome.

These survey visits were timed to reflect the seasonality of the hen harrier breeding activities (see Table 2) and includes the periods of territorial display/mate advertisement, incubation, nestling and fledgling periods (Hardey *et al.,* 2009). The additional visit between late May and late June was to increase the likelihood of detecting a nest location (Hardey *et al.,* 2013) when valuable data can be obtained via hen harrier sightings (see Appendix 1).

## 2.5 Data recording and data entry

Surveyors were tasked to record key data including contact information; survey effort (location & duration); hen harrier observations (date, time, location, behaviours & habitat); other priority bird species (*i.e.* other raptor species; breeding wader species; red grouse) observations (location & behaviour) and any observed pressures and threats to the harrier in the survey area.

Where available, surveyors were also provided with additional information including any previously used vantage point locations, previously defined suitable habitats, and historical hen harrier sightings from previous national surveys. Surveyors were advised that the habitats and/or habitat suitability may have changed since the previous surveys and similarly any hen harrier may have moved since previous surveys or visibility of vantage point locations may

have changed since previous surveys (*e.g.* increased forest height). It was outlined to surveyors that it was important for them to familiarise themselves with the suitable breeding habitats in the chosen 10 km square(s) and survey all areas that contain suitable breeding habitat for hen harrier.

Surveyors utilised the provided maps and aerial photograph of the allocated 10 km square(s) and used a different map and recording form for each visit to an area of suitable habitat to record the surveyed areas and the locations of hen harrier sightings and/or nests. The key tasks for surveyors prior to and during the field survey were to familiarise themselves initially with the field map, suitable hen harrier habitats, main roads, and potential vantage point locations (such as elevated hills or topographical features). Aerial photographs assisted with the exclusion and mapping up of unsuitable habitat prior to first visits, but surveyors were also made aware these photos may have been taken a few years earlier and some habitat changes may have occurred. Subsequently, during the first field visit, any further unsuitable hen harrier habitats were marked, and mapped accordingly on field maps.

During vantage point watches, surveyors marked the area visible during observations, and vantage point grid references were recorded in the main recording form. Where nest areas were located, surveyors marked these with an X on the map and/or provided a grid reference, based on the estimated nest site location derived from their behavioural observations. Surveyors were advised to complete the survey form during each vantage point watch and finalise forms at the end of the survey day. Surveyors were required to submit nil return sheets even if there were no sightings, and to record all survey effort details, habitat suitability, activities, threats, or pressures on the habitat for nesting hen harrier.

Surveyors were also required to record data in a standard way on either hard copy forms, Microsoft Excel data forms or through a Survey123 online portal. Records derived from vantage point watches and/or casual sightings were recorded throughout the survey period. All survey data entry forms captured the same data (see Table 5). Casual sightings, which are ad hoc observations seen by observers out with a timed vantage point survey, of hen harrier in squares were also welcomed and were submitted on a recording form for the relevant 10 km square as casual sightings.

Surveyors documented pressures and threats using standardised criteria (see Appendix 2 & 3), as per previous national reporting under the EU Birds Directive (*i.e.* Article 12) (see Ruddock *et al.,* 2016) and although an in-depth examination/assessment of pressures will not be covered here, summary information is presented in the report.

## 2.6 National and regional population estimates, population change and breeding density

As detailed in previous national surveys (Ruddock *et al.,* 2016), territories, *i.e.* areas of suitable habitat, were all classified according to observed breeding activity as ‘confirmed’, ‘possible’, ‘seen’ or ‘not seen’. To ensure comparability, the same criteria were used for these categories as in previous surveys (see also Barton *et al.,* 2006; Table 4). A territory was considered to be occupied by a pair (‘pair-occupied’) if two birds were seen simultaneously within the territorial home range. A territory was considered to be ‘single occupied’ if only one bird had been observed and this individual could be excluded from belonging to a neighbouring territory by independent observations (or by the absence of a known neighbouring territory).

Where a territory was classified as confirmed or possible despite only a single bird having been recorded during observations, it was deemed to be either a confirmed breeding pair (*e.g.* where only a female was observed carrying food to an active nest and no male was seen; see Table 4) or a possible breeding pair (*e.g.* male bird seen displaying on multiple occasions and could be discriminated from separate territories; see Table 4). The survey co-ordinators analysed all raw data provided, with a view to ensuring independent territories were correctly identified and/or where necessary, clarified the status of the territory with regional co-ordinators and directly with surveyors.

The key criteria used to classify status were the display of territorial and/or breeding behaviours indicative of breeding and the repeated presence of birds at/near the same location. This minimises the risk of over-estimation of breeding activity that would occur if sightings of foraging activity or birds that were only casually, or temporarily, present in an area were included. Throughout the report, these territorial classifications are termed 'confirmed' or 'possible' breeding pairs.

National and regional population estimates for breeding hen harrier were derived by adding the total number of confirmed territories to the number of possible territories to obtain minimum and maximum population estimates *i.e.* the range of confirmed to confirmed + possible territories. Where estimates were available from the 1998–2000 (Norriss *et al.,* 2002), 2005 (Barton *et al.,* 2006), 2010 (Ruddock *et al.,* 2012), and 2015 (Ruddock *et al.,* 2016) hen harrier surveys, the national and regional population changes were examined by calculating the percentage change in the estimates across the five surveys. Additional estimates of national population change were derived by comparing the total number of pairs found in the subset of squares surveyed during the previous national surveys and held in the NPWS 1998–2005 database (Norriss *et al.,* 2002; NPWS, unpublished data).

In this report, three separate subset analyses were undertaken to compare the hen harrier numbers in; (i) squares surveyed in both 2022 and 2015; (ii) squares surveyed in 2022; 2015; 2010 (iii) 2022; 2015; 2010 and 2005; and (iv) the subset of squares surveyed in all five national survey periods 2022; 2015; 2010; 2005 and 1998–2000. The use of such subset analyses reduced the risks of biases created by changes in survey effort and survey areas over time and allows direct comparison of changes between survey periods. Despite survey effort and survey area increasing over time, total numbers of squares covered in each of the subset analyses has declined (i: n = 212; ii: n = 125; iii: n = 105; iv. n = 74). Nonetheless, this subset analyses allows for the most comparable estimates of change, *i.e.* increase or decline, over time.

Whilst breeding pairs in the national surveys are defined based on categorical (behavioural) observations, to provide comparison between survey years, the mid-point value of each of the survey ranges ('confirmed pairs' to 'confirmed + possible pairs') was also used to establish any increase or decrease in pairs between surveys. Mid-point values can be used in population estimates (Anthony *et al.,* 1999) to compare 'calibrated' figures, particularly where effort varies between surveys (Cao *et al.,* 2008). Therefore, no weighting of this mid-point estimate was given to the discrete categorical classification of breeding pairs, but rather it provides a further comparison of population estimates between surveys. To identify high density areas, the number of pairs within each 10 km square was reviewed and classified as a 'high density' square where a minimum of three confirmed or possible territories were recorded following the methods of Barton *et al.,* (2006).

## 2.7 Population estimates, population changes and habitat composition within SPAs

Estimates of population change were calculated, where possible, for the six breeding hen harrier SPAs. The areas that were surveyed during both the 2005 (pre-designation); 2010; 2015 (post-designation) and 2022 surveys were identified, and the numbers of breeding pairs found were compared between the four surveys. This was achieved, firstly, by comparing the 10 km square summaries for each of these areas between the four surveys. Secondly, to increase the accuracy of the estimates, a point feature database was created in ArcGIS 10.8 of all confirmed and possible territories recorded in the survey and calculating the number of territories within the polygon (downloaded July 2023) of each SPA boundary.

Territory locations for this analysis were plotted at a six-figure grid reference resolution, if the nest was located and at a four-figure grid reference resolution if no nest was located and the area of key breeding behaviours was plotted within a specific 1 km square. That is, the territory is plotted centrally by convention *i.e.* centrally in the 1 km square of breeding activity. Due to

the spatial error associated with plotting such grid references, where territories were near the polygon boundary, the distance from the point to the boundary was calculated to assess inclusion in, or exclusion from, the SPA. This was to establish if the territory was within 100 m of the boundary for six figure grid references and within 1000 m of the boundary for a four-figure grid reference. The number of breeding pairs in 2022 in each SPA was also compared to the population counts used to identify the candidate SPAs selection in 2007 (see Norriss *et al.,* 2002, Barton *et al.*, 2006) and which were subsequently designated as SPAs.

A further spatial analysis was undertaken to establish the number of territorial pairs that were located within 500 m and 2 km of each SPA boundary and that may be dependent on the SPAs for breeding season requirements *e.g.* foraging. This was undertaken by using the proximity tool in ArcGIS to create a buffer to allow identification of those adjacent territories within 500 m and 2 km.

## 2.8 Breeding outcomes and habitats utilised

The breeding activity at nest locations was established through behavioural observations from vantage points at a distance from nest sites (Hardey *et al.,* 2006; 2009; 2013). Nest visits were not required as part of the survey effort.

Behavioural observations were used to infer the status of nesting attempts as to whether incubation had started. That is, before incubation begins, females typically do not fly from the nest to receive a food-pass from the male, and do not return to the nest directly after feeding. After incubation has begun, however, females tend to fly directly from their nests to receive food-passes, and fly back to the nest after feeding, often carrying nest material. Behavioural evidence was also used to infer hatching, after which females (and, later on, males) deliver prey directly to the nest. The female usually removes prey remains from the nest following feeding until the young are well-feathered and approaching fledging. Therefore, post-season nest visits can also be useful in establishing breeding outcome (Hardey *et al.,* 2009). NPWS-licensed surveyors visited a sample of nest sites after the nests were no longer in use to establish status and/or location information. Nest visits during active breeding efforts were not undertaken during 2022 and to avoid potential disturbance (Hardey *et al.,* 2006; 2009; O'Donoghue, 2010; Hardey *et al.,* 2013).

Territories were classified as 'successful' when at least one young fledged from a confirmed breeding territory (Green & Etheridge, 1999; Barton *et al.,* 2006). Breeding failure was determined either (i) no activity was recorded on third and fourth visits to the area of a previously-known active nest; (ii) if no fledged chicks were observed during at least two visits between early July and the end of July; or (iii) if late-season, licensed nest visits 'post-breeding' confirmed that the breeding attempt had failed. Territories with an uncertain breeding outcome, when no fourth visits (during late June to the end July) were conducted or when no evidence was provided by the surveyor that a breeding attempt was initiated were classified as 'outcome unknown'.

Where nest locations were identified, habitat was broadly classified within 100 m of the nest as one of the following: heather/bog; first rotation forest; second rotation forest; failed forest; scrub (where isolated from plantation forest); mature forest (*i.e.* tree nests), or unknown, where the precise nest location was not explicitly identified.

# 3. Results

## 3.1 Survey implementation, coverage, and data submission

A range of online and field-based training workshops were undertaken for the survey to recruit surveyors and to ensure a minimum standard of survey experience and knowledge across all surveyors before its commencement. There were more than 500 potential participants contacted and invited to participate from the respective organisations (IRSG, BWI, GET and NPWS). Relevant information about the training, workshops, and the potential 10 km squares for survey, was published on the project website (www.irishhenharriersurvey.com). The details of the survey were also shared across social media and email platforms to reach a wider network of potential surveyors across Ireland.

The training workshops took place online on 15 March, 22 March and 26 March 2022. A total of 176 people registered for both the online training events and to indicate their willingness to participate in covering the various 10 km survey areas. Subsequent to the workshops, 155 participants registered to undertake a survey square. Following the collation of survey data, an additional 74[1] surveyors submitted supplementary 10 km records and/or casual sightings. A total of 249 observers contributed to the survey which compares to a total of 259 participating during the 2015 survey.

In order to minimise the duplication of effort, across the country, co-ordinators were allotted to three respective sub-regions, as utilised in 2015 (see Figure 1). Respective co-ordinators undertook the liaison with surveyors directly in each of those regions. Regular team meetings between the regional co-ordination teams consistently reviewed survey coverage and square allocations throughout the survey season to maximise allocation of squares and to identify any gaps in coverage that would need to be addressed.

The Hen Harrier European Innovation Programme (HHP)[2] monitoring team continued the survey of the SPAs during 2022, while volunteers and other surveyors focused on areas outside the SPAs. The Northern Ireland Raptor Study Group (NIRSG) assisted in covering 10 km survey squares that included parts of Northern Ireland, with participation from an additional 23 surveyors. The NIRSG also undertook to survey the Northern Ireland population to inform a wider All-Ireland population estimate.

Data from the 2022 survey were inputted to the bespoke Survey123 ® data portal that was developed for the purposes of the survey. Data submissions were requested on or before the 31 August 2022, but all required final submissions were not received until 24 February 2023, with further lengthy scrutiny required on foot of final submissions. The allowance of time and facilitation of extended data submission periods is important to ensure all collected data is obtained and adequately incorporated within the final survey report and outputs. Several hundred hours of work were undertaken by the regional co-ordination teams to obtain data submissions and to input any hard copy data received into the standardised Survey123 data portal.

For the 2022 survey, the survey squares, including those used in 2015 (n=308) were reviewed and 327 10 km squares were initially identified as potentially suitable and/or known to be within the historical breeding range of the species. Nineteen of these 10 km squares were defined as unsuitable or no longer suitable for hen harrier and were excluded from overall survey effort. Casual sightings were received for three of these 19 excluded squares and these sightings

[1] 27; 46; 21 observers from the respective workshops

[2] The HHP was funded by the Department of Food and Marine (DAFM) to deliver a results-based landscape-scale habitat management programme for hen harriers and monitored the six hen harrier Special Protection Areas (SPAs) in Ireland annually between 2017 and 2022.

indicated two of the 10 km squares had hen harrier seen and/or sightings were made outside of the breeding season and were known wintering sites.

Therefore from the 327 squares as potentially and/or historically suitable, 46 were not suitable at the time of the survey for breeding harrier with an additional 26 squares considered to be of marginal suitability and/or rendered mostly unsuitable during the survey year by virtue of recent burning activity and therefore unsuitable habitats within squares was not surveyed further (see Appendix 6). There were 272 of the 327 squares initially allocated for coverage (*i.e.* 83%), of which 31 squares were defined as unsuitable and/or no-longer suitable for breeding hen harrier. Nineteen of the allocated squares were considered to have marginal suitability of breeding habitat for hen harrier.

The total allocation of 272 survey squares to all surveyors from the known / recent / likely breeding range of hen harrier was broken down across the following:

- 101 of 105 (95%) 'green' squares (see Methods; Figure 1)
- 26 of 28 'yellow' squares (93%)
- 101 of 129 suitable 'orange' squares (78%) and
- 44 of 65 of suitable 'red' squares (68%).

Final data submissions obtained information from 258 squares within the priority allocation as 'green' 100 (95%); yellow 24 (86%); orange 93 (72%) and red 41 (63%) respectively.

Levels of coverage were comparative to the 2015 survey (which achieved 100%; 82%; 73%; 67% of green, yellow, orange and red squares respectively) and higher than 2010 survey (85%; 52%; 51%; 34%). There was a notable increase in the assessment by surveyors of squares categorised as unsuitable or of marginal habitat suitability (22%) in 2022 compared to the 2015 survey (14%). Consequently, these squares were not typically covered extensively during the survey, which decreased apparent survey coverage within all the priority categories.

Within each of the above priority categories there were 7; 2; 48 and 15 squares considered to be unsuitable or of marginal suitability during the 2022 survey which reflects an apparent deterioration of habitats since the previous survey (Appendix 6). This included nine squares (3%) which had previously (2015) held confirmed and/or possible breeding pairs of hen harrier. Sizeable proportions of the orange (37%) and red (23%) squares were defined as not suitable for hen harrier.

Data was received for 13 additional 10 km squares in 2022 that were not identified within the original survey planning. Most of these records were derived from casual sightings although two squares that were not previously covered in national surveys held a single confirmed pair each of hen harrier. Data was not received for 33 10 km squares (see Appendix 6) in time for inclusion in analyses, although it is understood that survey coverage was undertaken and that no further pairs of hen harrier were encountered during the completed visits and/or habitat was no longer suitable for the hen harrier.

## 3.2 Survey effort and observations

A minimum of 3,279 visits were undertaken across the survey areas. This is similar to 2015 (3,296; Ruddock *et al.*, 2016) and higher than 2010 (2,712; Ruddock *et al.,* 2012). Records received spanned from 4 January 2022 to 23 January 2023. Most visits were conducted during the breeding season (1 March–30 August; n= 3,011) whilst the remainder were undertaken prior to the survey commencing (n = 254; 8%) or after the breeding season *i.e.* post August (n = 14; 0.5%).

The standardised data submissions via the Survey123 portal increased the analytical and cross-referencing ability of the co-ordination team in order to follow up on data submissions and surveyor records. Hard copy and/or excel data records and maps were digitised by the regional co-ordinators within the online portal system.

Survey visits within the survey schedule (Table 1) were completed as 1 March – mid April (Visit 1: 59%; n = 777; range 0–30 visits); mid-April – mid-May (Visit 2: 62%; n = 947; range 0–23); mid-May – mid-June (Visit 3: 42%; n = 581; range 0–18) and mid-June – end July/August (Visit 4: 53%; n = 706; range 0–15).

Survey effort comprised 7,704 hours, which is more than the 7,225 hours during 2015 and considerably greater than 2010 (4,074 hours). Survey visits were conducted between 0515h and 2300h and surveys ranged in duration from 5 minutes to 15 hours 45 minutes, with an average duration of 2 hours and 32 minutes.

Records ranged from null (*i.e.* none seen) to six birds per individual sighting in 2022 and a total of 1,872 hen harrier sightings made during the survey. This number of sightings, despite similar survey efforts, is lower than previously in 2015 (2,222) and therefore a 16% decrease in sightings overall was recorded. Most of the detections in 2022 were males (73%; n = 1117) followed by females (41%; n = 620); sub-adult males (2%; n = 37) and juveniles (6%; n = 98). Like previous surveys, habitat classifications and behaviours were recorded for each sighting, as well as observations of pressures and threats. No further interpretation of the breakdown of these sightings results (by habitat or behaviour or pressures) is being undertaken within this analysis (see Appendix 1 for summary sightings table for 2022 and previous national surveys).

## 3.3 National and regional population estimates, population change and breeding density

### 3.3.1 National status

The 2022 survey identified 85 confirmed and 21 possible territorial hen harrier sites (85-106) in Ireland. This represents a decline from all the previous national surveys including 2015 (108–157); 2010 (128–172); 2005 (132–153; and 1998–2000 (102–129) (refer to Table 11). The percentage decrease, based on maximum population estimate (confirmed + possible) from each of these surveys is -33% (since 2015), -38% (since 2010), -31% (since 2005), and -18% (since 1998-2000) respectively meaning the population has declined from all previous estimates and now comprises only around 100 pairs (Table 6).

A review of mid-point values (see Ruddock *et al.*, 2016) reveals that, between the 2022 and 2015 surveys, the population has declined by 28% (Figure 3; Table 6). Survey effort was relatively similar during 2022 and 2015, therefore reducing the likelihood of bias regarding estimates of population size or change between surveys.

In 2022, 48 10 km squares were confirmed with breeding hen harrier and a further 13 10 km squares contained at least one possible breeding hen harrier territory. The total breeding range therefore spanned 48–61 10 km squares, a decline from 2015 (62–84 squares) and more akin to the earlier survey results from 1998–2000 and 2005 (Table 7). Also in 2022, 64 squares were classified as ‘seen’ and 126 squares classified as ‘not seen’ and various regional changes are evident across the species distribution plotted from 2022 (Figure 4) and compared to previous surveys (Figures 6–9; Ruddock *et al.*, 2016).

The density and number of hen harrier recorded within each 10 km square varied between 1 – 10 confirmed territories and between 1–2 possible territories. Most confirmed breeding 10 km squares contained between 1 and 4 territories and only a single 10 km square contained more than four, with a remarkable 10 territories recorded. Nationally, the density of territories per 10 km square appears to have largely decreased (Figure 10) and various regional changes are evident across the species distribution plotted from 2022 (Figures 6–9; 11) and compared to previous surveys (see Ruddock *et al.,* 2016).

### 3.3.2 Subset Analysis (1998/2000 - 2022)

Various subset analyses of the 10 km squares that were covered in each sequential survey, allows for like-for-like comparisons to examine range trends and population change over the short term (2022–2015), medium term (2022-2015-2010), longer term (2022-2015-2010-2005) and since national surveys began (2022-2015-2010-2005-1998/2000). Each of these comparative analyses show declines across the species range, including up to the 2022 survey. Based on total population estimates (confirmed + possible), these declines amount to

- 35% in the short term (2015);
- 34-46% (2010) in the medium term;
- whilst longer term the declines are between 37% and 48% since 2005; and
- between 37% and 59% since national surveys commenced (1998/2000).

Overall, since the first national survey of 1998/2000, the population has decreased by up to 59% across those consistently surveyed areas and includes losses across most regional populations (see Table 9).

### 3.3.3 Regional changes

The various regional populations across Ireland have been monitored and reported on since the first national survey in 19982000 (Norriss *et al.,* 2002). These areas have fluctuated between different national surveys with declines and increases in some areas between survey years and various regional extinctions, which appear to have taken place during the past 25 years.

At least 15 of the regional populations, (see map in Barton *et al.,* 2006) scattered across the island, have seen further declines based on comparison of the 2015 and 2022 figures. Several of these defined regional populations (see Norriss *et al.,* 2002) includes lands within the now defined SPAs for breeding hen harrier, particularly the Devilsbit, Slievefelim, Silvermines, King Hill; the Slieve Aughties; the Slieve Blooms; the Stack's, and Glanarudderies, Knockanefune, Mullaghareirks, north of Abbeyfeale (see Section 5.4). Some of the regional populations have declined by more than 25% and up to 100% in some cases, such as at the Nagles and in several other regions where no pairs were recorded in 2022 (Table 9).

Declines of more than 25% were recorded within the Ballyhouras; Blue Stack Mountains, Pettigo Plateau & south Donegal; Devilsbit, Slievefelim, Silvermines, King Hill; Galtys; Knockmealdowns, Kilworth, Comeraghs; Leitrim, Slieve Rushen & Cavan; Longford, Roscommon; Nagles; Slieve Aughties; Slieve Bernagh to Keeper Hill; Slieve Blooms; west Cork; and Wexford.

Some of the regional populations appear relatively stable since the last national survey and/or exhibit smaller declines (10-25%) within the range and since the previous national survey including east Cork & Waterford; north & west Clare; Slieve Beagh; and Stack's, Glanarudderies, Knockanefune, Mullaghareirks, north of Abbeyfeale.

During 2022, three areas have exhibited small increases since the 2015 survey which includes Boggeraghs, Derrynasaggarts (1-3 pairs); West Kerry (1 pair) and newly identified areas since 1998-2000 *i.e.* beyond the original survey range in Other Areas (1-2 pairs; see Table 9). Single sightings of flying ringtail[3] hen harrier within the north-west (north of Nephin Beg) and Wicklow (north-east of Lugnaquillia) were recorded during the breeding season. Neither of these exhibited breeding behaviours or were recorded subsequently, despite extensive prior and follow up-surveys across the range of suitable habitats in these two regions; records were defined as 'seen' only.

[3] *i.e.* either females or juveniles, both with white rump and dark rings, often referred to as ringtails

Some of the known historical regional populations appear functionally extinct for breeding purposes including Castlecomer, Blackstairs, Kilkenny; Curlew Mountains; Inishowen Peninsula; Kildare; Longford-Roscommon; north-west; Ox Mountains; west Cork; Wexford and Wicklow Mountains although some do contain wintering hen harrier. In 2022, there was confirmation that some regional populations held no breeding pairs (see Table 9) and have not done so for the last number of national surveys. No known breeding hen harrier has been recorded for the past 10 to 20 or so years in Castlecomer, Blackstairs, Kilkenny; Curlew Mountains; Inishowen; Kildare; the north-west; Ox Mountains; and Wicklow Mountains.

## 3.4 Population estimates, population changes and habitat composition within SPAs

The 10 km squares across the six breeding SPAs held a recorded 48 – 55 breeding territories which is fewer than previous surveys 2015 (55–77), 2010 (69–94) and 2005 (85–93). This is an overall 41% decline in breeding territories since these sites were identified for designation. The previous change between the third and fourth national surveys was 17% (2010 to 2015; Ruddock *et al.*, 2016) and subset analyses of changes indicate greater declines showing 29% between 2022 and 2015 and 41% between 2022 and 2010.

Within the now defined SPA boundaries, there are fewer pairs present in 2022 than at the times these sites were proposed for designation (2007), with the 2022 data highlighting a substantial decline with just 38–43 territories remaining. This is 26 fewer pairs for the SPAs than in 2015 (51–69) and a decline of 38% with an overall loss since 2005 (82–94) of 51 pairs which is a decline of 54% (Table 10). Over half of the SPA population of hen harrier in Ireland has been lost in the 15 years since these sites were proposed for designation in 2007 (NPWS, 2022).

Hen harrier populations have declined in five of the six SPAs (between 20–80%) since the 2005 survey and only one site, the Slieve Bloom Mountains has maintained a broadly stable breeding population of hen harrier since the 2005 survey, with fluctuations of no more than one pair across the subsequent national surveys (Table 10).

In 2022, within proximity to the SPAs (500 m and 2 km respectively), there were between four and seven pairs of harriers located. The Slievefelim to Silvermines Mountains SPA had several pairs that were located between 1.8 km and 3.7 km beyond the SPA boundary (4-5 pairs). These pairs may have displaced or moved from within the SPA itself to the wider area beyond the boundary since the previous national surveys. At Sliabh Beagh SPA, other pairs were located across the border in Northern Ireland (2-3 pairs within 2 km in the Slieve Beagh-Mullaghfad-Lisnaskea SPA). The Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA also held a wider connected breeding population (six pairs) in areas adjacent to the SPA boundaries, ranging from just 20 m away to 1.6 km.

## 3.5 Breeding outcomes and habitats utilised

### 3.5.1 National assessment

Observations of breeding habitats and breeding outcomes were collected during vantage point surveys. No nest visits were conducted during the breeding season by observers as part of the survey. Nor were the coordinators aware of any research involving nest visits during 2022. A small number of licensed post-season visits were conducted. Behavioural observations by surveyors provided informative sightings such as repeated nest visitation (with or without prey) by adult birds; prey delivery to nests and remote counts of fledged chicks (see Methods) to establish stages of breeding and outcomes.

Once territorial behaviours by harriers were observed, a high proportion of nest initiation behaviours (89%; n = 76 of 85 confirmed pairs) including birds observed visiting nests and

nest building / egg-laying was subsequently confirmed. A small proportion of confirmed breeding pairs held a territory but did not exhibit behaviours consistent with pairs that had clutches or were brooding young chicks (5%; n = 4 or it was not known if a nest was initiated (6%; n = 5). Based on behavioural observations *i.e.* delivery of prey to an identified nest site, there were a minimum of 65 pairs (76%) which hatched nestlings during the 2022 breeding season. This reveals conversely that a lower proportion (24%) of sites (n = 20) failed to hatch and/or there was no certainty of the stage of subsequent failure *i.e.* at egg or nestling stage. There were no brood sizes counted within any nests during the 2022 survey season since no nest visits were undertaken or submitted to the databases.

Breeding outcome was defined as a binary output (failed or successful) depending on whether chicks were fledged. Fledging was verified and/or observed at 37 (44%) identified sites which represents an overall detected rate of success of nesting pairs as 49% (37 of 76 pairs). For the pairs with confirmed fledging counts, there were between one and four chicks fledged (average 2.0 fledged young per successful nest) and a total of 75 young were recorded to be fledged from 37 pairs. This equates to an average of 0.9 young fledged per confirmed pair and 1.0 young per nesting pair or 0.7 young per breeding (confirmed + possible) pair.

Based on field observations of those nests active for numerous weeks *i.e.* with adults feeding young in the nest, the proportion of nests which failed prior to fledging was relatively high (40% *i.e.* 26 of 65 pairs). If we include the 21 possible records that failed to produce any chicks during the 2022 season, then overall breeding failure rates are at 60% (64 of 106). It is acknowledged that specific nest monitoring, which is required for robust data on breeding performance and the factors, which may cause, or influence nest failure was not conducted in this survey. However, the suspected or observed reasons for failure at nests in 2022 included:

- forestry management (harvesting) activity and associated human and vehicular/machinery-related disturbance;
- human (walking) disturbance;
- dog walking (on and off leads);
- off-road trail motorbike (scrambler) disturbance;
- predation (mammalian);
- predation (dog);
- predation (avian); and
- digging (turf / machinery) disturbance.

For confirmed breeding territories, the habitat within which the nest site was located was dominated by:

- scrub habitats (n = 29);
- second rotation forest (n = 16);
- heather (n = 16);
- heather / scrub (n = 13);
- heather / second rotation forest (n = 6);
- scrub / second rotation forest (n = 3);
- clearfell (n = 1); and
- heather / failed forest (n = 1).

Breeding success was similar across the main habitats where nests were located *i.e.* heather dominated (45%) and scrub dominated (42%) and in second rotation / forest dominated habitats (41%) albeit sample sizes were small across all these categories, given the extent of the overall decline in the national breeding population (see Appendix 4).

### 3.5.2 SPAs assessment

In the SPAs, there were 38 confirmed pairs of which 15 were successful (39%) and the remainder failed to fledge any young (61%). The successful breeding sites within the SPAs fledged a total of 31 chicks, which accounts for 61% of all recorded fledged young in Ireland for 2022. The SPA with the highest number of fledged chicks, and 65% of the SPA network total, was the Stack's to Mullaghareirk, West Limerick Hills & Mount Eagle (n = 20 chicks from 8 confirmed and successful pairs).

The Mullaghanish to Musheramore Mountains SPA and Slieve Beagh SPA failed to fledge any chicks during in 2022 from one and 2-3 pairs respectively and Slievefelim to Silvermines Mountains SPA fledged only a single chick from one nest site.

The Slieve Bloom Mountains SPA and Slieve Aughty Mountains SPA held three successful nest sites each and fledged a total of six and four chicks respectively in 2022.

Within the SPAs, nesting habitats of confirmed pairs were predominantly in:

- scrub (n = 13);
- heather (n = 9);
- second rotation forest (n = 7);
- heather/scrub (n = 5); and
- heather/second rotation forest (n = 4), although these varied across the SPAs.

As set out in the results above, the numbers of pairs nesting in scrub habitat in 2022 in SPAs and the wider countryside, reflects an increasing occurrence of the use of this habitat within hen harrier breeding sites.

At least eight of the SPA nest sites were recorded to reach late nestling stage. Some nests were known to be within days of fledging young *e.g.* chicks observed jumping up to meet parent birds from the nest, and yet subsequently failed, most likely due to predation. Sudden failures observed at this late stage of the nestling stage are typically due to predation. Predation appears to remain a key cause of failure for this species including in the SPAs. Other disturbances recorded within the SPAs included off-road motorbikes; recreational walkers and unleashed domesticated dogs which were thought (by NPWS rangers) to have killed nestling harriers prior to fledging within the Slieve Blooms.

# 4. Discussion

## 4.1 Survey implementation, coverage, and data submission

Survey delivery was maximised by an experienced co-ordination team, the majority of whom were involved in the previous (2015) national survey, thus allowing the augmentation of overall survey coverage during 2022. The partnership of co-ordinating organisations (IRSG, GET & BWI) and NPWS has delivered a national survey which has hugely benefited from the survey proficiency and survey management experience of the collective stakeholders. In particular, the provision of substantial volunteer effort through leveraging a wide network of surveyors, and in the cost-savings accrued via pooling of resources and effort. Lessons learned from the 2015 survey were implemented for the 2022 survey, which included using regional co-ordinators to oversee coverage zones (Figure 1) to support the increased efficacy of survey deployment, fieldwork, follow-up, communication, and collation of data with the surveyor network.

In 2022, the total numbers participating in workshops, training and in the survey itself were similar to 2015 (249 compared to 259). Workshops were given online, which offered high levels

of national coverage and greater resource efficiency compared to in-person workshops operated for previous surveys. Online training formats have become increasingly useful and applicable for spatially dispersed working teams since the Covid-19 pandemic. As a result, greater online and remote access working is evident, and some efficiencies were evident in taking this approach for the national survey. Subsequent field-based training and survey team visits allowed more personable interaction opportunities with surveyor networks and particularly new recruits.

The IRSG noted that several long-standing experienced surveyors were not able to participate in this survey due to an increasing age profile. Several novel but highly experienced hen harrier surveyors participated in 2022. Many of these novel experts are a product of various university and project-based training (*e.g.* HHP) programmes since the 2015 survey. There were a range of newly-participating surveyors, who were offered additional support, engagement and pairing with more experienced surveyors. The dynamics between national surveys in volunteer participation highlights the importance of training and upskilling of new hen harrier surveyors on an on-going basis for future surveys to counteract turnover and provide legacy of expertise for future surveys. For the national hen harrier surveys, the coordinating organisations and their respective networks contribute, and leverage, a significant volunteer effort comprising around 74% of total survey effort representing a substantial financial resource contribution.

Differing survey effort and/or coverage can complicate both estimates of numbers and/or the veracity of conclusions on any measured changes between years (Lewis & Gould, 2000; Johnson *et al.,* 2019; Steiner *et al.,* 2022). However, the consistency of total numbers of surveyors involved in recent national surveys is reassuring particularly with reference to the comparison of results and findings. Similarly, the extent of coverage of 10 km squares between surveys has been consistently high across the hierarchy of priority squares (green; yellow; orange; red) and, importantly, is comparable between the years of national surveys. For the 2022 survey, there was overall high coverage of priority squares at 95%; 93%; 73% and 71% respectively (see Appendix 6) and compared similarly to coverage in 2015 at 100%; 82%; 73%; 67% and is higher than coverage achieved in 2010 (85%; 52%; 51% and 34%).

Surveyors may be unable to complete all planned survey visits, for various reasons, during a field season. Each co-ordinator encouraged surveyors to engage with others and/or the regional teams to increase the total survey visit coverage. However, some coverage gaps were not known to co-ordinators until after the survey season was completed. Ongoing encouragement to surveyors throughout a field season to complete the 10 km coverage and survey visits remains important for national surveys. The total survey effort is largely comparable between national surveys, which is important for establishing direction and/or significance of changes in hen harrier numbers between survey years.

Since the first national survey (1998-00), there has been an ever-increasing number of 10 km squares added to the list of potential survey squares for hen harrier including 2010 (233); 2015 (308) and 2022 (327). However, an increasing proportion of these squares are subsequently being identified as unsuitable or no longer suitable for hen harrier during subsequent field surveys. This increase in unsuitable squares may reflect further losses and fragmentation of hen harrier supporting habitats. Human-mediated factors including agricultural reclamation, drainage, scrub removal, afforestation and maturation of forested areas were reported as drivers of extensive habitat changes during 2022 and reflected in surveyor observations.

Though these aforementioned changes in habitat suitability of some squares have been observed and verified by surveyors, the habitat change metrics in terms of precise scale and extent have not been measured and is beyond the scope of this survey. Estimates of changes in habitat suitability of survey squares between national surveys are complicated by survey square coverage between years. However, a total of 72 of the 340 (21%) squares initially identified for survey in 2022 were subsequently defined as marginal or unsuitable for breeding hen harrier. In past surveys, these squares would have been identified to contain suitable habitat and/or breeding birds. Examination of habitat changes and losses over time would be best reflected in a specific analysis of the National Land Cover data (overlapping with the core

hen harrier breeding range) and/or repeated surveys of specific site-based assessments such as that completed by Moran & Wilson-Parr (2014) for the breeding hen harrier SPAs.

The complexity of habitat changes over time within the known breeding range of hen harrier requires on-going assessment and periodic review to detect changes in suitability both before, during and after national surveys. For example, for survey squares where habitat becomes unsuitable over time, and these may be subsequently excluded from surveys, the comparability of survey results between years may be affected. Conversely, if habitat improvements were to occur between national survey years, and potentially suitable squares were to be excluded, future hen harrier recovery for these areas may not be detected. Reviews of likely suitability of 10 km survey squares before and during surveys remain a key component of the survey to ensure suitable habitat and range of the species are adequately covered.

The capture of late wintering hen harrier records also adds several squares that do not contain breeding habitats or birds during the breeding season. The addition and subtraction of squares between surveys is becoming a multifarious issue, both prior to and after survey visits, during survey planning and subsequent analysis. That is, some survey effort deployed on squares that may not contain breeding habitats nor birds. Conversely, some previously unsurveyed squares have been found to contain breeding birds in both the 2022 and 2015 surveys.

In 2022, there were two squares which were not previously identified for survey but were found to contain a single confirmed pair in each square. These may be an artefact of displacement from adjacent squares into less suitable habitats and/or habitat improvements and/or demonstrate the capacity for recovery and population increases over time. Thus, the expansion into new survey squares and suitable habitat must remain fundamental in the review, assessment, and survey of 10 km squares covered during national surveys.

Data submission and analysis is a core part of the national survey and data entry portal technology and the improvement of software over time has enabled increased efficiency of data submission. The ArcGIS software and Survey123 portals are robust at data capture and allow ready mapping, interpretation, and analysis. There were minor issues detected with the online portals. A small number of surveyors inputted a spatial location of the data submission location, *e.g.* the vantage point or an office-based grid location, rather than the spatial details of the bird sightings. These were easily identified via the mapping of the sightings and subsequent review of same by survey co-ordinators. This spatial information was checked, validated, and followed up with individual surveyors to capture the required locations. Some mobile devices also allowed the circumvention of the required ‘entry of a grid reference for each sighting’, despite having a requisite data capture box and these examples also required follow up to verify sighting and vantage point grid references. Any online submission process requires robust review procedures and analysis to cross-reference and verify data.

Sighting and effort submissions were streamlined with online portals and analysis of the vantage point and sightings data can take a variable amount of time depending on the level of interpretation required. Analysis of breeding territories, locations and overall determination of breeding status for each territory took until 24 August 2023 to complete, to obtain the requisite clarifications and to establish population estimates, abundance, and distribution.

## 4.2 Survey effort and observations

Survey effort in 2022 was higher than in both 2010 and 2005 and thus the accuracy of breeding population estimates, and breeding range continues to improve with each national survey. There was a maintained level of high survey square coverage, as per the 2015 survey, with similar numbers of surveyors and survey visits across the national breeding range and a slightly increased number of survey hours (7%) compared to 2015. The consistency of effort enhances the accuracy and comparability of findings within and, between years. Effort may be influenced by the visit schedules (see Table 1), seasonality, repeatability, extent of suitable habitats, number of surveyors and the duration of surveys within individual 10 km squares.

In 2022, of the 254 squares for which data were received, all three requisite visits were completed for 132 (52%) and only 101 of these had all four visits completed (39%). First visits were higher (at 79%) in 2022 than both 2015 (62%) and 2010 (59%) whilst second visits (82%) were broadly on par with previous surveys (2015; 81%; 2010; 81%). More final visits were completed (at 63%) than in 2015 (57%) and 2010 (54%). Although numbers of final visits could be higher to establish final breeding outcomes, the requirement for some of these visits at some sites lessens as the season progresses since they are optional if any first visits have had no detections of hen harrier. A similar proportion of surveyors completed the third visits in 2022 (56%) compared to 2015 (57%) and more so than in 2010 (50%).

The overall status (Table 4) of the 10 km survey squares in 2022, was hierarchically linked to the numbers of survey visits completed, as per previous national surveys (see Ruddock *et al.,* 2016). The average total number of visits for confirmed squares (mean 22.6 visits), was higher than possible (mean 17.6 visits), seen (mean 6.6. visits) and not seen (mean 6.5 visits). It remains essential in future surveys to maintain visit frequency and survey effort to ensure robust conclusions, and confidence in same regarding the final breeding status assessment of pairs within 10 km squares.

With similar survey efforts between the two most recent surveys (2022 and 2015), albeit some 10 km squares were not covered in both years, the observed decline in the sightings of hen harrier is marked. It is recognised that survey effort was lower during the 2010 survey. The total numbers of sightings of birds declined by around 16% across all sex and age classes combined in 2022 comparted to the 2015 survey. For total sightings of females, there was a more striking apparent reduction (620 in 2022 and 1066 in 2015 and 865 in 2010), or a -28 to -72% reduction between 2022 and the previous two national surveys.

More than a 70% decrease in the sightings of females compared to 2015 seems alarming. The numbers of sightings of males between surveys was similar (-0.5%) and/or increased (19%): 1117 (2022); 1123 (2015) and 943 (2010). Sightings of immature males (*i.e.* second or third calendar year birds are readily identifiable with interspersed brown and white mixed plumages) also declined, similar to females, between 2022 (37) and 2015 (120) by -69% and between 2022 and 2010 (50) by -26%. Total sightings of juveniles similarly declined by -74% from 2015 (378) to 2022 (98) and by -11% compared to 2010 (110).

The declines in sightings of females, immature males and juveniles can be a sign of skewed sex and age ratios indicative of small populations under-going numerical and/or range declines and can highlight a severe threat to the population (Venables & Brooke, 2014; Morrison *et al.,* 2016a). There is an apparent male preponderance in the recorded hen harrier population in 2022, suggesting availability of females may be the limiting factor in population growth and/or proliferation and/or expansion (Hunt *et al.,* 2017). Similarly, an absence of juveniles or young birds is indicative of a decline in potential recruits for subsequent breeding seasons. The on-going observed declines in the overall population, and a lack of any potential population growth rate, points to an unstable breeding population. Any recovery would require an increase in abundance of breeding females and young birds to allow for any expansion of breeding territories.

It is widely recognised that delayed maturity and low reproductive rates make raptors vulnerable to high mortality rates, and a wide variety of human-related threats negatively affect their population dynamics and persistence over time (De Pascalis *et al.,* 2020). The recorded changes in observed detection frequency for females and young hen harrier during the breeding season and across their range in Ireland indicates that there may be a sex- and age-biased mortality occurring. This may be mediated via some of the observed threats or pressures such as loss of females and nestlings during nest destruction (*e.g.* through fire or forest clear-felling or nest predation) or perhaps over-wintering mortality (*e.g.* at roost sites), all of which may be leading to a disproportionate mortality of these sex / age classes compared to adult males (Grüebler *et al.,* 2008). Future management and protection measures for hen harrier in Ireland requires efforts to focus on increasing brood success and optimising the survival of females (Newton *et al.,* 2016).

## 4.3 National and regional population estimates, population change and breeding density

### 4.3.1 National change

Between 2015 and 2022, the national breeding population of hen harrier declined by 33% in total or maximum numbers (*i.e.* confirmed + possible pairs). This appears to be an acceleration of losses and is greater than the 8.4% decline recorded between 2010 and 2015 (Ruddock *et al.,* 2016). Using the mid-point values for comparison between 2022 and 2015 confirms a 28% decline in the population. The maximum population recorded in 2022 is lower than all previous national surveys including 2015 (157); 2010 (172); 2005 (153) and 1998-2000 (129). The mid-point estimate (95.5 pairs) is lower than all previous national population surveys including lower than the population estimate (115.5 pairs) in 1998-2000 (Norriss *et al.,* 2002). The population is now at its most depleted point of the past 25 years.

Previously, Ruddock *et al.,* (2016) predicted that based on declines observed between 2010 and 2015 (estimated as 11.7% every five years or 2.3% annually), there could be fewer than 100 pairs of hen harrier in Ireland within 25 years *i.e.* by 2040. This prediction has since proven to be an underestimate, since the national population has now declined to less than 100 confirmed pairs and by one third overall within just seven years. The prediction at that time assumed that the magnitude of decline would not double again, as it had done over the previous 10 years (2005–2015). There has been no national population growth or stabilisation recorded since 2015. Instead the magnitude of the decline has more than tripled (33%) indicating at least a 4.7% annual decline over a seven-year period 2015 to 2022.

The use of the mid-point values showed an increase from the first national survey to the second and third, and to some extent may be explained by increasing survey effort over time which is a critical determinant in population estimation (Calladine *et al.*, 2009; Symons *et al.*, 2018), including for raptors (Johnson *et al.,* 2019). Total population numbers and mid-point values have declined sequentially since the 2010 survey (including for both 2015 and 2022 surveys). Though both survey coverage and effort across national surveys have been broadly equivalent, the magnitude of the population decline has increased. At the current rate of decline, population extinction could be expected within 25 years and there could be fewer than 50 breeding pairs of hen harrier remaining within the next 10 years.

The specific subset analyses (*i.e.* review of 212 10 km squares covered in both 2015 and 2022), equates to 83% and 79% of the total squares surveyed in those respective surveys. Comparative survey effort for these subsets was equivalent to 7,095 hours in 2022 and 6,554 hours in 2015. The total population change estimation from 2015 to 2022, based on the comparative number of squares (*i.e.* 212 total), shows a higher rate of decline (35%) than the overall direct comparison (33%), with losses of both possible and confirmed breeding territories. For the second subset analyses (comparing 125 squares covered in 2022, 2015 and 2010), declines across all breeding categories ranged from 34% (2022 vs 2015) to 46% (2022 vs 2010). That is nearly 50% of a decline in the comparative subsets over the past 13 years.

Longer-term comparisons over the third subset analyses 2022-2015-2010-2005 (17-year span; 105 squares) further supports evidence of declines, particularly the total number of possible breeding pairs in both 2015 (37%) and 2010 (48%), and 2005 (44%) (Table 8). Some of these observed patterns may be an artefact of a single 10 km square in 2022 that held 10 confirmed breeding pairs, which was surveyed in all survey years. It is also recognised that movements of pairs between 10 km squares may not be reflected in these subset analyses should the surrounding squares not have been covered during one or other of the national surveys. Over the longer term (24-year span) subset analyses, including all five national breeding hen harrier surveys of 2022-2015-2010-2005-1998/2000, the recorded declines using the subset square analyses are relatively stark. These analyses indicate 37% declines from 2022 to 2015 (compared to 33% recorded by comparison of total figures) and declines of

more than or equal to 50% for the other three national surveys (52% in 2010; 50% in 2005 and 59% in 1998-2000) (Table 8).

The observed declines in the national hen harrier population set out above would warrant breeding hen harrier meeting the Red-list criteria, as described in the Birds of Conservation Concern in Ireland (BOCCI; Lynas *et al.,* 2007; Colhoun & Cummins, 2013; Gilbert *et al.,* 2021) *i.e.* "species whose populations have declined by at least 50% over 25 years". In summary, the status of the breeding hen harrier population in Ireland now meets these red-list criteria. The comparable consideration of surveyed squares between survey years, and comparable estimates of the All-Ireland population (Ireland + N. Ireland), should be used to inform the next BOCCI assessment. The hen harrier population has declined by more than 50% within the past 25 years and requires increased and urgent conservation management and implementation.

The range (or distribution) of the species, based on 10 km square comparisons, has contracted since 2005 and is similar to the range recorded in the 1998-2000 national breeding survey. The purported range expansion of previous national surveys now appears to have retracted with declines in the short term (2015; -27%); medium term (2010; -12% & 2005; -8%) and a small difference in the long term (1998-2000; 3%). The reduction in breeding range across Ireland is recorded across the various mountain ranges, with only a small number of new pairs located during 2022 (Table 9).

### 4.3.2 Regional changes

A range of changes were recorded across the regional populations which are reviewed here. In addition, a series of pressures and threats were recorded by surveyors, which may be operating within the range, or potential range, of the hen harrier in those regions. Whilst a selection of site-specific examples are presented below, the effects may not be limited to those sites and various pressures and threats may also be operating at a national level, but observed across regional areas.

Despite showing increases in previous national surveys, the Ballyhouras population is now lower than the total number of pairs recorded in 1998-2000 and it is evident that a significant population crash (63%) has occurred since the peak in 2005. Surveyors in the Ballyhouras recorded a range of activities (including human recreational activities such as scrambling, mountain biking and forestry management works) which are considered to be sources of disturbance to breeding hen harriers (Carravaggi *et al.*, 2019). The development and spatial planning of new mountain bike track networks and trails for the Ballyhouras should consider hen harrier and other Annex 1 species (peregrine falcon) in their environmental assessments.

The Blue Stack Mountains, Pettigo Plateau and south Donegal population increased by 1100% between 1998-2000 to 2015. Between 2015 and 2022, this former stronghold has now declined by 42%, with a maximum of seven pairs recorded. The border area with Northern Ireland at south Donegal previously held several pairs but total numbers have declined. Furthermore, several known pairs have been reported by surveyors in 2022 to have been likely displaced by recent wind energy developments, including *e.g.* due to works at Meenbog (Co. Donegal) where extensive environmental damage was caused due to peat slippage. These factors are also operating nationally (see NPWS, 2021) and across various regions. Invasive species, particularly rhododendron, are damaging extensive areas of previously suitable breeding habitat for hen harrier in this region.

The Boggeraghs, Derrynasaggarts region (Co. Cork) has maintained a similar population throughout the sequence of national surveys with a small increase recorded up to 2010, but since then, similar numbers remain present, with a marginal increase recorded in 2022 since 2015. In this region, surveyors have indicated that breeding pairs are likely to be influenced and/or disturbed by dog walking (in close proximity to known and past nest sites), proposed windfarms, agricultural reclamation (scrub removal), over-grazing and maturing conifer forests. The latter contributes to high levels of inter-specific interaction with buzzards which are

associated with the mature conifer plantations and therefore habitat changes may be causative in the displacement of hen harriers through the loss of suitable habitat for one species which favours another *i.e.* the buzzard.

The Castlecomer, Blackstairs, Kilkenny region did not hold any pairs of hen harrier in the current survey nor since 2005, despite the presence of a range of suitable habitats. A single male hen harrier and a ringtail were seen during April and early May separately, but no breeding behaviours were observed, and numerous interactions were recorded with buzzards locally which seem to be the dominant raptor observed in the region due to the loss of hen harrier preferred habitats and the predominance of mature conifer plantations preferred by the buzzard.

Similarly, no breeding hen harrier were observed in the Curlew Mountains region (Co. Roscommon) during any of the national surveys to date, despite it holding a range of suitable habitats. A foraging and hunting male was seen in June 2022, but no breeding behaviours were observed. Surveyors reported that recreational and tourism walking activities were a cause of likely disturbance to hen harrier in this region, particularly where users stray from trails across breeding habitats. Surveyors have also reported that over-grazing (by sheep and deer) is negatively influencing the sward height of heather across potential breeding habitats, making large areas less suitable for breeding hen harrier.

The breeding population of Devilsbit, Slievefelim, Silvermines, King Hill complex (Co. Tipperary) was marginally higher in 2022 than the first national survey in 1998-2000, but it has declined by one third since 2015. There are a wide range of threats and pressures recorded in this region by surveyors, associated particularly with agricultural activity, forestry management, wind energy, tracks and paths and recreational activities, including humans on foot, horses, scramblers and other off-road vehicles. Self-seeded conifers have been reported as a likely significant factor negatively affecting the suitability of heather moorland for hen harrier across this set of mountain ranges.

Only small numbers of breeding hen harrier have ever been recorded in east Cork and Co. Waterford. In 2022, there was a maximum of one pair recorded (same as 2015 and 2010). This region may have potential to hold more breeding hen harrier as some extensive areas of suitable breeding habitat were recorded by surveyors but also some extensive mature forest plantations any of which were occupied by breeding buzzard.

The Galtys (Co. Cork and Tipperary) population has declined by around one third since 2015 and by more than two thirds since a peak in 2010 (six breeding pairs). Surveyors reported that habitat suitability in the region was poor and highly fragmented, and dominated by mature, thicket stage (closed canopy) conifer forest. There were also reports by surveyors of agricultural improvement and over-grazing of both grassland and heather moorland, with low prey abundances.

The Inishowen Peninsula (Co. Donegal) continues to contain some suitable habitat and winter roosting birds were frequently recorded. There were no breeding hen harriers recorded here in the 2022 survey. In the past, this region held small numbers of breeding hen harrier and surveyors are optimistic that breeding hen harrier could occur in this area if suitable habitat is protected and maintained (D. Moloney, local observer, pers. comm.).

County Kildare has not held records for any of the national breeding hen harrier surveys, although a number of sites in the county support wintering hen harrier, particularly around some of the lowland raised bogs. There seems limited likelihood of a large range expansion for the county, but it may hold important overwintering reservoirs for the species.

Within the Knockmealdowns, Kilworth, and Comeraghs (Co. Cork & Co. Waterford), a region which has been a stronghold for the species, numbers have fallen by 70% since 2015. Surveyors have identified pressures from extensive sheep-grazing of moorlands and the occurrence of intra-specific interactions of hen harrier with tree-nesting raven and buzzard. Both species are associated with mature conifer plantations. Across this region, and

elsewhere, the habitat composition is dominated by mature conifer woodlands, which favour nesting buzzard. Such habitat changes have resulted in the displacement of hen harrier, rather than any effect of the buzzard per se. Human disturbance, walking trails and wide-ranging fly-tipping have also been recorded for the region. Habitat factors such as the presence of invasive species, *e.g.* rhododendron, heather burning, and maturation of conifer plantations are likely contributing to a reduction in suitability of habitat for breeding hen harrier across this region.

The population of the Leitrim, Slieve Rushen, Cavan complex (Co. Leitrim, Co. Cavan) has increased from all surveys until 2015, to a maximum of 15 breeding hen harrier territories. However, by 2022, a decline of 27% from this peak has been observed. Nearly one third of pairs in this region appear to have been lost, although a few novel pairs were also located during 2022 around Cuilcagh Mountain, which held the majority, six of eight pairs identified. The remaining two pairs were recorded in Northern Ireland, on the Fermanagh side of the mountain. The wide range of pressures and threats for hen harrier reported within parts of this region ranged from recreation (including pressure from quad-biking), wind energy development, over-grazing, agricultural disturbance, invasive species (*i.e.* self-seeded conifers, rhododendron), forestry management and afforestation, loss of scrub and natural habitats, fragmentation, wildfires and burning and erosion of peatlands. A review of hen harrier populations in this region over a multi-year study (GET, 2022a) has provided a detailed assessment of pressures, threats, and opportunities within the Cuilcagh Mountain part of the Leitrim, Slieve Rushen, Cavan complex for conservation of the species.

The counties of Longford and Roscommon have only occasionally held one pair combined in the past. None were recorded during the 2022 survey, although some various suitable habitats were evident, and the hen harrier is often recorded in this region in the over-winter period. Small numbers of breeding curlew and red grouse are present. While future survey effort in this region may encounter a small number of novel pairs of hen harrier, the 2022 surveyors reported that forestry, fly-tipping, human and vehicle disturbance, and turf cutting are factors which likely compromise the suitability of the region for breeding hen harrier.

The Nagles (Co. Cork) population has been lost, a region that formerly held up to 11 pairs of hen harrier. Surveyors covered all of the known breeding sites and any additional suitable habitat, which is now very scarce. The hen harrier is now extinct as a breeding bird in the Nagles and probably has been for the past two to three years (T. Nagle, local surveyor, pers. comm.). The last known breeding attempts were in 2019 and the last confirmed breeding that can be established was in 2017 or possibly 2018 (anecdotal information). Surveyors reported that the condition of supporting habitat for hen harrier has deteriorated significantly over the past 10 years and vast tracts of the Nagles are now covered in mature forest, and former large areas of rough grassland around the perimeter have since been reclaimed for dairy farming. Recreational disturbance caused by scramblers, quad bikes, and walkers with dogs (particularly at weekends) are also problematic. The buzzard population has increased dramatically throughout the hen harrier range in Ireland, including the Nagles. The interactions between these two raptor species can result in mobbing behaviours by the hen harrier, and its associated energetic costs defending territories (M. Ruddock, personal observation). The increase in the buzzard population and range, both in the Nagles and nationally, has been supported by the changed afforested landscape, within which the hen harrier previously occurred, and the mature forest stages more suitable for buzzard than hen harrier. Thus, habitat change due to forest maturation in areas juxta-positioned within the former breeding range of hen harriers, is driving an increase in observed buzzard-hen harrier interactions. Nationally and locally, buzzard numbers were lower during the 2015 survey and the Nagles has since reached close to optimum conditions in terms of habitat suitability for buzzard, whereas former hen harrier breeding areas have been planted and/or are now matured forest and largely unusable for hen harrier. Surveyors report that harrier winter roosts have declined to zero occupancy in the last three to four years and that both proposed and consented wind energy developments in the region may further reduce suitability of habitat for hen harrier. Overall, these associated land use pressures may stymie attempts at future re-colonisation if the amount of available and useable forest habitat for hen harrier improves over time (T. Nagle, local surveyor, pers. comm.).

The breeding population of hen harrier in north and west Co. Clare has declined by around one quarter since 2015 (22%) and by around 56% since the peak recorded in the 2010 survey. These declines are extensive, although some novel areas were identified just beyond this region where some pairs may have relocated since 2015. Surveyors here observed that wind turbines and associated infrastructure (including erection of electricity pylons) may be causing disturbance and displacement. Interactions with other species were also reported, primarily raven and buzzard. As previously mentioned, these two species are present largely due to the abundance of mature conifer plantations. Other pressures include recreational users (including dog walkers), reported near to existing and previous nest sites causing direct disturbance and a wide extent of unsuitable habitat. Some pairs of breeding curlew were recorded, which was a positive for the region.

There has been no record of breeding hen harrier in the north-west region or in the Ox Mountains, Co. Sligo over the last three surveys. The Ox Mountains held small numbers of breeding hen harrier (<3 pairs) up to and including the 2005 national survey, but none have been recorded subsequently. These areas are heavily overgrazed by sheep across extensive parts of the heather moorland and blanket bogs but are considered by species experts to have high suitability for potential habitat restoration and could be optimised for breeding hen harrier in the future.

The Slieve Aughties region (Co. Galway and Co. Clare), which is larger than the Slieve Aughty Mountains SPA, has had its population decline by around two thirds since 2015 and now holds fewer than six pairs of breeding hen harrier. The extent of declines here since previous surveys is severe, with an 82% decline when compared to the peak population recorded in 2005 (27 breeding pairs). The extent of losses of breeding hen harrier in the region are widespread and substantial in the national context. The range of pressures and threats recorded by surveyors include a predominance of coniferous forest plantation and the associated forest and plantation management and use, forest clearance (clear-cutting, removal of all trees) and wind energy developments and associated utility and service lines (*e.g.* power-lines, pipelines). There was also a spectrum of grazing levels across the region, from intensive grazing by sheep and deer to non-intensive grazing. In some areas, a notable abandonment of pastoral systems, and lack of grazing provided excellent suitable habitat but was countered by totally unsuitable habitat in other areas. The extent of turf cutting, including both hand-cutting of peat and mechanical removal of peat, is widespread, across large areas of supporting peatland habitat, and the associated impact includes human and machinery disturbance at key temporal periods during the breeding season. Various recreational activities including paths, tracks, cycling tracks, outdoor sports and leisure activities, recreational activities such as walking, horse-riding and various off-road vehicles were also recorded by surveyors. In addition, extensive and uncontrolled burning (*e.g.* widespread unmanaged and/or malicious burning) was reported by surveyors across the region which is likely contributing to the loss and/or poor condition of supporting habitats for both breeding hen harrier and their prey.

The Slieve Beagh region, which is similar to the area covered by the SPA boundary (see Section 6.4) has had a similar number of breeding hen harrier since national surveys commenced and there have been no nett changes since previous surveys in 2015. There was a single year where numbers peaked (six) in 2010 and numbers are now 50% lower (three pairs) than that peak. There is potential capacity at this cross-border complex to hold greater numbers of pairs, but it is also known that pairs can move across the border to Northern Ireland in some years. As a result, there is a flux in total population numbers between years. A wide range of pressures in this region were reported by surveyors and include extensive disturbance and displacement associated with industrial scale turf extraction that is occurring extensively across this mountain range. The known loss of habitat for hen harrier due to this activity appears sizeable. There have been recent habitat restoration activities within Northern Ireland, at the border region (CANN, 2022) with red grouse, snipe and breeding curlew recorded. A review of hen harrier in this region over a multi-year study (GET, 2022b) has provided a detailed assessment of pressures, threats, and opportunities within the Slieve Beagh Mountain complex for conservation of the species. This includes tackling the wide range of pressures

and threats within parts of this region ranging from recreation (*e.g.* quad biking), over-grazing (by cattle, sheep and deer), agricultural disturbance, invasive species (self-seeded conifers, rhododendron), forestry management, loss of scrub and natural habitats, fragmentation, fencing, turf cutting, wildfires and burning, and erosion of peatlands.

The Slieve Bernagh to Keeper Hill (Co. Limerick, Co. Tipperary) population has declined since 2015, by around 43%, a notable change from a recorded increase between 2010 and 2015. At present, the population is slightly higher than recorded numbers in 2005 and 2010. Available habitat has been reported by surveyors to be increasingly modified due to agricultural activity in this area with the loss of scrub and both foraging and nesting habitats for hen harrier. This region, which includes the boundary edge of Slieve Felims to Silvermines Mountains SPA, could be important in terms of wider recovery and/or population management within the SPA itself (see Section 5.4)

The Slieve Blooms region, similarly bounded by the SPA (see Section 6.4) has decreased by one quarter since the 2015 national survey. This region has been long dominated by high quality and extensive tracts of open heather moorland habitats which supported relatively high numbers of breeding hen harrier previously, although many forested habitats are found across the lower slopes and valleys of this mountain range. Forest management activities including forest and plantation management and use; forest replanting (*i.e.* replanting on forest ground after clear-cutting) and forest clearance (clear-cutting, removal of all trees) are large determinants of hen harrier distribution and abundance. Alongside forestry management activities, the 2022 survey recorded high levels of recreational usage in this region associated with existing walking paths, tracks, cycling tracks, created through a combination of outdoor sports and leisure activities and other recreational activities including walking, horse-riding and both non-motorised vehicles and motorised vehicles and off-road motorised driving (scramblers, quads, cars). These recreational activities are regarded as causing high levels of human-related disturbance and/or displacement to hen harriers. Improved access across the region is being generated through path creation, including cutting trails across areas of deep heather and ultimately these disturb and compromise high-quality breeding habitats. In many of the farmed habitats within this region, surveyors reported agricultural intensification and grazing (under- and over-) and agricultural fertilisation as affecting hen harrier and altering their distribution and abundance. The mechanical removal of peat and installation of utility and service lines (*e.g.* power-lines, pipelines) are also leading to increased human activity and further fragmentation and loss of habitats in the region and is considered by surveyors to be affecting breeding hen harrier locally.

The Stack's, Glanarudderies, Knockanefune, Mullaghareirks, north of Abbeyfeale region is an extensive area of land, which includes the Stacks complex SPA, and historically has held the largest proportion of the national population. This region's population has declined by around 10% since the previous national survey in 2015, and by 38% since the population peaked in 1998-2000 (45 pairs) and 2005 (45 pairs). Whilst this complex retains the largest proportion of the national population of the hen harrier in Ireland, more than a third of this former stronghold for the species has been lost in the last 20 to 25 years. Surveyors in the region in 2022 reported that afforestation (*i.e.* forest planting on open ground, an increase in forest area, planting such as on grassland, heathland) and forest and plantation management and use and reafforestation, or forest replanting (*i.e.* replanting on forest ground after clear-cutting) are considered substantial factors affecting the distribution and abundance of hen harrier in this region. There are also large areas of supporting habitats, which are subject to intensive grazing and uncontrolled burning (*e.g.* widespread unmanaged or deliberate burning) across grassland and heather moorland and blanket bog habitats. These activities are known to be particularly damaging to the prey abundance and suitability of habitats for the hen harrier (NPWS, 2015b). Similarly, field observations report that both hand-cutting and mechanical removal of peat are sources of disturbance and damage to hen harrier and their breeding habitats. Often, such activities co-occur with both extant and prospective wind energy development sites and addressing these requires the implementation of appropriate management actions for the region (NPWS, 2017; Mee, 2019).

West Cork has only ever held minimal numbers of hen harrier: a maximum of one pair in the previous survey (2015), with none recorded in 2022. This area was reported by surveyors to have poor condition of suitable habitats, indicative in some cases of past fires leading to loss of suitable heather moorland habitats. High levels of buzzard activity were recorded in some areas which is due to a preponderance of mature conifer habitats occupied by that species, and which are typically actively avoided by hen harriers.

Similarly, west Kerry has not during the time-frame of any of the national surveys 1998/2001 – 2022 held any breeding hen harrier, but one novel pair was recorded during the 2022 survey. Successful breeding of small numbers of pairs has been recorded in this area in recent years, including broods of four chicks fledged, and if appropriate conservation actions were implemented to support the birds, then this region could increase the range of the species with a small number of pairs within suitable habitat. Small scale localised management applied across Ireland at regional levels could result in national numbers increasing. Associated disturbance of potential breeding pairs due to clear-felling, has been anecdotally reported in west Kerry.

County Wexford previously supported up to two breeding pairs of hen harrier, but none have been recorded in 2022, nor in recent years (T. Murray, NPWS, pers. comm.). Surveyors reported that agricultural improvement and reclamation of formerly hen harrier-occupied land parcels has occurred in recent years, and the suitability of past breeding sites has been significantly compromised.

The Wicklow Mountains holds large areas of extensive heather moorland and blanket bog habitats although extensive over-grazing (by sheep and deer) and a number of extensive fires have been recorded in the region in recent years, including during 2022. This region historically held a population (7–10 pairs) of hen harrier in the 1960s (Watson, 1977) but since national surveys began in 1998/2000, there have been no breeding territories recorded here, despite apparently suitable and available habitats. A single female was seen passing through in the summer season of 2022, but no breeding behaviours, or indications of such, were observed.

Other areas, not located within these aforementioned defined mountain ranges (as per Norriss *et al.*, 2002; see Barton *et al.,* 2006 for map of regions), held a small number of pairs, including in squares that have not previously held records of breeding hen harrier. For this grouping, there were five confirmed pairs and one possible pair recorded in 2022 which is a 50% increase since the 2015 survey. These squares also held a further 23 records of harriers which were defined as ‘seen’ but exhibited no breeding behaviours; some of these were recorded outside of the breeding season and therefore considered moreso records of over-wintering birds. Surveyors reported some areas of suitable habitat and a range of pressures and threats in these areas including those related to forestry management, human disturbance, agricultural activities and recreational users (particularly off-road vehicles) (see Appendix 2 and 3 for details of activity, pressures and threats descriptions). Some areas were reported to have been re-occupied by breeding hen harrier, for example in an area where turf cutting has ceased over recent years.

## 4.4 Population estimates, population changes and habitat composition within SPAs

The hen harrier SPAs have been recorded to hold most of the national hen harrier population in the majority of the national breeding surveys. The 10 km squares (n = 56) that overlap the SPAs held 50 confirmed and six possible breeding territories (56 pairs) during 2022 which is 53% of the national population. Within the SPA boundaries, a smaller number of pairs occur (38-43 pairs) since the SPA boundaries do not encompass the whole 10 km squares. The rate of population decline appears to have accelerated within the SPAs. It may also be the case that some pairs persist beyond the boundary and/or some localised redistribution has occurred beyond the SPA boundaries, although the total numbers of pairs in these ‘SPA 10 km squares’ are much lower (at 56 pairs) than recorded in 2015 (total of 77 pairs). Thus, declines have

occurred both within and beyond the SPA boundaries in the SPA regions (see Section 6.3). Declines appear to have accelerated since all previous surveys, from 18% for the period 2005 to 2010; 10% for the period 2010 to 2015 to 38% for the latest comparison of 2015 to 2022. The rate of decline in the SPAs has more than tripled within these past seven years despite extensive management supports via the Department of Agriculture, Food and the Marine (or DAFM's) Green, Low-Carbon, Agri-Environment Scheme (GLAS) and the Hen Harrier locally-led, results-based programme (HHP).

During the 2022 survey, the six SPAs held around 41% of the national population (43 of 106 pairs). This is lower than the 44% of the national population held by SPAs in 2015 (Ruddock *et al.*, 2016). The SPA population decline (38% since 2015) amounts to a loss of 26 pairs across the seven-year period. The 1998/2000 and 2005 national survey data were used to inform the selection of candidate SPAs in 2007 and the total SPA population has declined by more than half since that time. The Slieve Blooms SPA had one more pair in 2022 (9) than in 2005 (8) and fewer pairs than in 1998/2000 (11) and declines, at the other five SPA sites, across this period (1998-2000 & 2005) ranged from 20% to 80% (-53%; -80%; -20%; -67% and -25% respectively; see Table 10).

It is known from annual monitoring of breeding hen harrier conducted as part of the DAFM results-based programme (HHP, 2018; 2019a; 2019b; 2020; 2021) that total numbers of pairs and productivity can vary between years. Most recently, in 2021, HHP monitoring (HHP, 2021) indicated a stabilisation of numbers of territorial pairs, ending a year-on-year decline for the SPAs from 2018 to 2020. However, the 2021 breeding season was the least productive on record, with just a third of nesting pairs in the SPA network successfully fledging a total of just 34 young (HHP, 2021). Subsequently, in 2022, the sudden decline in the total number of nesting pairs is marked (see Appendix 4). This sudden and sharp decline may be an artefact of continued poor breeding productivity and/or other constraints acting on the population, both within the SPAs and nationally, that have reached unsustainable levels and/or contributed to high levels of mortality (Murgatroyd *et al.*, 2019). It is recognised there may also be an absence of breeding due to extrinsic factors such as weather or low prey availability but the recorded sex-biased observation information, with more males seen than females across the survey data (Appendix 1), indicates a wider population problem and requires further research. Notwithstanding agricultural programmes, the other sectoral pressures such as recreation, wind energy developments, and forestry within the SPAs and nationally may also exacerbate such sudden declines as all these factors are likely operating cumulatively on the hen harrier.

The SPA populations have not stabilised since the time they were proposed as candidate SPAs, 15 years ago. The species needs strategic and long-term, objective focused management plans to improve the fortunes of the species both within and beyond the SPA sites. A Hen Harrier Threat Response Plan (HHTRP) has been in development for 11 years; and incorporates a strategic environmental assessment, appropriate assessment, and public consultation. Annual monitoring of the SPAs has shown that productivity can be high within some years (HHP, 2019b) and measures to improve breeding success must be a key focus of management and conservation of the species (Newton, 1979; Fielding *et al.,* 2011; Fernandez-Bellon 2020).

The Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA population has declined by 53% since 2005. This SPA supports many scrub nesting hen harrier, with heather nest sites rarely recorded and second rotation sites recorded less frequently, due perhaps to maturation of forest estates within this site and a widespread absence of heather moorland (M. Ruddock and F. Connolly, *pers. obs*.). The total numbers for this site are around 25% lower than in 2015 and have steeply declined (38%) since 2021 (34 pairs; HHP, 2021). The SPA is located across 18 different 10 km squares and 12 (67%) of these 10 km held at least one breeding pair. Spatially, the hen harrier is widespread in the SPA but occurs at low densities for the most part, except for one area where at least six pairs occurred within one 10 km square. As noted, (Section 5.4), a range of pressures and threats have been recorded in this SPA and wider region but most frequently occurring issues recorded by surveyors were the loss of habitat due to afforestation, disturbance by forestry management activities and the

loss of scrub habitat through agricultural activity, predation and displacement by recreational activities and wind energy development.

The Mullaghanish to Musheramore Mountains SPA has historically been one of the smaller populations within the SPA network, with a maximum of five pairs recorded in 2005. It has declined successively across each of the subsequent national surveys, with the 2022 estimate on par with 2015 (one pair). Since that 2005 peak of five pairs, there has been an 80% decline in the population of hen harrier. Recent monitoring between 2017 and 2021 revealed a consistent population of only 1-2 pairs, a single year (2020) when the population peaked at five pairs (HHP, 2020) and a decline again in 2021 to three pairs (HHP, 2021). The SPA extends across six 10 km squares, but only a single 10 km contained breeding hen harrier in 2022, with an additional pair recorded beyond the SPA within a second 10 km square. The range of the species at this site has substantially reduced, with hen harrier now occupying only one part of their former range. Surveyors reported a high dependency of harriers on scrub habitats within this SPA. However, the area is frequently subjected to agricultural intensification and activities such as the removal of scrub habitats and over-grazing, are negatively affecting the suitability of breeding and foraging habitats across the SPA resulting in direct and indirect loss of habitats.

The Slievefelim to Silvermines Mountains SPA was one of only two sites that recorded an increase in the hen harrier population during the period 2005 to 2010 and to 2015, with a doubling of the population between 2005 and 2015 from 5 pairs to 10 pairs although a slightly higher number were recorded in 1998-2000 (8 pairs). In 2022, the population was 60% lower than 2015, and 43% lower than in 2021. Overall, it is lower than previous yearly totals for the period 2017 to 2021 which fluctuated between six and nine pairs (HHP, 2018; 2019a; 2019b; 2020; 2021) (HHP, 2021). The SPA extends over nine 10 km squares and only 44% (four) of these squares held breeding hen harrier; these were located primarily in the southern portion of the site. Surveyors observed a significant level of disturbance at this site due to walkers and off-road (scrambler) bikes and forestry activity. The moorland and other suitable hen harrier habitats are also observed to be affected by invasive self-seeded conifers and, increasingly, by rhododendron.

The Slieve Bloom Mountains has generally maintained a stable or slightly increased population since the first national surveys (1998/00, 2005) (8-11 pairs). It peaked during the 2015 national survey (12-13 pairs) but has by 2022, apparently declined to around 2010 levels (8-9 pairs). Annual monitoring for the SPA (HHP, 2021) recorded a peak in 2017 (10-14 pairs; HHP, 2018) and the population declined thereafter to around 10-11 territorial pairs annually, between 2018 and 2021. Variable numbers of young fledged across years, including recorded zero productivity in 2021. The decline in 2022 from more recent years (HHP 2017-2021) is marginal and changes since 2015 demonstrate an overall 12% increase, indicating relative stability in the total number of pairs. All of the Slieve Bloom breeding pairs were located within heather habitats and none in afforested habitats. Surveyors reported that the adjacent coniferous forest plantations are a source of potential predation risk (see also Sheridan *et al.*, 2020) and that extensive and invasive self-seeded conifers are compromising the remaining available heather moorland and other supporting habitats, preferred by the hen harrier. The preservation and protection of areas of deep heather from cutting, or flailing management and heather burning is critical, and any such damaging activities of these supporting habitat features should be prevented, with appropriate measures taken with respect to any breeches of conditionality and/or the wildlife legislation. Recreational walkers should be targeted for awareness raising to discourage and prevent the creation of new, and extension of existing, paths and routes through nesting habitats. Collectively, surveyors in the area consider that there is a lack of spatial and temporal planning of disturbing activities, particularly forestry management, recreation and recreational events that are causing disturbance and displacement to hen harrier in the area and requires collective conservation action (Gallagher & Lauder, 2016).

The population of the Slieve Aughty Mountains has declined extensively and successively across all national surveys and by two thirds since 2005, with just five pairs recorded in 2022, a loss of more than 20 pairs in the intervening 17-year period. Annual surveys of the SPAs

(HHP, 2018; 2019a; b; 2020; 2021) found continued gradual declines between 2017 (12 pairs); 2018 (9 pairs); 2019 (6 pairs); 2020 (6 pairs) and 2021 (7 pairs). This SPA has declined to the point where, largely due to habitat fragmentation, it may be ecologically compromised (*e.g.* Jones *et al*., 2009; Fernández-Bellon *et al*., 2021) with only small numbers of young produced each year. A former stronghold for the species, it held the second highest numbers of pairs nationally in 1998-01; 2005; 2010 and 2015. There is a probability, given the magnitude of declines recorded from 2017 – 2022, that at the current rate of decline that there will be no successfully breeding pairs of hen harrier in the SPA within five years. The surveyors in the region reported that habitat-mediated effects, dominated by non-native conifer plantations, are key determinants of hen harrier population levels and breeding success and ultimately population viability in this region. That is, the extent and configuration of conifer plantations across the site, and the maturation of the forest estate in recent years, has resulted in a lack of availability of breeding habitats (including loss of open habitats through afforestation and the prevalence of thicket stage forest, which is unsuitable for nesting hen harrier). Other effects associated with dominant forest cover include elevated predation risk, and associated edge effects and resultant poor productivity (Irwin *et al*., 2012). Forestry management actions and recreational projects and other potentially disturbing activities exhibit a lack of strategic planning occurring in the region resulting in excessive levels of disturbance and displacement of hen harrier during the breeding season and a site-specific management plan is much needed for the Slieve Aughty Mountains.

Slieve Beagh is a relatively small SPA, but the area has regularly held hen harrier for many decades. This SPA is part of a wider cross-border mountain range where pairs regular switch jurisdiction between years as foraging ranges of pairs are contiguous, in both directions, across the border with Northern Ireland. The highest total of six pairs in 2010 (Ruddock *et al.*, 2012) has since declined by half to three pairs in 2022. Earlier surveys recorded three pairs (1998-2000) and four pairs (2005). The HHP EIP (2021) review of annual surveys (2017-2021) shows that there were typically three to four pairs in most years indicating that the site was relatively stable with a consistent population. In one year (2018), there was a peak (six pairs) which then decreased the following year again. The tendency of the population to increase (and decrease) precipitously gives cause for both concern and optimism about the capacity for rapid changes within populations. The population fluctuations in this region are more complex due to the dynamic spatial changes across the Northern Ireland border within and between years (GET, 2022b) and it may be ecologically more coherent to consider both jurisdictions as a collective population when reporting. Surveyors in this region cite the extensive and damaging occurrence of turf cutting, which happens primarily in Ireland, not Northern Ireland, through various mechanical means as the most significant land management activity affecting hen harrier and their prey. The widespread occurrence of turf extraction across the mountain and its temporal nature (typically from early May – August), results in seasonal sterilisation of hen harrier foraging habitats, combined with direct breeding season disturbance and displacement of hen harrier. Human activities, particularly rally cars / events, walking, unleashed and unsupervised dogs, and agricultural activity (notably fencing) including cross-border actions are considered to be creating high levels of displacement and disturbance to a range of species including red grouse, snipe, curlew, and hen harrier. Wildfires and deliberate burning are a feature at this locality, year on year, causing widespread loss of habitat, most often in the spring when such fires destroy large numbers of nests including hen harrier and other upland ground-nesting bird species (red grouse, meadow pipit and skylark) (see also GET, 2022b). These issues have persisted (see RSPB, 2011) in the region, and in many cases, have intensified over time (GET, 2022b). Some progress into the management of specific issues have been made *e.g.* PauCosta, 2022 (Wildfire Management Plan) and there are a mosaic of stakeholder needs and aspirations locally (Sliabh Beagh Master Plan, 2017). Many of the aspirations, *e.g.* tourism and hen harrier, are interlinked, and are not mutually exclusive and may be competing.

## 4.5 Breeding outcomes and habitats utilised

Breeding performance and breeding success of pairs is known to vary between years (see Ruddock *et al.,* 2012; 2016) and is influenced by intrinsic (*e.g.* breeding age; experience; survival) and extrinsic (*e.g.* weather; disturbance; prey availability) factors (Paviour, 2013). Nest initiation rates observed in this survey were relatively high in territorial pairs of hen harrier (89%) which is greater than both 2010 (66%) and 2015 (87%) (Ruddock *et al.,* 2012; 2015). Overall, though the observed hatching success (76%) of confirmed pairs in 2022 provides some basis for optimism that the capacity for producing young exists within the Irish hen harrier population. This is countered by the subsequent fledging rates which are much lower (44%). The latter (*i.e.* fledging rates) is akin to the rates observed in 2015 (45%; Ruddock *et al.*, 2016); 2010 (39%; Ruddock *et al.,* 2012) and 2005 (44%; Barton *et al.*, 2006) indicating ongoing poor final breeding performance at the fledging stage and outputs. The inclusion of "possible" pairs of hen harrier that have also failed then the overall failure rates of 60% is comparable to figures for 2015 (62%) and remains higher than 2010 (51%) (Ruddock *et al.*, 2016; 2012 respectively).

The high failure rates after hatching and prior to fledging (40%) indicate that there is capacity for recovery of the Irish hen harrier. If the rate of fledging can be increased, through targeted management particularly in the late nestling stages when high levels of failure appear to be occurring. These parameters can be highly dependent on habitat optimisation (Newton, 1979) and improvement of year-on-year success and consistency within prey-rich habitats (Tapia & Zuberogoitia, 2018) that can be enhanced by:

- habitat, species- and site-specific management (Fernandez-Bellon *et al.*, 2021)
- potentially by supplemental feeding (Redpath *et al.*, 1999; 2001; Amar & Redpath, 2002) and/or
- nest protection measures such as predator management (McMillan, 2014)
- regulation and management of activities within protective buffer zones (Ruddock & Whitfield, 2007).

The overall productivity rates recorded during 2022 were 0.9 young fledged per confirmed pair, 1.0 young per nesting pair and 0.7 young per breeding pair. The number of young per confirmed pairs is similar to 2015 (Ruddock *et al.*, 2016; 0.94) and higher than 2010 (Ruddock *et al.,* 2012; 0.81). Recently, NPWS (2022) defined productivity targets for the site-specific conservation objectives based on 1.0-1.4 young (per confirmed breeding pair) for SPAs within Ireland. The observed rates recorded during the survey are 10% to 36% lower than the productivity targets set by NPWS (2022) for confirmed pairs and are 38% below the 1.45 young per breeding pair target of O'Donoghue, (2010) used to define the HHP threshold targets (HHP, 2019; 2020; 2021). The observed productivity rates also remain below that of other populations (Watson, 1977, Green & Etheridge, 1999; Redpath *et al.*, 2002a; 2002b; Barton *et al.,* 2006; Amar *et al.,* 2007; Irwin *et al.,* 2008; Scott & Clarke, 2008; Whitfield *et al.*, 2008; Whitfield & Fielding, 2009; O'Donoghue, 2010; Fielding *et al.,* 2011; Irwin *et al.,* 2012; O'Donoghue, 2021). This continued poor performance, compounded by poor juvenile survival rates (McCarthy, 2022), exacerbates the population decline (Ruddock *et al.*, 2016).

For a population to be considered stable, the net losses through mortality and dispersal (emigration) comparative to gains through productivity, juvenile survival, and dispersal (immigration) must be equivalent. The average number of young that each pair must produce annually, given the level of mortality and displacement, to maintain a steady population is known as the 'recruitment standard' (Newton, 1979). For a population to be increasing and considered to be at 'favourable status', it needs to be capable of maintenance and/or expansion where population gains (inputs) are greater than losses (outputs) of birds, and without dependency on recruitment from other populations *i.e.* immigration.

Various productivity thresholds for population stability and/or expansion and to achieve favourable conservation status have been set out for different sub-populations including 1.1-

1.2 young (Newton, 1979); 1.0 young (per occupied site; Fielding *et al.,* 2011); 1.2 young (per breeding site; Fielding *et al.,* 2011); 1.2 young (per breeding attempt; Whitfield & Fielding, 2009). The latter study (Whitfield & Fielding, 2009; Whitfield *et al.,* 2008) was of an increasing population and productivity was 1.42 young (per breeding attempt) and Fielding *et al.,* (2011) also recommends a target of a minimum of 1.2 young per breeding attempt is required for stability in the medium to long-term.

For the 2022 survey, the number of young (per confirmed breeding pair) observed was 1.0 young outside the SPAs (wider countryside) and 0.82 young inside the SPAs. These estimates are sub-threshold or below the lower limit of the targets set out by NPWS (2022), albeit marginally higher than national estimates for 2015 (0.94 young) and 2010 (0.81 young) surveys. Thus, there is a shortfall in the mean number of young being fledged in Ireland within or outside the designated sites and that needed to maintain or increase the population. Current productivity rates are insufficient to increase the population which is, in turn, likely to be incompatible with either maintaining population stability or indeed population recovery. The population productivity threshold could be achieved by either achieving a relatively low number of young fledged per successful nest combined with a high proportion of nests being successful, or by reaching higher productivity per successful nest but with relatively few nests fledging any young. The target for conservation objectives (1.0-1.4 fledged young per confirmed pair), may be lower than required for the immediate reversal of the population declines in the short-term and to restore a self-sustaining population of hen harrier in Ireland.

Following the methods of Ruddock *et al.*, (2012; 2016), a population model for each SPA and the wider countryside was constructed using breeding parameters from 2022 (see Appendix 5). This model assumed age-specific annual survival estimates (Etheridge *et al.,* 1997), that the populations were closed and in the absence of any existing estimate of non-breeders in Ireland. These survival parameters were utilised for the purposes of comparability with previous surveys. Although specific estimates for adult survival of harriers are not known, there are Irish estimates of juvenile survival (O'Donoghue, 2010; McCarthy, 2022) which are much lower than Etheridge *et al*., (1997). The model predicts a national deficit of 19.9 hen harrier from 2022 to 2023 as both the SPA network and wider had no surplus (-7.9 & -12.1 respectively). Using the juvenile survival estimates in Ireland, which are lower than those reported for Scotland, the deficit may be much higher -28.3 (based on 0.25 of McCarthy, 2022) and -35.1 (based on 0.16 of O'Donoghue, 2010).

There was no surplus of hen harrier recorded either within or outside any of the SPAs, and although deficits were apparently lower from initial models than previous estimates of deficits (Ruddock *et al.,* 2012; 2016), this may be an artefact of a much-decreased population since previous surveys. Year to year variability in productivity for hen harrier in Ireland is established (see review in NPWS, 2022), but the current scenario appears to be one of ongoing year-on-year deficits, resulting in an ever-decreasing national and SPA population. The reversal of population declines requires significant efforts to improve breeding success and numbers of fledged young in order to produce an annual surplus both within and beyond designated sites. The populations within and outside the SPA network cannot be considered favourable and may continue to operate as population sinks that are dependent on recruitment from areas outside of Ireland. Further consideration of the multi-year datasets and breeding parameters (from all national surveys, research studies and HHP 2017–2022) for the conservation objectives, as detailed in NPWS (2022), will improve estimates of the population model parameters (see Fielding *et al.,* 2011; New *et al.,* 2011; Morrison *et al.,* 2016b) for Ireland's hen harrier SPAs.

Surveyors have recorded that the wider loss and degradation of formerly-suitable breeding and foraging habitats, particularly through agricultural improvement, removal of scrub and heather; afforestation and intensification of land management often associated with wind energy development are determinants of hen harrier occurrence and/or abundance. The quality and quantity of prey species are also likely to be significantly affected by these factors (Fernandez-Bellon *et al.,* 2019). In addition to the direct effects of land management activities on nesting failure, a range of foraging and nesting habitats have been lost through fires, afforestation, and

agricultural reclamation, both during the 2022 survey year and since the previous national survey (2015), as demonstrated by the increased numbers of unsuitable survey squares and habitat within survey squares. These field-observations are supported by the wider research (Wilson *et al.,* 2016; NPWS; 2021; Fernandez-Bellon *et al.,* 2021) and identified within the draft threat response plan (NPWS, 2021) which will require cohesive and collective will and action to restore the hen harrier breeding population.

Surveyors have also recorded various suspected reasons for breeding failure during 2022 and these were largely related to anthropogenic factors and/or predation. Predation, in particular by foxes, has been shown to be an important cause of hen harrier breeding failure in some areas of Ireland and the UK (Whitfield & Fielding, 2009; O'Donoghue, 2012; Baines & Richardson, 2013; McMillan, 2014). Whilst likely to be highly site specific, in a review of fox predation at hen harrier nests on the Isle of Skye, Scotland, McMillan (2014) states that, in areas not managed for red grouse, high failure rates at the chick stage may indicate a problem of fox predation. The general view amongst raptor surveyors, including during the 2022 survey, is that most fox intrusions occur when broods are at the later stage of development (Rooney & Ruddock, 2021; F. Connolly, *pers. obs.)*. At least eight of the SPA nest sites were recorded to reach late nestling stage. Some nests were observed to be within days of fledging young *e.g.* jumping to adults for food from nest site, and yet subsequently failed. Sudden failures observed at this late stage of the nestling stage are typically due to predation (McMillan, 2014) and predation appears to remain a key cause of nest failure, including in the SPAs.

Forested areas, and the associated habitat provision and optimisation for other predatory species *e.g.* pine martens, buzzards and foxes, may cause direct effects whereby forested habitat, particularly as it matures, is displacing hen harrier while providing suitable habitat instead for those other species *e.g.* buzzards nesting in mature commercial plantation woodlands which are not used by hen harrier. Furthermore, such change is contributing to increased interactions *e.g.* mobbing and chasing between the two species can occur at the interface/edge of these habitats. Forest and forest edge can also lead to indirect predation effects arising (Sheridan *et al.,* 2020).

Forest management is identified as a primary threat to breeding hen harrier (Bonsu *et al.,* 2019; Fernandez-Bellon *et al.,* 2021) and is having a direct disturbance effect both within and outside of the SPAs. This is causing direct disturbance and displacement both in the early breeding season (in February and March) during territorial settlement or prospecting phases and during the rest of the breeding season and nesting cycle. Machinery usage, most frequently through agricultural and turf cutting activities, is causing extensive loss of habitat year on year and also direct disturbance to harriers during the breeding season. Similarly, the inappropriate timing and usage of off-road motorbikes, along with recreational users, including dog walkers, would benefit from extensive engagement to reduce negative effects on hen harrier and their habitats.

Observers report that these various activities above, occurring within forested areas, are resulting in the displacement of 'territorial' birds, prevention of nesting, as well as direct losses of nests due to direct disturbance to nesting pairs including nest destruction. The timing and occurrence of highly disturbing or destructive activities during the breeding season requires remediation and an increased level of awareness and enforcement amongst stakeholders. Although there are sometimes competing temporal or seasonal management needs for some activities, *e.g.* good weather for hiking events, winter / summer timings of activities or sports, related aquatic interests and water quality including other conservation priorities like fresh-water pearl mussel, within forested habitats with the current low levels of breeding success observed, many of these pressures may be avoidable and preventable. If these were reversed or mitigated, it could help support higher levels of breeding success to the Irish hen harrier population. This requires the implementation of increased spatial and temporal prescriptive and adaptive measures (Currie & Elliot, 1997; Ruddock & Whitfield, 2007) and stakeholder cooperation and measures to avoid and prevent disturbance and displacement.

Natural and semi-natural habitats are preferred by hen harrier (Watson, 1977) but increasingly these are being affected by habitat changes, fragmentation, and loss; these are cited as key

pressures acting on the species (Fernandez-Bellon *et al.,* 2021). Suitable, heather habitats (>40 cm; Redpath *et al.,* 1999) have become scarce within the uplands of Ireland, with restricted availability and/or highly fragmented occurrence. Their loss is frequently compounded by afforestation; over-grazing; burning (associated with provision of grazing for livestock) and intentional removal of habitat which are principally driven by agricultural improvements and the eligibility criteria within agri-environment subsidy frameworks. This has been recognised across sectors by members of the Joint Consultative Committee for the Threat Response Plan (*e.g.* IFA and eNGOs in DHLGH, 2024). There has been some progress with the recognition of scrub eligibility within agricultural subsidies (DAFM ACRES, 2023), and the further expansion of this support for biodiversity, and hen harrier, will benefit both species and farm communities. The inclusion of heather, in all its growth forms, as a beneficial feature within the eligibility framework will alleviate significant pressures on hen harrier preferred habitats in Ireland.

Scrub was the dominant habitat recorded, for nesting, within the network of habitats utilised by the hen harrier during the breeding surveys in 2022. The wooded habitat types also demonstrated similar breeding success rates 41% (second rotation) and 42% (scrub) whereas heather-dominated habitats showed a marginally higher rate of breeding success (48%). Scrub is a highly valuable habitat and appears to be recorded more frequently within the hen harrier breeding sites, both inside and outside the SPAs in this survey. Perhaps this outcome may be due to losses of heather habitats and the wider maturation of pre-thicket forest habitats within the hen harrier range. The increased prevalence of scrub nesting behaviour, in the absence of alternative habitats, has precipitated the active selection of these important scrub habitats, particularly where undisturbed. Further research on suitability and availability of habitats is required to establish if this habitat is being selected according to availability. Breeding success appears slightly higher in this habitat, although this may be an artefact of the higher proportional occurrence of scrub nesting pairs now in Ireland and/or this habitat may confer additional barriers to nest failure *e.g.* protection from predation and may be more impenetrable to ground predators.

## 4.6 Conclusions

This report presents a comprehensive series of results along with review and discussion of same. The observational data provided by surveyors have identified key pressures, and threats acting on the hen harrier locally, either singly or in combination and which may be operating at regional and/or at national scales and cumulatively contributing to the nationally observed decline. All local observations by surveyors were reviewed to consider potential sectoral opportunities and whilst different scales of interventions or management may be required locally, regionally, or nationally, any such opportunities for restoration and conservation of the hen harrier population should be developed with targeted measures and outputs at the scale they are applied. The recommendations (set out in Section 6.7) are informed by the 2022 survey results including the current population status of hen harrier in Ireland. Whilst not intending to replicate or duplicate the work being undertaken to develop the draft Hen Harrier Threat Response Plan (HHTRP), but they should inform the implementation of that Plan.

### 4.6.1 Status of breeding hen harrier

The 2022 survey of breeding hen harrier in Ireland has shown a continued decline in the national population, and the rate of decline has also accelerated since the previous survey in 2015. The total population of 106 breeding pairs is one third (33%) smaller than the total population of 157 breeding pairs recorded in 2015 and 38% smaller than that recorded in 2010 (172 breeding pairs). The magnitude of decline in total numbers of breeding pairs of hen harrier in Ireland is unsustainable and appears to have increased since 2015 (Ruddock *et al*., 2016). If the current trajectory continues (33% between 2015 and 2022 or approximately 5% per annum), then there will in all likelihood be less than 50 breeding pairs of hen harriers within the next 10 years. As required under the Birds Directive the species needs urgent and specific

interventions to stabilise to reverse the population declines and support population recovery of the hen harrier in Ireland across local, regional, and national scales.

The reliability of population estimates arising from national breeding surveys of hen harrier are important for assessing the status of the population and setting out conservation objectives[4]. There are potential biases that can arise from 5-year or, in this case, 7-year intervals between surveys. A comprehensive review of information is thus required including available data between national surveys. Various subset analyses, set out in the methods and results sections, have been used to provide comparable estimates of change between national survey periods for areas where coverage has been consistent throughout. Where survey effort is significantly different between surveys, this can complicate the drawing of clear conclusions (Lewis & Gould, 2000; Johnson *et al.,* 2019; Steiner *et al.*, 2022).

Based on the subset analyses described earlier in this report, there is certainty of a decline in population numbers of 36% between 2022 and 2015 and 47% between 2022 and 2010 and 14% between 2022 and 2005 and 59% between 2022 and 1998/2000. These are substantial declines and warrant urgent implementation of the HHTRP and specific conservation priority setting and the recommendation to use these subset analyses in the next BoCCI review. The timing of the next national survey is recommended to be conducted in 2025, and the 5-year interval schedule re-instated, given the critical level of the population in Ireland.

### 4.6.2 Pressures and threats for breeding hen harrier

Fernadez-Bellon *et al.,* (2021) summarised the range of pressures and threats across the hen harrier biogeographical range in Europe and identified key issues as drivers of hen harrier declines including:

- prey availability;
- agricultural intensification;
- shooting (*i.e.* persecution);
- deliberate nest destruction;
- predation;
- extreme weather
- afforestation;
- accidental nest destruction; and
- habitat loss.

The most frequently occurring pressures and threats (Appendix 2) highlighted by surveyors in 2022 as negative for hen harriers close to breeding / nesting sites (*i.e.* in the 500 m zone) include; forest management and use; the mechanical removal of peat; increased access (via paths, tracks, cycling tracks (includes non-paved forest roads); non-intensive grazing; wind energy production and agricultural intensification. These activities, at distances proximate or close to nesting sites (*i.e.* within 500 m) of breeding pairs, are considered to heighten risk of negative outcomes (*e.g.* reduced productivity, nest failures via abandonment or predation or nest destruction) although it is recognised that some of these factors can also have positive effects. For example, non-intensive grazing[5] is reported as a positive indicator for scrub and such low-intensity agricultural activity can help support hen harriers in some areas. Positive landscape features should be maintained and optimised, potentially by further grazing

[4] Conservation Objective – a conservation objective is the specification of the overall target for the species and/or habitat types for which a site is designated in order for it to contribute to maintaining or reaching Favourable Conservation Status. (NPWS, 2022)

[5] (*i.e.* reduced levels of grazing and/or abandonment of pastoral systems and/or sustainable grazing allowing regeneration of flora particularly scrub and heath)

reductions and retention and expansion of suitable habitats and habitat matrices which are beneficial to the hen harrier.

In the wider landscape, at the 2 km zone around territories (Appendix 3), surveyors also reported pressures and threats by frequency of occurrence. Again, those highlighted included all activities referenced in the paragraph above, as key determinants of hen harrier presence or absence and/or habitat suitability, with the exception of 'non-intensive grazing'. These activities are also listed in the draft HHTRP (NPWS, 2022) but there are limited recommendations and/or actions identified to address some of the pressures and/or threats, *e.g.* turf cutting and wildfires/illegal burning or recreation. At some sites, these activities are problematic for hen harrier *e.g.* turf-cutting at Slieve Beagh SPA (CANN 2022) or scramblers and quad bikes in the Slieve Felims (HHP, 2019). Some of these activities will need to be addressed in tandem with the wider sectoral pressures of agriculture, forestry, and wind energy identified in the draft HHTRP, as all of the aforementioned pressures which can operate singly or in combination at any one site or wider. Thus, mitigation will require holistic and specific management to reduce likely negative cumulative effects of these pressures on breeding hen harriers and their habitats.

Surveyors in 2022 identified three main sectoral pressures across breeding hen harrier sites: forestry (NPWS, 2015), wind energy development (NPWS, 2021) and agriculture (NPWS, 2015). The negative effects of activities associated with these sectors typically manifest directly on the species (*e.g.* nest destruction, disturbance, or displacement) and also indirectly on the supporting breeding and/or foraging habitats via destruction, disturbance, or displacement *i.e.* loss of habitats. Often forested habitats are sub-optimal for the hen harrier but are optimal for other species, such as buzzard or red fox, and this land-use is exacerbating losses of hen harrier from parts of the landscape due to changed habitat composition. The accommodation, protection, and proliferation of hen harrier suitable habitats within current landscapes (*i.e.* plantation forests, windfarms and agricultural) requires an interdepartmental approach to retain and restore suitable, and optimal, breeding habitats for hen harrier and prevent native habitats and vegetation *e.g.* heather and scrub and natural grasslands being diminished year-on-year.

### 4.6.3 Forestry

The Forest Service's (of the Department of Agriculture, Food and the Marine or FS-DAFM) Red Areas Procedure (Forest Service, 2012) aims to manage the interactions with hen harrier including through the implementation of protective buffer zones (also often referred to as 'Red Zones') where forestry-related activities are restricted in SPA areas. These restrictions are in place as of 2022 (from 1 March–15 August in a calendar year), but they are not being applied retrospectively to existing licenses *(i.e.* pre-2022, which continue to run from 1 April–15 August annually). This protocol applies within HLNAs which are within/overlap with the SPA boundaries only. Currently, no formal procedures are in place to protect hen harrier breeding sites from forest management disturbance outside the SPA network. Several incidents of forestry management activities (including harvesting and afforestation) which have led to the direct disturbance, loss, and displacement of breeding hen harriers both within and outside the SPAs have been recorded in recent years (M. Ruddock, *pers. obs.*). Minimising disturbance in the early season (particularly during March) would reduce displacement of birds in the breeding settlement period (Hardey *et al.,* 2013).

The Red Areas Procedure, which has been in place since 2012, requires a comprehensive review and update by the regulatory authority *i.e.* DAFM's Forest Service. A review should assess the efficacy of this management measure in protecting breeding hen harriers in the SPAs taking into consideration the changes over the past 10 years in the hen harrier population, forest management techniques, and understanding of hen harrier ecology since the protocol was first implemented. Such a review needs to consider the current population status of the hen harrier, at SPA and national level, the current rate of decline, ongoing effects of forestry management practices on the population as a whole and Ireland's obligations under the Birds Directive and upcoming Nature Restoration obligations. The existing Forest Service Red Areas Procedure is dependent on the comprehensiveness, accuracy, and contemporary

status of the data provided on hen harrier breeding sites so that unnecessary protective buffers are not enforced, and to ensure that any changes in the distribution of breeding pairs are captured between years.

The spatial extension of the current FS-DAFM Red-Areas Procedure is required and should identify and include all important breeding areas for hen harrier, not only inside SPAs but also in the wider countryside. Supports for the protection of hen harrier breeding habitats and breeding sites, via the spatial extension of the current procedure beyond SPAs would help to reduce the impact from forest sector activities during the breeding season and thereby further deterioration of the national hen harrier population and its habitats. This review and a strategic consideration of the spatial and temporal sensitivities of the species and increased annual data collection would allow improved standardised procedures for planning consents and forestry managers. Annual hen harrier surveys are feasible and repeatable across wide areas of the country (HHP, 2018-2022) and the on-going availability of this information, for both SPAs and the wider countryside, would support adaptive and improved measures for both the hen harrier, forest planners and foresters *e.g.* by inputting locational and breeding status information directly into any Red Areas procedure and these data could also to help inform wider planning decision makers and other sectors to offer improved protection for the hen harrier.

### 4.6.4 Agriculture

The total SPA population has continued to decline; with a singular site exception of the Slieve Bloom Mountains SPA. These downward trends are despite extensive investment in agricultural supports since the 2015 survey *e.g.* GLAS (Green Low Carbon Agri-Environment Scheme), results based EIPs (*i.e.* HHP); and various protective measures for forestry planning and forestry activity (*e.g.* FS-DAFM's Red Areas Procedure) using spatial and temporal buffers (*e.g.* Higher Likelihood Nesting Areas (HLNAs[6]). The conservation of the hen harrier in Ireland requires urgent finalisation and implementation of the cross-sectoral threat response plan to establish meaningful conservation and sectoral priorities and management measures for the SPAs and wider.

A strategic review of both inputs (both monetary and adopted measures) and outputs (results) from the aforementioned agri-environment programmes for GLAS and HHP, and a robust analysis of results, is required to inform successor programmes such as ACRES and CSP (2023-27), and to ensure that the hen harrier is benefiting from the supporting mechanisms and measures that are in place and funded by the EU and taxpayers. Surveyors have reported an enduring negative perception of hen harrier amongst landowners *i.e.* that the species is responsible for limiting livelihoods and farming aspirations. State funded agri-environment subsidies for farmers and landowners, together with community funding support programmes, are crucial to ensure the roles and skills of locals are supported and valued. A social and supportive culture of farmers and landowners within the SPAs and wider was adopted by the HHP (EIP), an extensive and locally adapted funding programme which ran from 2017-2023 (M. Ruddock, *pers. obs.*). This approach should be encouraged through all programmes including locally-targeted funding opportunities (The Community Environment Action Fund; LEADER programme for Rural Development 2023-2027; Heritage Council).

There is a potential wider issue arising with agri measures (including CAP and EIPs) as they require sustained support over the longer-term, and the timescales of typical supporting 'projects' (often no more than five years duration), may not adequately allow sufficient time for hen harrier population responses. National funding support mechanisms which are targeted, objective-driven, well-designed and practicable, to allow more long-term and consistent hen harrier specific provisions, including those provided via the Common Agricultural Policy (CAP) are necessary.

[6] HLNA are sensitive areas which are identified within SPAs to help avoid forestry-related disturbance which were defined using studies of territorial / nest movements between years which identified nearest neighbour distances from detailed annual studies of the species and the application of a 1.2 km radius as a direct and indirect protective buffer.

The use of machinery and quad bikes across the uplands can cause high levels of disturbance and habitat loss as well as Some targeted and specific management and restoration of sites, including ground-predator exclusion measures for nesting hen harriers, may be required to improve the species locally and to demonstrate best practice opportunities for wider landscape scale recovery. Farming practices and grassland structure and cropping regimes as well as grazing levels can be a particular determinant of grassland and moorland and scrub habitat quality, biodiversity, and carbon capture (Staddon & Faghininia, 2020) for example. It should be noted that some positive changes have occurred in recent years (DAFM, 2022), including the potential eligibility of scrub for Pillar 1 (agri-environment) payments. It is recommended to counteract some of the ineligibility criteria under the previous CAP and increase transfer to heather within incoming CAP frameworks and also and create opportunities for further rewarding of landowners for optimum hen harrier habitats (scrub, heather) and to also discourage the removal of these habitats and also the wider protection and improvement of linear supporting habitat features, such as hedgerows, within wider agricultural policy frameworks. Future measures for hen harrier are needed to broaden and restore semi-natural habitats across their former range to redress the balance of past losses. The Cap Strategic Plan (CSP) should ensure that DAFM advisors, forest planners, Teagasc and the private farm advisor network in Ireland play a role in preventing such losses through a training and upskilling programme delivered by hen harrier ecologists.

### 4.6.5 Landscape and habitat changes

A key priority is to better understand any causal linkages between the hen harrier population declines and habitat changes at the landscape-scale over time. Further research to assess such habitat changes (including forest maturation) since the previous habitat mapping was completed (Moran & Wilson-Parr, 2015) is needed and the potential influence of such changes on the hen harrier population trends and nesting distribution (Tapia *et al*., 2004) including within the SPA network. This will require examination review of more recent satellite imagery and other relevant datasets (*e.g.* related to forestry, development and planning, wind energy developments, agricultural areas, roads *etc*). This update should also extend beyond the SPAs into the wider countryside and to include the non-designated regionally-important breeding areas. In addition, the functional connectivity of the landscape and habitats with respect to hen harrier needs to be determined incorporating all relevant layers (as described above). The models should factor in variables such as energetic costs, predation risk, and available species location/activity data to predict optimal areas to reconnect and prioritise areas to rehabilitate and/or restore. The development of an integrated GIS mapping resource/tool, showing habitat and land-use information to support hen harrier conservation management planning in Ireland is now required for implementing and targeting future management actions.

### 4.6.6 Renewable energy

Increasing and extensive renewable energy targets are important to counteract climate change as required through legislation (*e.g.* Climate Action and Low Carbon Development Act 2015) and policy (NAF, 2018; NECP, 2021). Wind energy development, including any future repowering of existing, is likely to increase across our landscapes over the next decade along with associated access and disturbance issues. There are a number of potential impacts on hen harrier from wind energy development (NPWS 2021). A range of negative interactions can occur with wind energy development, including displacement from foraging habitats, avoidance, disturbance at nesting or roosting sites, lower breeding success and mortality (*e.g.* Pearce-Higgins *et al*., 2009; 2012; Wilson *et al.,* 2015; 2016; Fernandez-Bellon *et al.,* 2015; 2018; O'Donoghue *et al*., 2020) surveyors across various regional areas reported widespread breeding season construction works for wind energy developments, and an increasing number of solar energy installations, both during the survey year and increased numbers of developments over recent years since the last national survey. Many surveyors reported that there is poor spatial planning around extant sites and there is persistent loss of suitable hen harrier habitats during wind energy development projects, but particularly in regions of Co. Donegal, Co. Clare, Co. Limerick and Co. Kerry. An increasing number of hen harrier collision

strikes have been reported since the last national survey (NPWS, 2022) and a number of well-used winter roost sites have had turbines constructed within and/or immediately adjacent and resulted in displacement effects on the birds at the roost sites (O'Donoghue, 2021).

### 4.6.7 Spatial planning

There is a need for consistent and recognised guidance and best practice methods for bird surveys to inform impact assessment (including for hen harrier) in Ireland. That is, to improve upon existing measures in Ireland for spatial planning for various human activities including renewable energy developments (*e.g.* windfarms and solarfarms), forestry and recreation and avoidance of sensitive sites for hen harriers (Currie & Elliot, 1997; Ruddock & Whitfield, 2007; Bright *et al.,* 2008; 2012; Wilson *et al.,* 2016; Caravaggi *et al.,* 2019). Specific guidance for conducting best practice surveys and ecological appraisals and hen harrier work programmes is needed to minimise practical and spatial conflicts across the regions and across the sectors in Ireland, such as potential losses of breeding (and wintering) habitats for hen harriers and ensure adequate baseline information is available for decision makers.

In Ireland for example, afforestation projects may be conducted by personnel with no specific hen harrier expertise but there is no recognised best practice format or template in operation and ecological competences may differ between personnel and require training and/or consultation with appropriate hen harrier expertise. Similarly within development planning and farm advisor networks or recreational event planners across the country a wide range of skills exist but a greater awareness of potential effects of actions or activities and training on the hen harrier is needed through robust survey and spatial planning *e.g.* risk or sensitivity mapping (*e.g.* McGuinness *et al*., 2015). More widely the wind energy work programmes in Ireland, typically follow the best practice guidance in Scotland (SNH, 2017; NatureScot, 2023). These methods may not be as appropriate in Ireland, and/or require modifications, due to variations in *e.g.* breeding or wintering seasons, typical home range size of hen harriers in Ireland, which may be much larger (Irwin *et al.,* 2012) than in Scotland (Arroyo *et al.,* 2009).

Survey guidance and best practice methods for renewable energy developments are required, for pre-construction and post-construction monitoring to improve standardisation and increase efficiency within the planning system for hen harrier ecological assessments. There are opportunities for the wind energy industry to increase levels of land management certainty, and regulation / management of the activities within and surrounding windfarms (*e.g.* recreational users, dog walkers *etc*) and identify opportunities for the retention and restoration of habitats suitable for breeding (and wintering) hen harrier within and surrounding renewable energy developments.

### 4.6.8 Future research and monitoring

To inform and understand population responses and direct conservation actions, more targeted monitoring at key sites, including the SPAs, is needed along with the continued 5-year national survey model. Developing targeted monitoring of nest locations and breeding outcomes (fledging) at local and regional scales on an annual basis is required to inform conservation decision making *e.g.* buffer avoidance zones for all potential disturbing activities. These measures should include an increase in training and building best practice for surveys and assessment including for foresters, agri-advisors, council planners and developing links between monitoring groups and knowledge transfer.

Following the development of best practice guidance the deployment of a community citizen scientist models, along with improved communication with other ornithologists (*e.g.* consultants), could be linked with local regional experts (*e.g.* NPWS and/or IRSG and/or BWI and/or GET) to corroborate the veracity of records. Such an approach should be reviewed and could conceivably collect a high proportion of the necessary hen harrier population data annually. This information would enable wider and more bespoke safeguards and extend

protection measures beyond SPAs providing more strategic consideration of spatial and temporal sensitivities to help inform sectoral responses and adaptations.

Specific research measures or outputs are required to improve the estimates of population modelling and the collation of all historical and extant hen harrier research data, through the agreement with multiple stakeholders, to inform more detailed understanding of regional projections of population changes (see Fielding *et al.,* 2011). Monitoring of hen harriers and their habitats and changes requires further consideration and an annual review of the adequacy of monitoring changes in both birds and habitats over time are needed and to assist identifying any information gaps and be developed alongside mapping tools and resources. As outlined above the next annual survey is recommended to take place in 2025.

There is a need for a better understanding of the lack of hen harriers in vacant areas with apparently high suitability of habitats for harriers, such as the Wicklow Mountains, could provide opportunities for restoration of the species range and abundance *e.g.* through reintroduction or translocation using best practice guidance for such ex-situ conservation measures (IUCN, 2013). The guidance requires that the reasons for extirpation in the first instance are not going to reoccur and appropriate policies are in place to address the existential threats and pressures to avoid subsequent failure of the reintroduction or translocation. Such conservation measures would require extensive review, stakeholder consultation and consideration before implementation.

Future research of SPA and nest site-specific management measures, and the learnings of from the HHP (*e.g.* Wilson-Parr, *in prep.*) with respect to supporting actions and measures implemented by that project and best practice opportunities would help improve linkages in understanding and reversing some of the direct causes of failure. This includes measures to prevent and better protect nests sites which are failing late in the breeding cycle and specific measures to be implemented to improve fledging success. The information derived from the 2022 national survey and comparative earlier surveys about the potential shifting of sex ratios based on those observed birds may relate to wider causes of mortality. For example, further research may be needed to understand the causes and drivers of the sex-biased sightings recorded, which may be due to a number of factors including survival (at nesting, post-fledging or post-dispersal stages) or the occurrence of environmental contaminants (*e.g.* rodenticides and plant protection products) in the wider landscape.

## 4.7 Recommendations

The hen harrier population is severely affected by a range of activities, pressures, and threats across Ireland. The population has declined substantially in the short-term 2015 to 2022 by one third and in the long-term 1998/2000 to 2022 by more than half and the species needs specific, targeted, and expeditious actions across the species' range and by stakeholders. A cohesive, collaborative approach is required to collectively reverse the decline of the species to ensure that the hen harrier does not become ecologically defunct, or extinct, within any region or nationally.

NPWS and key Government Departments are developing a Hen Harrier Threat Response Plan (HHTRP) in consultation with stakeholders and the public to cease, avoid, reverse, reduce, eliminate, or prevent threats on the hen harrier (NPWS, 2024). The legal basis for the HHTRP is established in Regulation 39 of the European Communities (Birds and Natural Habitats) Regulations 2011 (SI No. 477)[7]. NPWS has also published the conservation objectives for the hen harrier SPAs and the SPA network as a whole (NPWS, 2022).

Fernandez-Bellon *et al.* (2021) suggests that effective conservation of hen harrier populations should prioritise active management strategies rather than passive protection measures. Measures to conserve and restore hen harrier populations need to be locally-adapted, site-

[7] *S.I. No. 477/2011 - European Communities (Birds and Natural Habitats) Regulations 2011* https://www.irishstatutebook.ie/eli/2011/si/477/made/en/print

specific and targeted at various levels, *i.e.* localised, regional, and national populations, delivering. Hen harrier conservation in Ireland requires urgent implementation of concrete and significant actions promptly to prevent its further deterioration. Many of the required actions to improve the conservation status of hen harrier are identified in the HHTRP, here we outline specific recommendations arising from the national survey to inform the protection and restoration of the hen harrier population in Ireland.

- Urgent and specific interventions for the hen harrier are required in Ireland, including the prompt implementation of a robust and effective HHTRP to address population declines.
- Regular National Surveys are required (every 5 years), returning to the schedule as indicated prior to the Covid-interruption. Thus the next survey would take place in 2025.
- Survey data evaluation must continue to include subset analysis to ensure like-for-like comparisons between survey.
- The conservation status of the hen harrier must be continually assessed, utilising best available data. In forthcoming BOCCI reviews, it is recommended that the subset analyses (which demonstrate a >50% decline) be used to assess population changes.
- Annual monitoring is required for the hen harrier and opportunities for increased levels of interannual surveys, databases, and reporting, both within and outside the SPA network, including with the greater involvement of citizen scientists and new technologies (*e.g.* remote sensing) should be explored. This will provide better data to inform decision making across sectors within the species' range, including forestry, renewable energy, agriculture, and recreation.
- Given the status of the hen harrier and observations from surveyors in the 2022 survey, the protections for hen harrier currently in place needs to be reviewed and expanded upon. Many wide-ranging stakeholders interact with hen harrier conservation needs, including but not limited to forest, agriculture, renewable energy, and recreation sectors. Inclusive consideration of the threats and pressures, and actions that can be taken to improve its conservation status is required including within the HHTRP.
- In order to alleviate current pressures, *i.e.* disturbance during the breeding season due to forest management operations, a review of methods and protocols of hen harrier forestry protection measures is warranted, *i.e.* the FS-DAFM Red Area Procedure including the potential extension of protection measures to hen harrier breeding habitat outside the SPAs and implementation of additional measures to prevent the loss and deterioration of hen harrier habitats and direct disturbance of breeding sites.
- A review of the afforestation protocols, the survey methods and guidance used to inform such protocols, and other forest management activities in accordance with the legal obligations under the Wildlife Acts and the Birds and Natural Habitats Regulations, is warranted.
- Upskilling and training of foresters and ecologists involved in the preparation of impact assessments, in hen harrier ecological requirements is recommended.
- The deployment of annual and/or site-specific surveys for forestry and/or afforestation licences and the mitigation measures required should include consultation with relevant hen harrier expertise and recommend the formation of a working group to review this to include all relevant stakeholders.
- A review of the best available scientific evidence and data collection protocols, and data availability and sharing, to inform forest sector actions and activities is recommended and the deployment of annual surveys and/or site-specific surveys to ensure data are current and relevant for forest management activities and seasonal activities are in accordance with the Wildlife Acts and Birds and Natural Habitats Regulations.

- The agricultural sector has significant capacity to implement landscape scale changes that can be optimised for the hen harrier. The removal of any remaining conflicts within funding systems (*e.g.* scrub and heather eligibility) and their effective communication to agri-advisors and participants to prevent on-going loss and disturbance of breeding hen harrier and their habitats is recommended.
- Long-term support for local communities and locally adapted agricultural programmes is needed; farmers and land managers should be centrally positioned within these; and sufficient supports by way of knowledge sharing (in both directions) and monetary inputs should be provided via the community sector through local engagement mechanisms, to minimise negative perceptions of hen harrier conservation to reduce the negative sentiments towards the species across all sectors.
- As with the forest sector, it is recommended that the agricultural sector reviews methods and protocols for hen harrier nest protection measures (*i.e.* avoiding disturbance to nest sites) both inside and outside the SPAs, as well as implementing additional measures to prevent the loss and deterioration of hen harrier habitats, the direct disturbance of breeding sites, and to minimise potentially disturbing activities, particularly those involving machinery during the breeding season, as may be required and in accordance with the Wildlife Acts and Birds and Natural Habitats Regulations.
- The Cap Strategic Plan (CSP) should take into account the importance of supporting habitats and features for hen harrier in the wider landscape and include the provision of training and upskilling of agricultural advisors with respect to the ecological requirements of hen harrier.
- A cessation of cutting and burning of deep heather across Ireland is needed and clarity regarding ineligibility criteria of deep heather within farming subsidy frameworks is required. Disincentivising these actions, more effective communications by farm advisory, and the enforcement of the relevant nature legislation may be key in preventing these habitat losses. More action is required to address the loss of habitats through turf-cutting at inappropriate locations, by machinery and/or at critical times of the year and preventing disturbance in accordance with the Wildlife Acts and Birds and Natural Habitats Regulations.
- There is a need for long-term and consistent supports (greater than five years) a within the agricultural sector to implement ecologically-meaningful actions for the hen harrier.
- There are opportunities for knowledge transfer and skill sharing between hen harrier ecologists and the farm advisor networks to increase awareness across the species' range and provide significant levels of interaction, sightings and opportunities with landowners and farmers.
- The 2015 published habitat mapping for the SPAs needs to be updated and it is recommended that it be expanded to include the non-designated regionally important areas.
- In tandem with the habitat map update, research that examines land-use and habitat composition and suitability for hen harrier in the wider landscape and how these are likely to influence movements and population dynamics of hen harrier should be initiated.
- A programme using the learnings from habitat suitability research (see above) to work collaboratively with other relevant and existing projects and stakeholders to develop pilot studies and targeted rehabilitation/restoration measures at hen harrier study / trial sites, perhaps initially comprising groups of existing nests, which would then act as best practice demonstration sites and provide 'hot-spots' of hen harrier productivity.
- It is recommended that these restoration sites are implemented at an appropriate scale in the landscape and target measures to increase fledging success of the hen harrier. Protection from predation and disturbance between the nestling and fledgling stage will

be a key measure to reverse the population decline by increasing productivity (see also Ruddock *et al.*, 2016).

- Disturbance and habitat losses with the hen harrier range from land-use changes and development activities must be reduced.
- The development of best practice guidance for surveying hen harriers in Ireland is needed for the renewable energy sector. This should give due consideration to specific assessment and reporting needs for hen harrier including best practice developed in other jurisdictions, with a view to producing bespoke Irish guidance.
- Since recreation has been highlighted through surveyor observations in 2022, as increasing since 2015, and problematic at breeding sites it is recommended that further exploration is also taken forward by relevant stakeholders and Government Departments to consider how best to quantify and alleviate this pressure.
- A programme of awareness and education within the recreational sector in particular is recommended, focussed on dog walking, scramblers and off-road vehicle usage within the uplands and breeding ranges of the hen harrier and also with regard to the development of projects, trails and tracks within hen harrier areas.
- A programme and best practice of survey and assessment for recreational user groups could be adopted to help minimise the interaction between the hen harrier and events or group activities and development or update of risk / sensitivity mapping would provide a key resource to assist event planners.
- The key recommendations proposed by recent Irish hen harrier research (either published or in preparation), including on wintering ecology (O'Donoghue, 2021), seasonal ecology (McCarthy, 2022) and agri-ecology (Wilson-Parr, in prep) should be considered and implemented.
- There are additional research needs that must be met in order to address key knowledge gaps identified in this report, including the following; a specific focus on research determining causes of observed sex ratio imbalance; developing habitat suitability models; examining prey availability influence on hen harrier nesting distribution and breeding success; investigating rodenticide effects on the hen harrier and a review of all available information and research and horizon scanning of future needs.

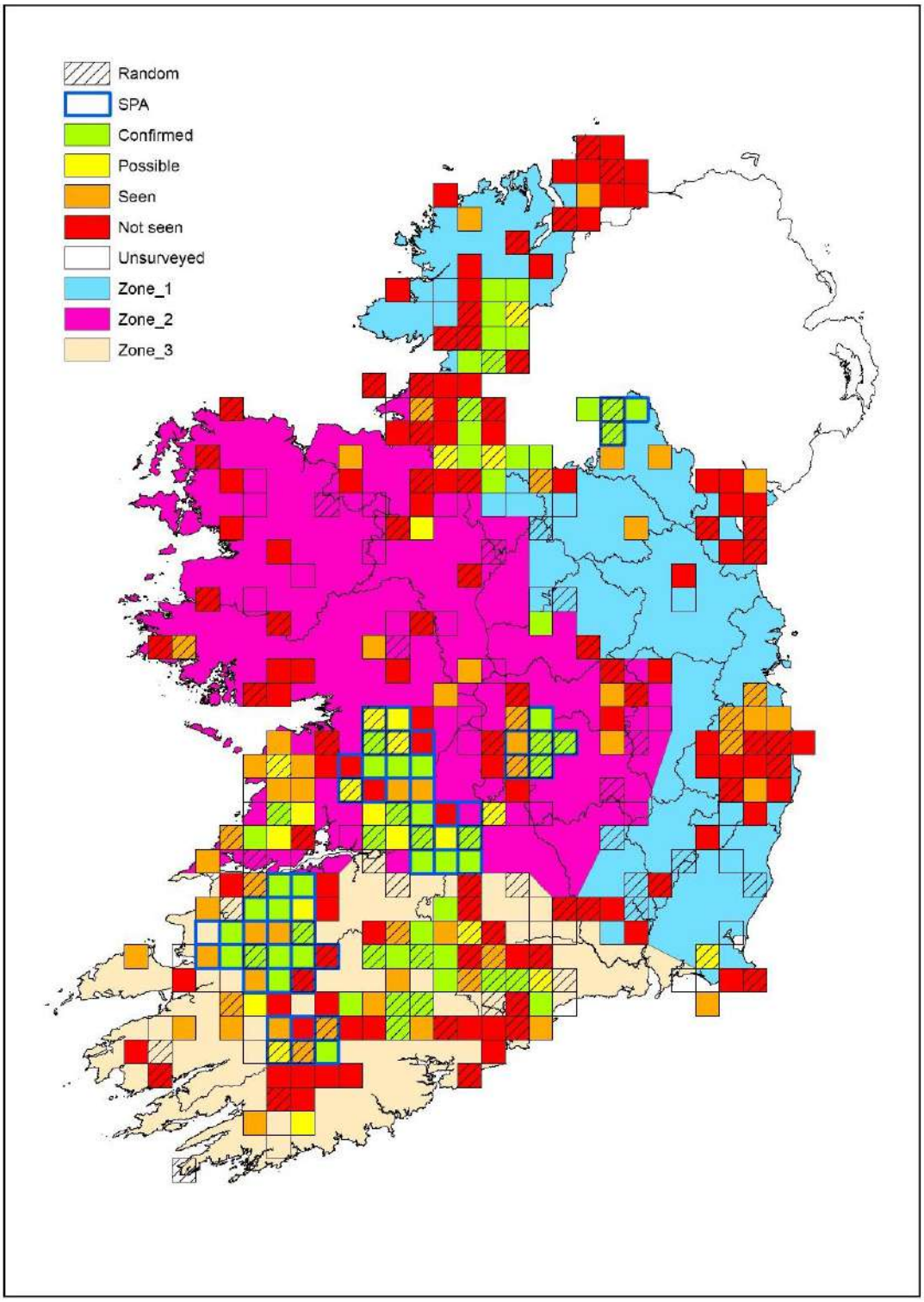



**Figure 1** The 10km squares selected for survey during 2022, including the historical maximum breeding status (1998-2021 inclusive), 10 km squares overlapping with SPAs and randomly selected squares.

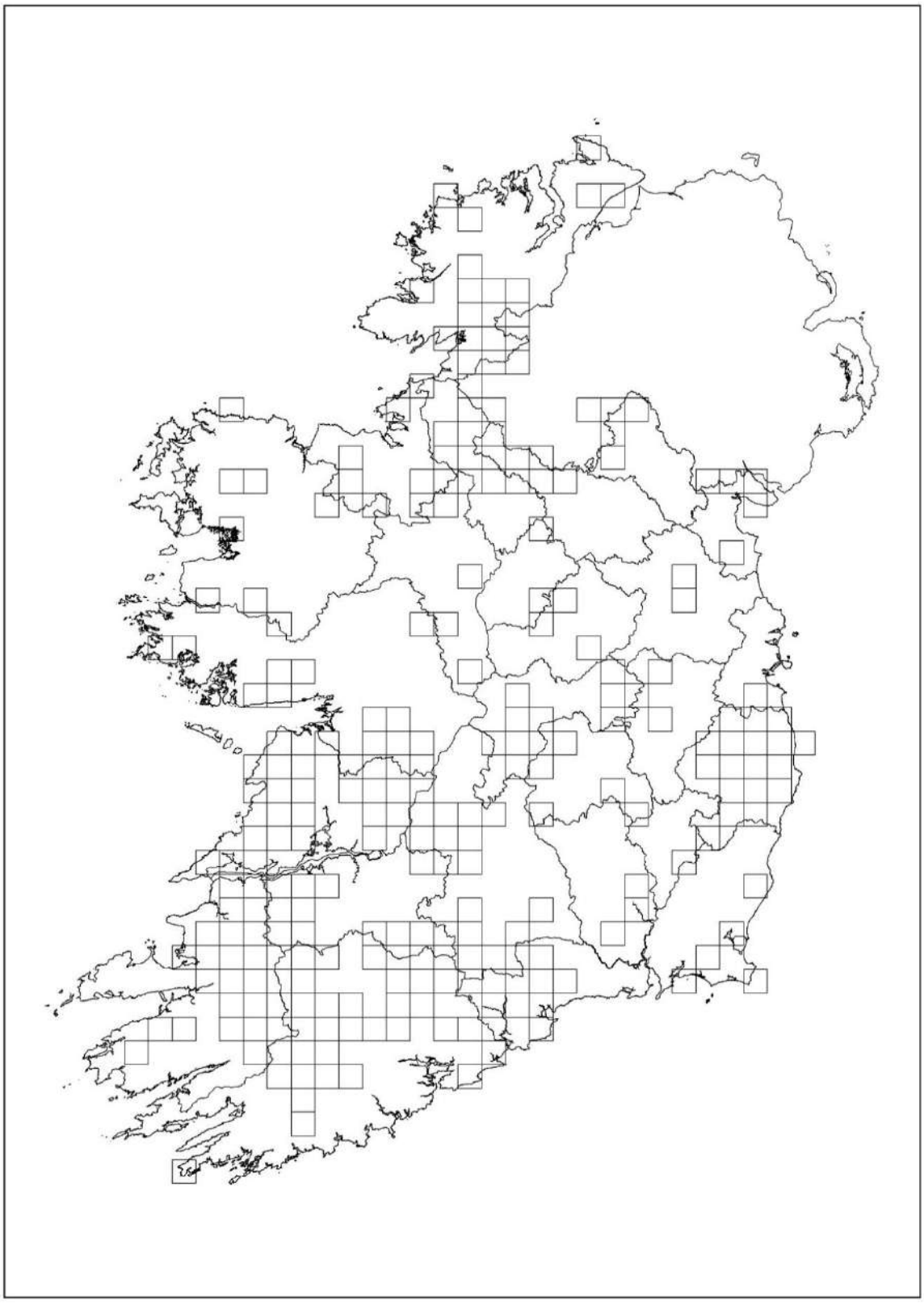


**Figure 2** Distribution of survey squares covered during 2022 for which data was received.

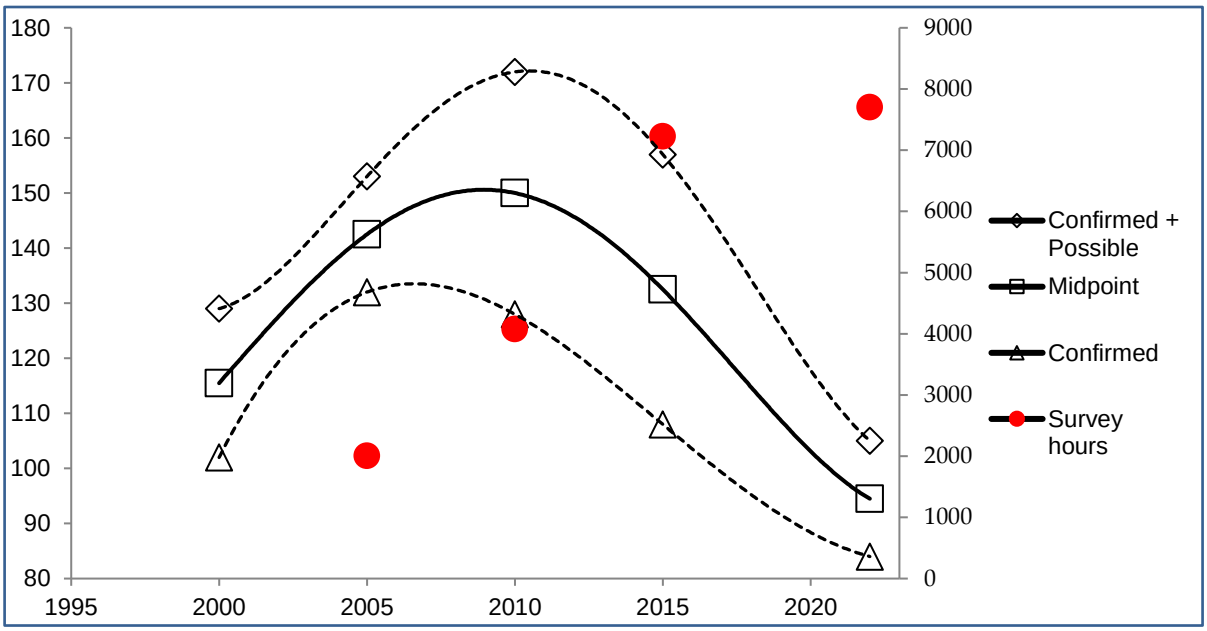



**Figure 3** Graph showing the recorded population range and mid-point estimates, trendlines and survey effort over the national hen harrier surveys.

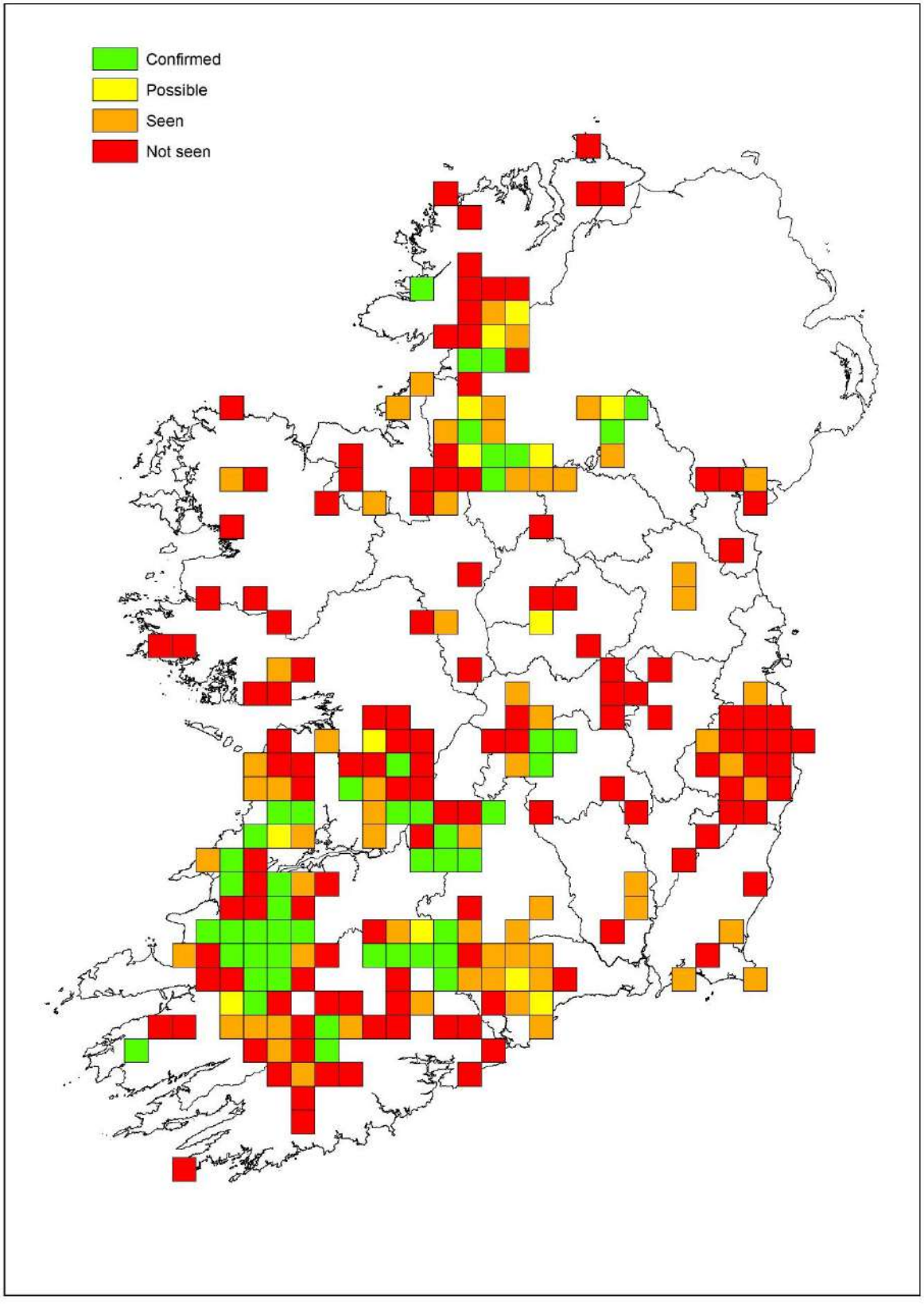



**Figure 4** 2022 distribution of breeding hen harrier in Ireland in 10 km squares, classified by breeding status.

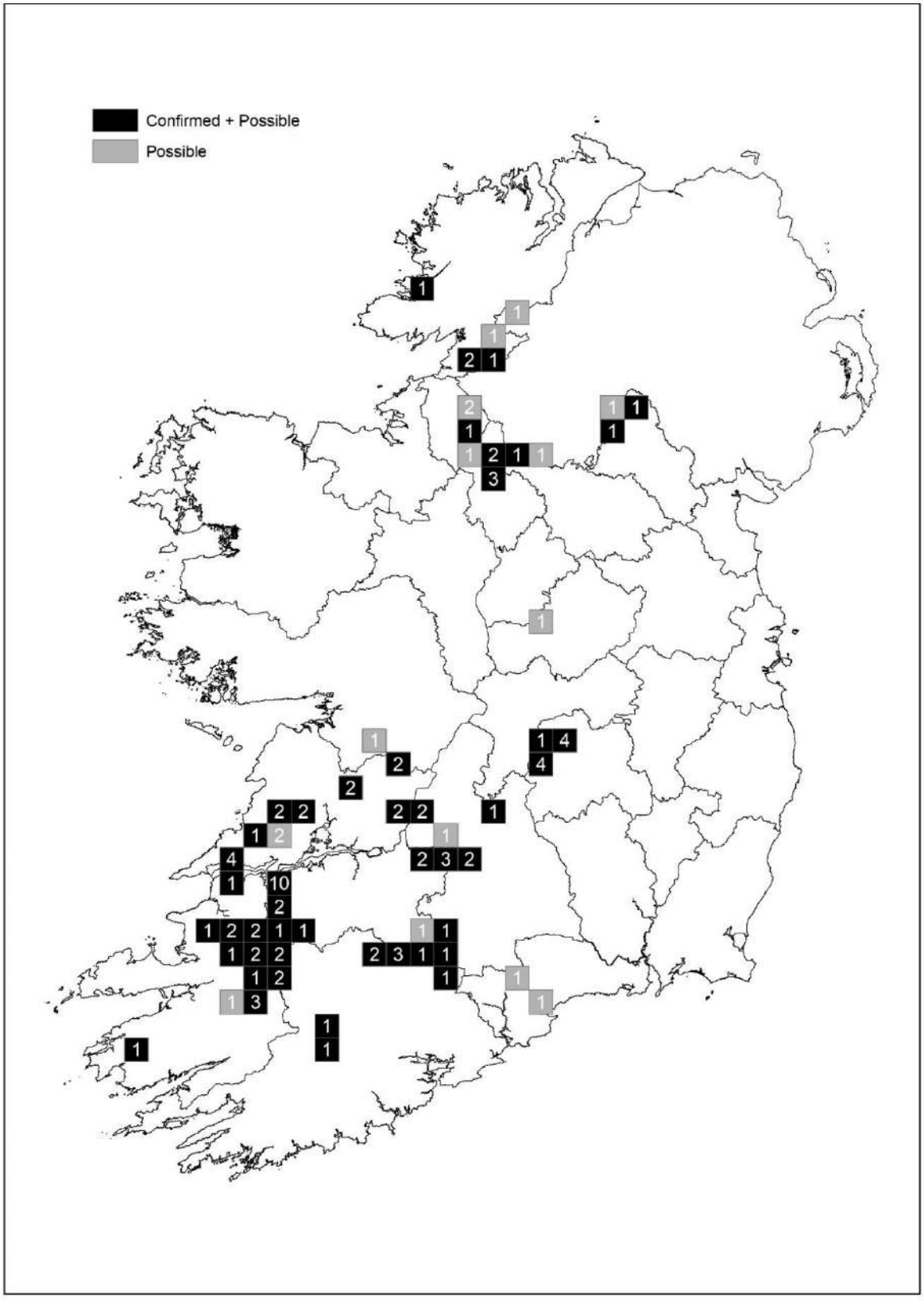



**Figure 5** The distribution (at 10 km square level) and numbers of confirmed and possible breeding hen harrier in Ireland during 2022. Black squares show total number of pairs (confirmed + possible) and grey squares show total number of pairs (possible only).

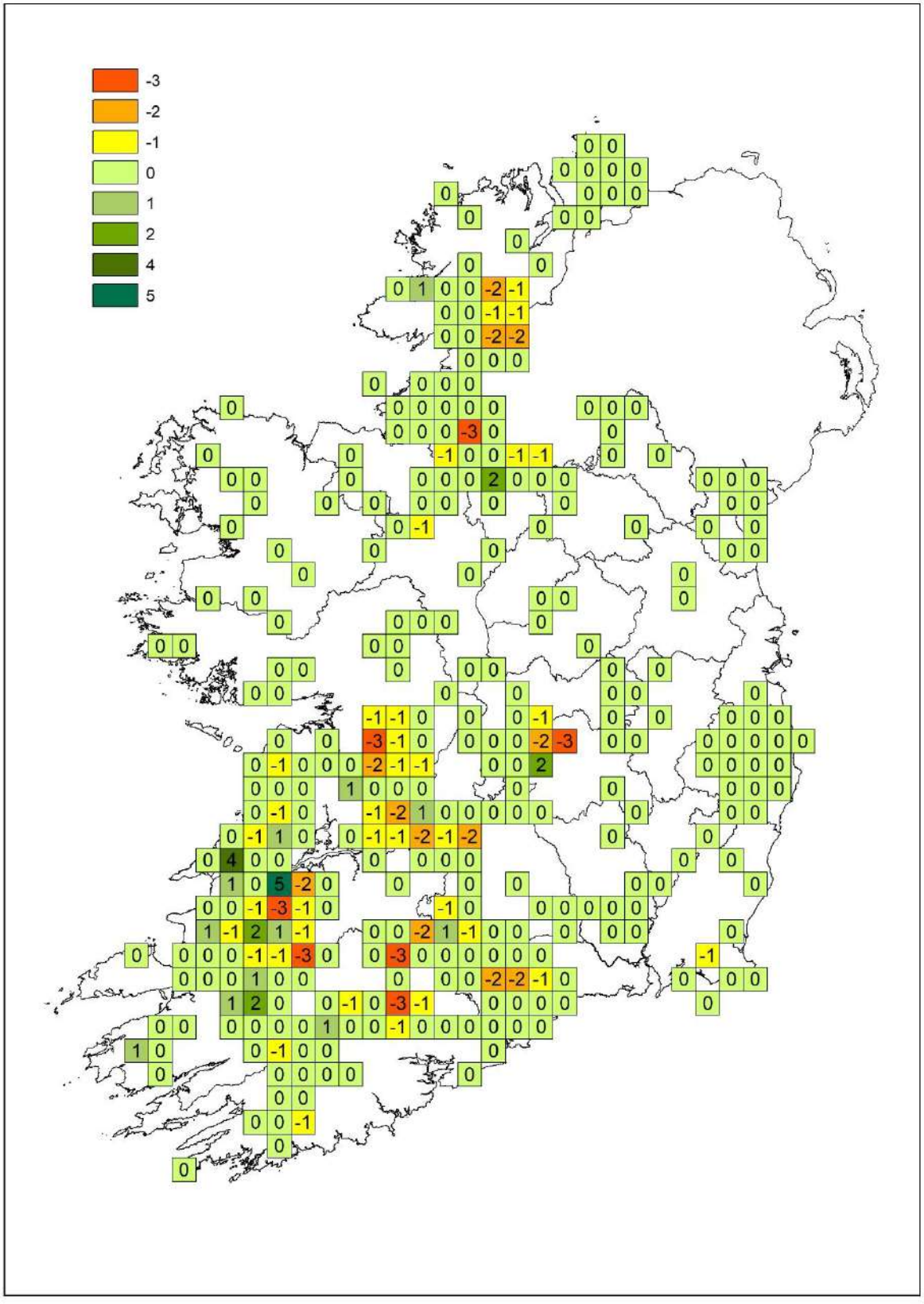



**Figure 6** The changes in distribution (at 10 km square level) and numbers of breeding hen harrier in Ireland between 2022 and 2015.

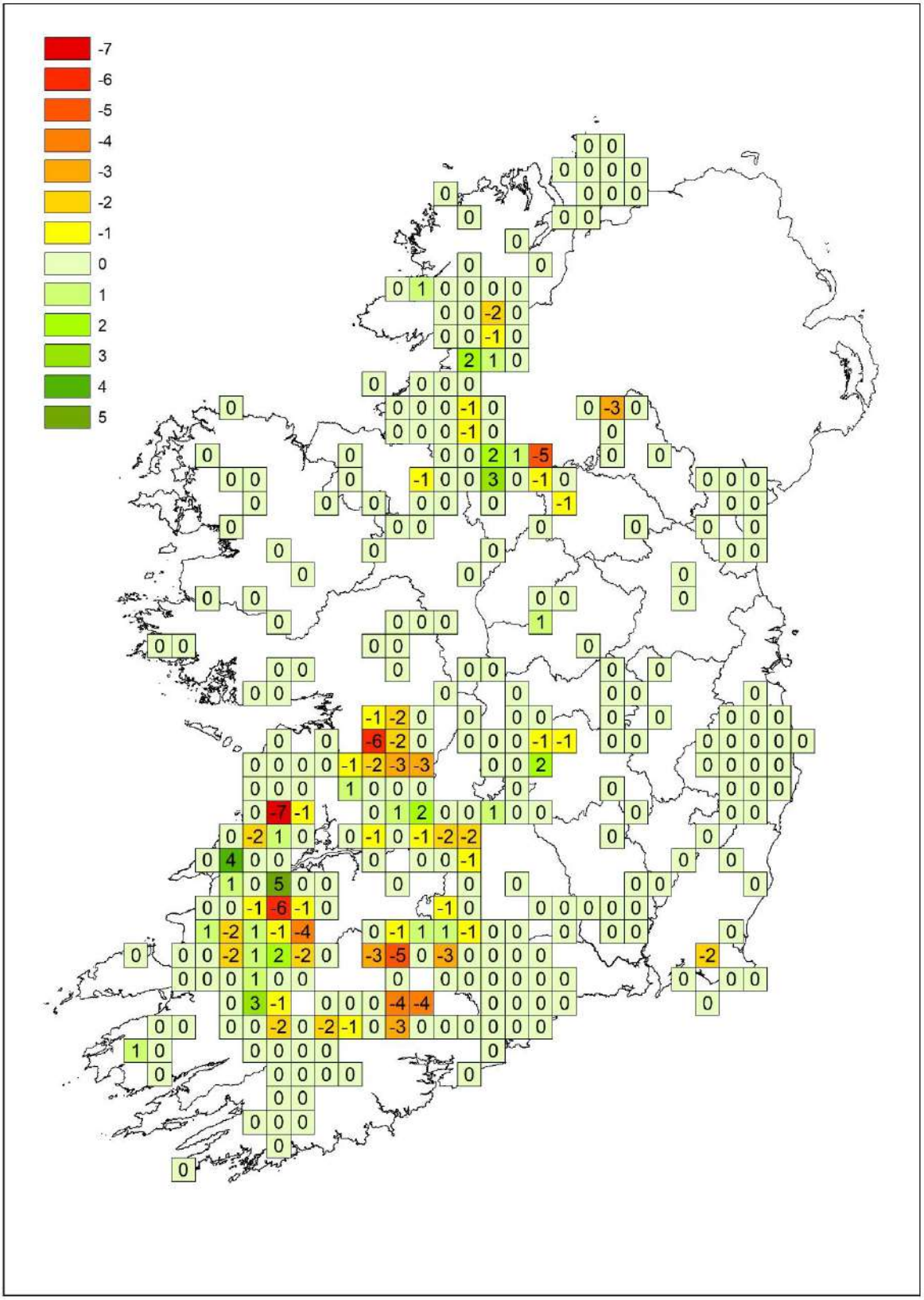



**Figure 7** Maps showing population stability, increase and/or decrease across 10 km squares between surveys in 2022 and 2010.

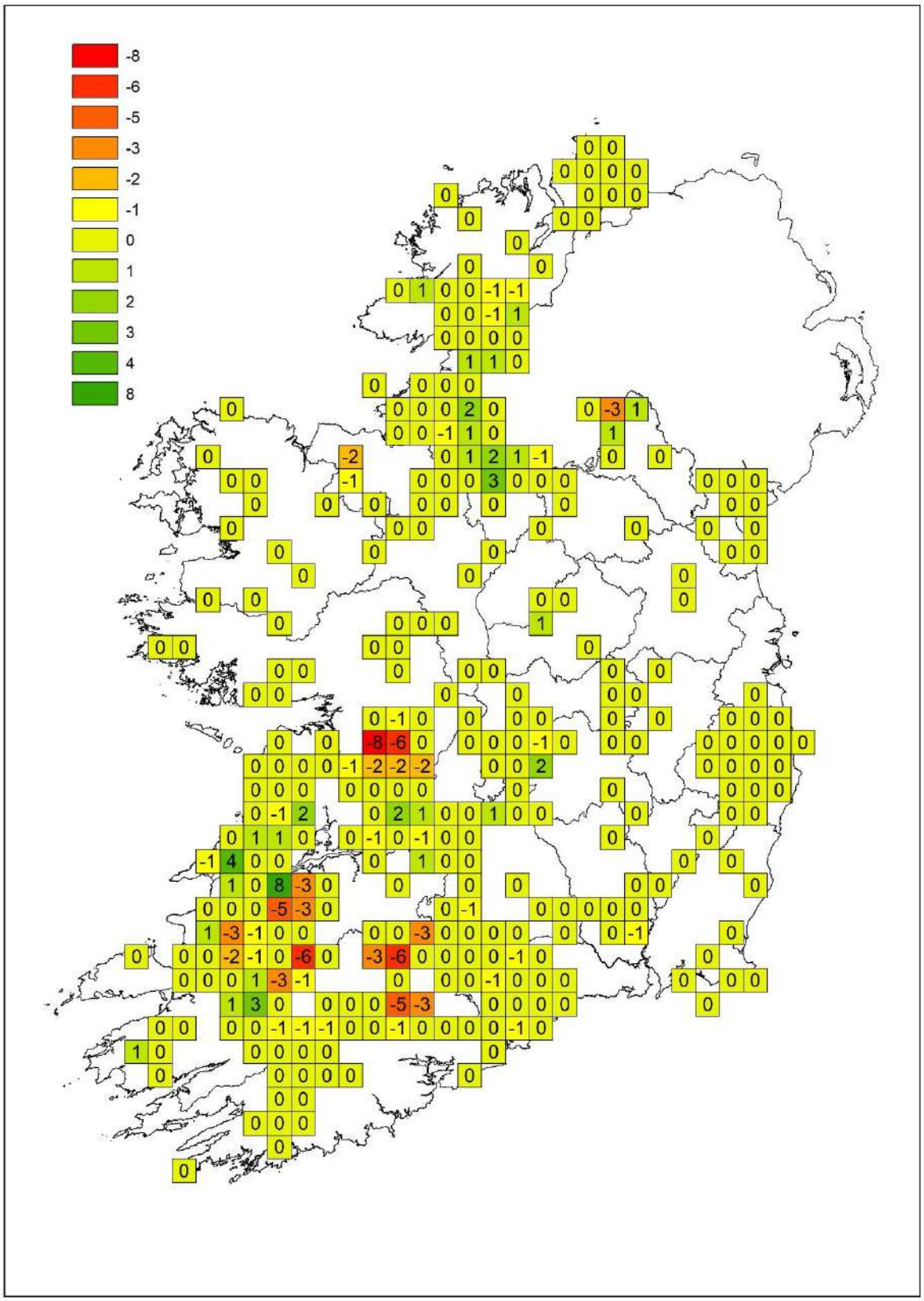



**Figure 8** Maps showing stability, increase and/or decrease between surveys in 2022 and 2005.

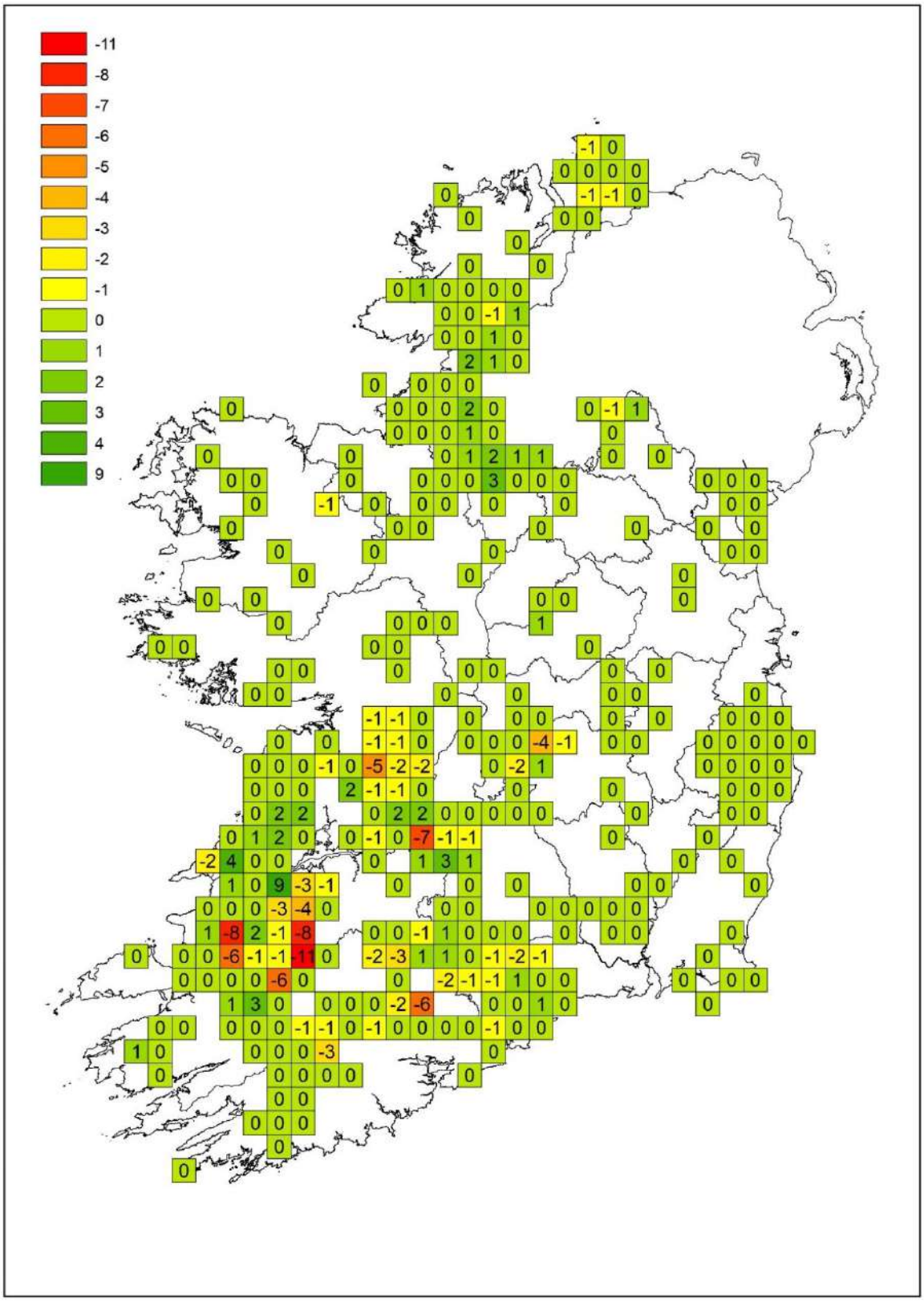



**Figure 9** Maps showing stability, increase and/or decrease between surveys in 2022 and 1998–2000.

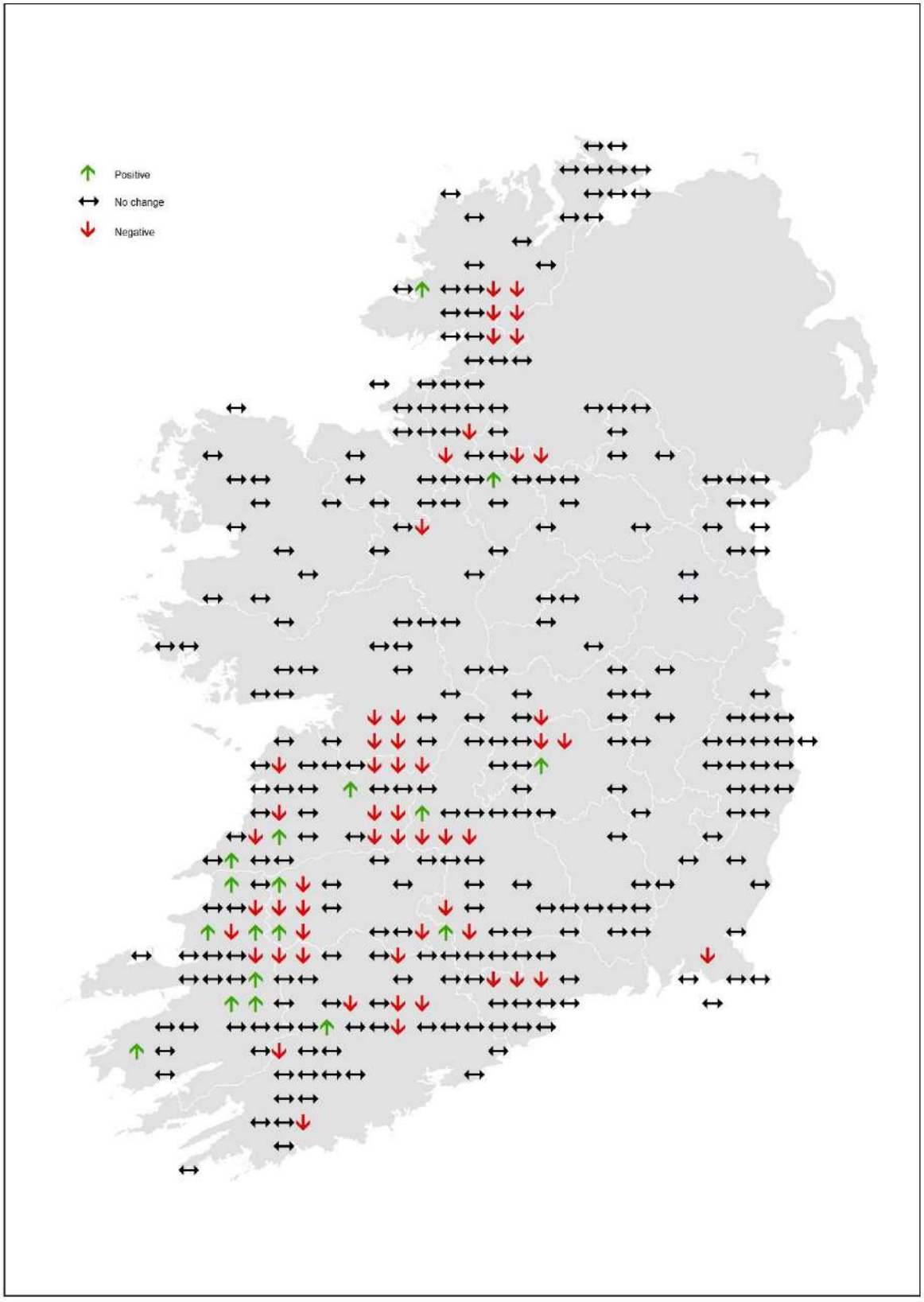



**Figure 10** The changes in distribution and numbers of breeding hen harrier in Ireland between 2022 and 2015, showing direction of change in numbers.

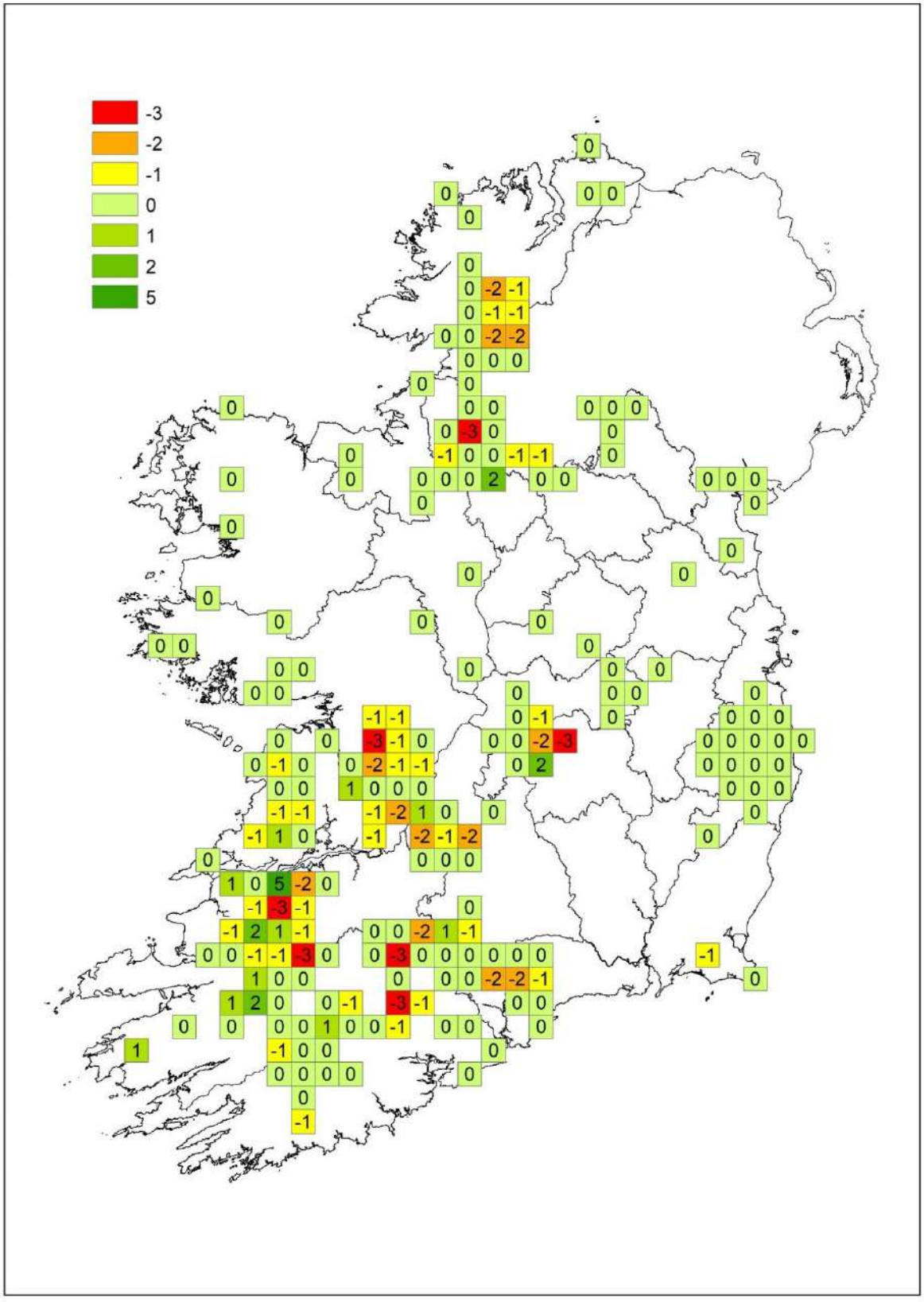



**Figure 11** The changes in distribution and numbers of breeding hen harrier in Ireland between 2010 and 2015 in the subset of squares (n = 212) surveyed in both 2022 and 2015.

**Table 1** Summary of hen harrier breeding season (Hardey *et al.*, 2013).

| Breeding activity (No. of days) | Range | Peak period |
|---|---|---|
| *Site occupation & display* | Late February to late May | Early April to early May |
| *Nest building* | April to late May | - |
| *Egg laying (5-12 days)* | Mid-April to late June | Late April to mid-May |
| *Incubation (29-31 days)* | Mid-April to late July | Late April to mid-June |
| *Hatching* | Mid-May to late July | Late May to mid-June |
| *Young in nest (28-39 days)* | Mid-May to late August | Late May to mid-July |
| *Fledging* | Mid-June to late August | Late June to mid-July |
| *Juvenile dispersal* | August to September | - |

**Table 2** Behaviour codes and descriptions utilised during the survey.

| Behaviour (Code) | Description of behaviour |
|---|---|
| *Display (D)* | Including “sky-dancing” or aerial display involving rapid stooping and climbing and occasionally mutual or individual high circling may be observed |
| *Food pass (FP)* | Male passing food to the female or adult to juvenile, usually in mid-air |
| *Hunting (H)* | Low level “quartering” flights <5m above ground level |
| *Flying (F)* | Flying or commuting where no other behaviours are recorded |
| *Alarm (A)* | Adults calling or appearing agitated, usually occurs close to the nest during territorial defence |
| *With Prey (WP)* | Carrying prey in its talons |
| *Soaring (S)* | Circling very high (above tree-tops) on thermals |
| *Circling (C)* | Circling below tree-top height |
| *Perched (P)* | Perched on a tree or fence post |
| *on Ground (G)* | Perched on the ground |
| *Mobbing (M)* | Territorial behaviour and chasing or attacking other harriers or other bird species. May occasionally be observed to attack mammal predators |
| *Other (O)* | Other behaviour(s) where not adequately described by any other category above |

**Table 3** Habitat codes and descriptions utilised during the survey.

| Habitat (Code) | Description of habitat |
|---|---|
| *First rotation (or new) forest (1F)* | First-rotation forest plantations before canopy closure. Characterised by prolific herb layer with varying shrub layer development. Trees generally >1 m tall with large open spaces between lines of planting. |
| *Second rotation forest (2F)* | Second-rotation forest plantations before canopy closure. Characterised by varying shrub layer development and brash and tree root-plates from the previous crop and large open spaces between lines of planting. Newly established second-rotation trees are not always obvious. Third rotation crops are likely in future years but none were recorded in this survey. |
| *Thicket (pole) or mature stage forest (T)* | Closed-canopy forest plantations including both 1F & 2F crops. Usually >10 years old. Characterised by absence of shrub layer, except in rides between stands of trees and in small patches of unplanted ground or failed crop. |
| *Clearfell (CF)* | Harvested plantation not yet restocked with trees. Characterised by limited development of herb and shrub layer, and brash and tree root-plates evident from the previous crop. |
| *Heather moorland/bog (H)* | Unenclosed heather-dominated moorland characterised by species such as heather, bilberry and purple-moor grass plus blanket bog characterised by ling and bell heather, bog cotton, deer grass and moss. Typically grazed by red deer and low densities of sheep. |
| *Grass moorland (G)* | Unenclosed grass-dominated moorland usually grazed by sheep. Characterised by species such as wavy hair grass, mat grass and heath rush. Stands of rush (*Juncus* spp.) and bracken (*Pteridium* spp) occasionally occur. |
| *Rough grassland (RG)* | Unenclosed or enclosed, neglected pastures occasionally stocked with sheep or cattle that have not recently been improved, re-seeded or fertilised. Usually contains long grass, waterlogged areas and stands of rushes (*Juncus* spp). |
| *Improved grassland (IG)* | Enclosed pastures that have been drained, fertilised or re-seeded characterised by lush green grass vegetation and containing higher densities of sheep or cattle. Also includes hay meadows. |
| *Scrub (S)* | Areas outside or away from plantation forests consisting of willow, bramble, furze *etc* which have not been tended by humans. Includes bushy vegetation such as willow (*Salix* spp), gorse (*Ulex* spp), bramble (*Rubus* spp), alder (*Alnus* spp), birch (*Betula* spp) and bracken (*Pteridium* spp). |
| *Linear feature associated with rough grassland (LR)* | Linear feature (*e.g.* hedgerows, ditches and drainage channels) that are contained, or in close proximity to, rough grassland |
| *Linear feature associated with improved grassland (LI)* | Linear feature (*e.g.* hedgerows, ditches and drainage channels) that are contained, or in close proximity to, improved grassland |
| *Other (O)* | Description of habitat where it does not fall into one of the categories outlined above. |

**Table 4** Classification of breeding status

| Breeding status | Behaviours, evidence and/or activities observed |
|---|---|
| *Confirmed breeding* | Food pass observed |
| | Adult carrying prey |
| | Recently fledged young |
| | Agitated behaviour or calls given by adults |
| | Direct evidence of a nest (eggs or chicks seen, chicks heard, used nest or eggshells found) |
| | Courtship or display behaviour involving both a male & female noted on two visits separated by at least a week |
| | A pair seen visiting a probable nest site on two visits separated by at least a week |
| | Nest building or carrying nest material |
| *Possible breeding* | Courtship or display behaviour involving both a male & female noted on only 1 visit, or only |
| | Only one bird is ever seen (*e.g.* displaying male seen twice but no female seen) |
| | A pair seen visiting a probable nest site on only one visit |
| | Pair or female seen in possible nesting habitat between mid-May & end of June |
| *Seen* | Single male, female or pair (outside mid-May & June) observed with no evidence of breeding behaviour |
| *Not seen* | Area of suitable breeding habitat with no observations of hen harrier |

**Table 5** Details of information requested to be collected by the surveyors on recording forms and digital data entry portals.

| Data Entry Item | Description |
|---|---|
| Name | the name(s) of observer name surveying the 10 km square |
| Email | the observer email address for follow up contact if required |
| Number of pages | the number of pages and current page number *e.g.* page 1 of 2, 2 of 2 *etc* |
| Organisation Name | the name of the organisation or study group to which the observer(s) belong |
| Phone number | the phone number of the surveyor |
| Observation Type | the type of observation (please tick) which should be either i) casual or ii) vantage point observation |
| 10 km Square | the 10 km grid reference of the square (1 letter & 2 numbers) |
| County | the county in which the 10 km square is located |
| Survey Area Name | the survey area name *i.e.* nearest place name or townland to the surveyed area (taken from the survey map) |
| Activity / Pressure / Threat | the activities/threats or pressures observed, if any, within 500 m and within 2 km of the survey area |
| Visit Number | the visit number *i.e.* whether visit 1, 2, 3 or 4 on the survey schedule |
| Date | the date please use the following format *e.g.* 01 06 = 1st June |
| Vantage Point Location | the vantage point grid reference (1 letter & 6 numbers). Specify the location from which your observation was made |
| Start Time | the start time of your vantage point watch or observation, this helps us understand survey effort |
| End Time | the end time of your vantage point watch or observation, this helps us understand survey effort |
| Sighting Time | the sighting time insert the time at which you saw the hen harrier(s) or the other species |
| Sighting Grid Reference | the grid reference of the sighting (1 letter & 6 numbers). Specify the grid reference of mid-point of activity where it occurs over a large distance or in multiple locations by the same pair/individual. Please specify clearly the grid reference of the nest (if located) and mark this on your map with an X. This data will all be kept confidentially. |
| Hen Harrier Number | the hen harrier numbers are to identify the number of individuals (0, 1, 2, 3 *etc*) seen during each sighting of each age group and sex. |
| Behaviour Code | the behaviour code(s) (see Table 2), please record all behaviours noted during sighting, you can record multiple behaviour codes here. The more information you provide the more useful your sightings will be during analysis |
| Habitat Code | the habitat code(s), which is the dominant habitat within 100m of the sighting or nest (see Table 3) |
| Other Species Code | the other species code(s) which are to record any other raptors, waders or priority species encountered during surveys. The main focus of the survey is for hen harrier but since surveyors will be widely dispersed over the country this is an opportunity to collect some additional information on some priority bird species. Please focus survey effort on hen harrier but it is useful to record any casual sighting time, sighting grid reference, behaviour codes and habitat codes also for some of the other species. BTO species codes are provided on the recording form. |
| Survey Area Summary | the survey area summary is to help inform us what your perception of the sightings and activity are at each of your surveyed areas and to |

| Data Entry Item | Description |
|---|---|
| | advise how we should classify each of your survey areas; these should be classified according to Table 6. |
| Notes | the notes section is to allow the addition of any relevant information. In particular, this should include any suspected persecution of hen harrier or disturbance, or poor weather recorded during your fieldwork, details of any wing tagged hen harrier should also be recorded to include colour of left-wing tag, colour of right-wing tag and any codes on the tags |

**Table 6** National (minimum, maximum and mid-point) population estimates between 1998-2000 (Norriss *et al.,* 2002); 2005 (Barton *et al.*, 2006); 2010 (Ruddock *et al.*, 2012), 2015 (Ruddock *et al.,* 2016) and 2022 (this study).

| Breeding Status | 1998-2000 | 2005 | 2010 | 2015 | 2022 | % change 2015 - 2022 |
|---|---|---|---|---|---|---|
| Confirmed | 102 | 132 | 128 | 108 | 85 | -21% |
| Possible | 27 | 21 | 44 | 49 | 21 | -57% |
| Confirmed + Possible | 129 | 153 | 172 | 157 | 106 | -33% |
| Mid-Point | 115.5 | 142.5 | 150 | 132.5 | 95.5 | -28% |
| Range | 102-129 | 132-153 | 128-172 | 108-157 | 85-106 | - |

**Table 7** Number of 10 km squares by breeding hen harrier status in Ireland during survey periods.

| Breeding Status | 1998-2000 | 2005 | 2010 | 2015 | 2022 | % change 2015 - 2022 |
|---|---|---|---|---|---|---|
| Confirmed | 42 | 60 | 62 | 62 | 48 | -23% |
| Possible | 17 | 6 | 7 | 22 | 13 | -41% |
| Range | 42-59 | 60-66 | 62-69 | 62-84 | 48-61 | -27% |

**Table 8** Change in distribution and abundance of hen harrier within subset analyses between 2022 and previous national surveys

| | **i (2002-2015)** | **Change (%)** | **ii (2022-2015-2010)** | **Change (%)** | **iii (2022-2015-2010-2005)** | **Change (%)** | **iv (2022-2015-2010-2005)** | **Change (%)** |
|---|---|---|---|---|---|---|---|---|
| Number of squares surveyed | 212 | | 125 | | 105 | | 74 | |
| Confirmed (2022) | 79 | | 72 | | 63 | | 54 | |
| Possible (2022) | 21 | | 20 | | 18 | | 10 | |
| Total | 100 | | 92 | | 81 | | 64 | |
| Confirmed (2015) | 107 | -26.2 | 99 | -27.3 | 95 | -33.7 | 78 | -30.8 |
| Possible (2015) | 47 | -55.3 | 41 | -51.2 | 34 | -47.1 | 24 | -58.3 |
| Total | 154 | -35.1 | 140 | -34.3 | 129 | -37.2 | 102 | -37.3 |
| Confirmed (2010) | | | 127 | -43.3 | 117 | -46.2 | 100 | -46.0 |
| Possible (2010) | | | 43 | -53.5 | 39 | -53.8 | 32 | -68.8 |
| Total | | | 170 | -45.9 | 156 | -48.1 | 132 | -51.5 |
| Confirmed (2005) | | | | | 125 | -49.6 | 110 | -50.9 |
| Possible (2005) | | | | | 19 | -5.3 | 17 | -41.2 |
| Total | | | | | 144 | -43.8 | 127 | -49.6 |
| Confirmed (1998-2000) | | | | | | | 110 | 50.9 |
| Possible (1998-2000) | | | | | | | 45 | -77.8 |
| Total | | | | | | | 155 | -58.7 |

**Table 9** Regional population estimates during 2015 utilising the squares as defined in 1998-2000, 2005 and 2010 for regional mountain ranges or site complexes.

| Region | Total pairs 1998-2000 | Total pairs 2005 | Total pairs 2010 | Total pairs 2015 | Total pairs 2022 | Trend since 2015 | Change since 2015 (%) |
|---|---|---|---|---|---|---|---|
| Ballyhouras | 6-8 | 17-19 | 10-15 | 10-12 | 6-7 | ↓ | -42% |
| Blue Stack Mountains, Pettigo Plateau & South Donegal | 1 | 3-5 | 4-5 | 8-12 | 4-6 | ↓ | -50% |
| Boggeraghs, Derrynasaggarts | 4-5 | 5 | 6-8 | 2-4 | 5 | ↑ | 25% |
| Castlecomer, Blackstairs, Kilkenny | 0 | 1 | 0 | 0 | 0 | = | 0% |
| Curlew Mountains | - | - | 0 | 0 | 0 | = | 0% |
| Devilsbit, Slievefelim, Silvermines, King Hill* | 5-7 | 7-8 | 10-14 | 7-15 | 9-10 | ↓ | -33% |
| East Cork & Waterford | 0-1 | 2 | 1 | 1 | 0-1 | = | 0% |
| Galtys | 0 | 3 | 5-6 | 2-3 | 2 | ↓ | -33% |
| Inishowen Peninsula | 1-3 | 0 | 0 | 0 | 0 | = | 0% |
| Kildare | - | - | 0 | 0 | 0 | = | 0% |
| Knockmealdowns, Kilworth, Comeraghs | 3-7 | 2-4 | 2 | 5-7 | 1-2 | ↓ | -71% |
| Leitrim, Slieve Rushen, Cavan | 0 | 3 | 12-14 | 9-15 | 7-11 | ↓ | -27% |
| Longford, Roscommon | 0 | 0 | 0 – 1 | 0-1 | 0 | ↓ | -100% |
| Nagles | 3-5 | 9 | 7-11 | 5 | 0 | ↓ | -100% |
| North & west Clare | 1-2 | 5 | 12-16 | 3-9 | 4-7 | ↓ | -22% |
| North-west | - | - | 0 | 0 | 0 | = | 0% |
| Ox Mountains, Sligo | 0 - 1 | 1-3 | 0 | 0 | 0 | = | 0% |
| Slieve Aughties | 10-21 | 24-27 | 16-24 | 8-14 | 3-5 | ↓ | -64% |
| Slieve Beagh | 3 | 4 | 5-6 | 3 | 2-3 | = | 0% |
| Slieve Bernagh to Keeper Hill | 1 | 1-2 | 2 | 5-7 | 2-4 | ↓ | -43% |
| Slieve Blooms | 10-11 | 5-8 | 9 | 11-12 | 8-9 | ↓ | -25% |
| Stack's, Glanarudderies, Knockanefune, Mullaghareirks, North of Abbeyfeale | 38-45 | 40-45 | 25-36 | 25-31 | 27-28 | ↓ | -10% |
| West Cork | 0 | 0 | 0 | 0-1 | 0 | ↓ | -100% |
| West Kerry | - | - | 0 | 0 | 1 | ↑ | 100% |
| Wexford | - | - | 1-2 | 0-1 | 0 | = | -100% |
| Wicklow Mountains | 0 | 0 | 0 | 0 | 0 | = | 0% |
| Other Areas** | - | - | 0 | 4 | 5-6 | ↑ | 50% |
| Total Numbers | 102-129 | 132-153 | 128-172 | 108-157 | 85-106 | ↓ | -33% |

**Table 10.** Numbers of confirmed and possible hen harrier territories within the boundaries of each of the six breeding hen harrier SPAs.

| SPA | 2000* | 2005 | 2010 | 2015 | 2022 | Change (2005 – 2022) | Change (2010 – 2022) | Change (2015 – 2022) | Change % (2005 - 2022) |
|---|---|---|---|---|---|---|---|---|---|
| Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle (4161) | 41 | 40-45 | 18-29 | 23-28 | 21 | -24 | -8 | -7 | -53% |
| Mullaghanish to Musheramore Mountains (4162) | 3 | 5 | 2-3 | 1 | 1 | -4 | -2 | 0 | -80% |
| Slievefelim to Silvermines Mountains (4165) | 8 | 4-5 | 6-7 | 4-10 | 3-4 | -1 | -3 | -6 | -20% |
| Slieve Bloom Mountains (4160) | 11 | 5-8 | 9 | 12-13 | 8-9 | 1 | 0 | -4 | 12% |
| Slieve Aughty Mountains (4168) | 21^ | 24-27 | 15-23 | 8-14 | 3-5 | -22 | -18 | -9 | -67% |
| Slieve Beagh (4167) | 3 | 4 | 5-6 | 3 | 2-3 | -1 | -3 | 0 | -25% |
| TOTAL | 71-87 | 82-94 | 55-77 | 50-69 | 38-43 | -51 | -34 | -26 | -54% |

* Totals based on review and determination of records lying within the now defined SPA boundaries.

^ a further two possible pairs outside boundary

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# 6. Appendices

**Appendix 1** Sex and age class of sightings of hen harriers during national surveys

| Sex | 2022 | 2015 | 2010 | Change 2022-2015 (%) | Change 2022-2010 (%) |
|---|---|---|---|---|---|
| Male | 1117 | 1123 | 943 | -0.5 | 18.5 |
| Female | 620 | 1066 | 865 | -71.9 | -28.3 |
| Immature male | 37 | 120 | 50 | -69.2 | -26 |
| Juvenile | 98 | 378 | 110 | -74.1 | -10.9 |

**Appendix 2** The range of threats and pressures observed by surveyors during 2022 within 500m of hen harrier suitable breeding habitats

| Code | Description of activity, threat or pressure | 500m (n) | % |
|---|---|---|---|
| B2 | forest and plantation management & use | 797 | 23.0 |
| X | no threats or pressures | 688 | 19.9 |
| C2 | mechanical removal of peat | 247 | 7.1 |
| D1 | paths, tracks, cycling tracks (includes non-paved forest roads) | 238 | 6.9 |
| A6 | non intensive grazing | 171 | 4.9 |
| C3 | wind energy production | 152 | 4.4 |
| A2 | agricultural intensification | 141 | 4.1 |
| G3 | walking, horse-riding and non-motorised vehicles | 141 | 4.1 |
| A5 | intensive grazing | 132 | 3.8 |
| B1 | forest planting on open ground (increase in forest area, planting *e.g.* on grassland, heathland) | 104 | 3.0 |
| D2 | roads, motorways (all paved/ tarred roads) | 81 | 2.3 |
| G2 | outdoor sports and leisure activities, recreational activities | 61 | 1.8 |
| B3 | forest replanting (*i.e.* replanting on forest ground after clear-cutting) | 60 | 1.7 |
| D3 | utility and service lines (*e.g.* power-lines, pipelines) | 57 | 1.6 |

| Code | Description of activity, threat or pressure | 500m (n) | % |
|---|---|---|---|
| B4 | forest clearance (clear-cutting, removal of all trees) | 56 | 1.6 |
| G1 | human intrusions and disturbances | 53 | 1.5 |
| C1 | hand cutting of peat | 46 | 1.3 |
| G4 | motorised vehicles | 31 | 0.9 |
| J3 | uncontrolled burning (*e.g.* widespread unmanaged or malicious burning) | 25 | 0.7 |
| G5 | off-road motorised driving | 23 | 0.7 |
| K1 | interspecific faunal relations - predation (by other birds *e.g.* crows) | 23 | 0.7 |
| K2 | interspecific faunal relations - predation (by mammals *e.g.* foxes) | 19 | 0.5 |
| B7 | other forest activities (*e.g.* erosion due to forest clearing, fragmentation) | 13 | 0.4 |
| J7 | anthropogenic reduction of habitat connectivity (*i.e.* fragmentation such as by removal of large areas of habitat or creation of barriers between habitats) | 13 | 0.4 |
| J5 | reduction or loss of specific habitat features (*e.g.* removal of hedgerows, deep heather, scrub, walls, drains) | 12 | 0.3 |
| E2 | dispersed habitation (*i.e.* little or no human disturbance) | 9 | 0.3 |
| A3 | mowing / cutting of grassland | 8 | 0.2 |
| A9 | removal of hedges and copses or scrub | 7 | 0.2 |
| B6 | fertilisation (forestry) | 7 | 0.2 |
| D5 | improved access to site | 7 | 0.2 |
| J4 | modification of water levels or waterbodies | 5 | 0.1 |
| A1 | modification of cultivation practices | 4 | 0.1 |
| A4 | abandonment / lack of mowing | 4 | 0.1 |
| A7 | abandonment of pastoral systems, lack of grazing | 4 | 0.1 |
| B5 | thinning of tree layer | 4 | 0.1 |
| H1 | pollution (*e.g.* water pollution, fly-tipping) | 4 | 0.1 |
| O | other threats or pressures not listed above | 4 | 0.1 |
| F2 | illegal killing (*e.g.* shooting, trapping, poisoning) | 3 | 0.1 |
| A8 | fertilisation (agricultural) | 2 | 0.1 |
| F1 | nest destruction | 2 | 0.1 |
| G6 | other outdoor sports and leisure activities | 1 | 0.0 |

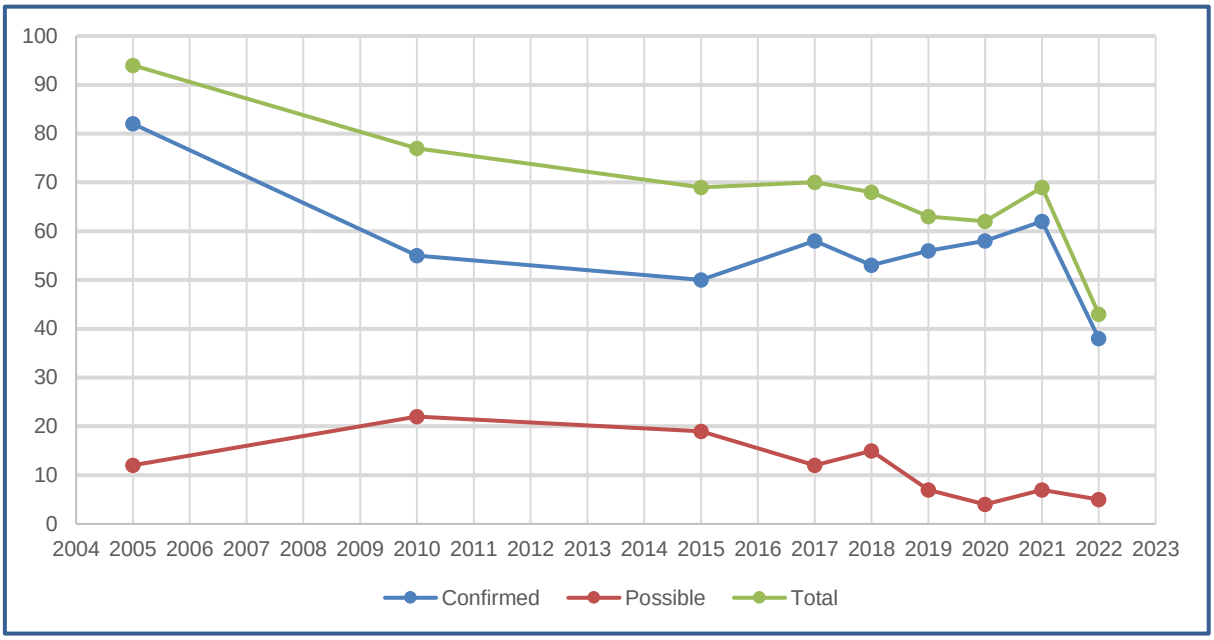
| Code | Description of activity, threat or pressure | 500m (n) | % |
|---|---|---|---|
| J1 | natural fires | 1 | 0.0 |
| D4 | aircrafts or flightpaths | 0 | 0.0 |
| E1 | urbanisation, residential and commercial development | 0 | 0.0 |
| G7 | military manoeuvres | 0 | 0.0 |
| J2 | controlled burning (*e.g.* strip burning for grouse management) | 0 | 0.0 |
| J6 | reduction of prey availability | 0 | 0.0 |
| | | 3460 | 100 |

**Appendix 3.** The range of threats and pressures observed by surveyors during 2022 within 2 km of hen harrier suitable breeding habitats

| Code | Description of activity, threat or pressure | 2 km (n) | % |
|---|---|---|---|
| B2 | forest and plantation management & use | 837 | 24.2 |
| X | no threats or pressures | 486 | 14.0 |
| C3 | wind energy production | 305 | 8.8 |
| C2 | mechanical removal of peat | 197 | 5.7 |
| A2 | agricultural intensification | 188 | 5.4 |
| D1 | paths, tracks, cycling tracks (includes non-paved forest roads) | 185 | 5.3 |
| A6 | non intensive grazing | 137 | 4.0 |
| A5 | intensive grazing | 126 | 3.6 |
| B1 | forest planting on open ground (increase in forest area, planting *e.g.* on grassland, heathland) | 126 | 3.6 |
| D2 | roads, motorways (all paved/ tarred roads) | 106 | 3.1 |
| G3 | walking, horse-riding and non-motorised vehicles | 100 | 2.9 |
| B4 | forest clearance (clear-cutting, removal of all trees) | 86 | 2.5 |
| B3 | forest replanting (*i.e.* replanting on forest ground after clear-cutting) | 76 | 2.2 |
| D3 | utility and service lines (*e.g.* power-lines, pipelines) | 66 | 1.9 |
| J3 | uncontrolled burning (*e.g.* widespread unmanaged or malicious burning) | 55 | 1.6 |
| G4 | motorised vehicles | 49 | 1.4 |
| G1 | human intrusions and disturbances | 44 | 1.3 |
| G2 | outdoor sports and leisure activities, recreational activities | 42 | 1.2 |
| C1 | hand cutting of peat | 37 | 1.1 |
| G5 | off-road motorised driving | 21 | 0.6 |
| E1 | urbanisation, residential and commercial development | 17 | 0.5 |
| K1 | interspecific faunal relations - predation (by other birds *e.g.* crows) | 17 | 0.5 |
| E2 | dispersed habitation (*i.e.* little or no human disturbance) | 16 | 0.5 |
| K2 | interspecific faunal relations - predation (by mammals *e.g.* foxes) | 15 | 0.4 |
| B6 | fertilisation (forestry) | 14 | 0.4 |
| A3 | mowing / cutting of grassland | 13 | 0.4 |

| Code | Description of activity, threat or pressure | 2 km (n) | % |
|---|---|---|---|
| B7 | other forest activities (*e.g.* erosion due to forest clearing, fragmentation) | 13 | 0.4 |
| A9 | removal of hedges and copses or scrub | 12 | 0.3 |
| O | other threats or pressures not listed above | 12 | 0.3 |
| A7 | abandonment of pastoral systems, lack of grazing | 7 | 0.2 |
| A8 | fertilisation (agricultural) | 7 | 0.2 |
| J5 | reduction or loss of specific habitat features (*e.g.* removal of hedgerows, deep heather, scrub, walls, drains) | 7 | 0.2 |
| J7 | anthropogenic reduction of habitat connectivity (*i.e.* fragmentation such as by removal of large areas of habitat or creation of barriers between habitats) | 7 | 0.2 |
| A1 | modification of cultivation practices | 6 | 0.2 |
| D4 | aircrafts or flightpaths | 5 | 0.1 |
| B5 | thinning of tree layer | 4 | 0.1 |
| D5 | improved access to site | 4 | 0.1 |
| G6 | other outdoor sports and leisure activities | 3 | 0.1 |
| G7 | military manoeuvres | 3 | 0.1 |
| J2 | controlled burning (*e.g.* strip burning for grouse management) | 3 | 0.1 |
| H1 | pollution (*e.g.* water pollution, fly-tipping) | 2 | 0.1 |
| J6 | reduction of prey availability | 2 | 0.1 |
| F1 | nest destruction | 1 | 0.0 |
| F2 | illegal killing (*e.g.* shooting, trapping, poisoning) | 1 | 0.0 |
| A4 | abandonment / lack of mowing | 0 | 0.0 |
| J1 | natural fires | 0 | 0.0 |
| J4 | modification of water levels or waterbodies | 0 | 0.0 |
| | | 3460 | 100 |

**Appendix 4** Hen harrier SPA population trends between 2005 and 2022



**Appendix 5** Indicative hen harrier population modelling 2022

| Region | Year | Confirmed pairs | Possible pairs | Total adults | Adult survival | Live adults | Dead adults | Mean young/ breeding pair | Juveniles fledged | Survival rate | Surviving young | Surplus / Deficit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| Stack's to Mullaghareirk Mountain, West Limerick Hills & Mount Eagle | 2022 | 21 | 0 | 42 | 0.778 | 32.676 | 9.324 | 0.95 | 20 | 0.361 | 7.220 | -2.10 |
| | | | | | | | | | | | | |
| Mullaghanish to Musheramore Mountains | 2022 | 1 | 0 | 2 | 0.778 | 1.556 | 0.444 | 0.00 | 0 | 0.361 | 0.000 | -0.44 |
| | | | | | | | | | | | | |
| Slievefelim to Silvermines Mountains | 2022 | 3 | 1 | 8 | 0.778 | 6.224 | 1.776 | 0.25 | 1 | 0.361 | 0.361 | -1.42 |
| | | | | | | | | | | | | |
| Slieve Bloom Mountains | 2022 | 8 | 1 | 18 | 0.778 | 14.004 | 3.996 | 0.67 | 6 | 0.361 | 2.166 | -1.83 |
| | | | | | | | | | | | | |
| Slieve Aughty Mountains | 2022 | 3 | 2 | 10 | 0.778 | 7.78 | 2.220 | 0.80 | 4 | 0.361 | 1.444 | -0.78 |
| | | | | | | | | | | | | |
| Slieve Beagh | 2022 | 2 | 1 | 6 | 0.778 | 4.668 | 1.332 | 0.00 | 0 | 0.361 | 0.000 | -1.33 |
| | | | | | | | | | | | | |
| Inside SPAs | 2022 | 38 | 5 | 86 | 0.778 | 66.908 | 19.092 | 0.72 | 31 | 0.361 | 11.191 | -7.90 |
| | | | | | | | | | | | | |
| Outside SPAs | 2022 | 47 | 16 | 124 | 0.778 | 98.028 | 27.972 | 0.76 | 44 | 0.361 | 15.884 | -12.09 |
| | | | | | | | | | | | | |
| Whole population | 2022 | 85 | 21 | 210 | 0.778 | 164.936 | 47.064 | 0.74 | 75 | 0.361 | 27.075 | -19.99 |

**Appendix 6** Hen harrier survey squares prioritisation matrix, coverage and suitability review

| Square Colour | Definition | Priority | No. Squares | Not Suitable | No. Allocated | % Coverage | Not suitable | No. Surveyed | % Surveyed | Data not received |
|---|---|---|---|---|---|---|---|---|---|---|
| | green' squares where breeding had been confirmed (see Barton *et al*., 2006; Ruddock *et al*., 2012; Balmer *et al*., 2013; Ruddock *et al*., 2016) in the period 1998 – 2021 | 1 | 105 | 7 | 101 | 96 | 7 | 100 | 95 | 3 |
| | 'yellow' squares where breeding had been recorded as possible (see Barton *et al*., 2006; Ruddock *et al*., 2012; Ruddock *et al*., 2016) in the period 1998 – 2021 | 2 | 28 | 2 | 26 | 93 | 2 | 24 | 86 | 2 |
| | 'orange' squares in which hen harrier had been sighted in the period 1998 – 2021 and/or where suitable habitat was recorded | 3 | 129 | 48 | 101 | 78 | 48 | 93 | 72 | 25 |
| | 'red' squares which had no historical hen harrier sightings, but which contained known or potentially suitable breeding habitat | 4 | 65 | 15 | 44 | 68 | 10 | 41 | 63 | 3 |
| | pink' squares where no square was allocated but survey effort was undertaken, and results submitted by surveyors | - | 13 | 0 | 0 | 0 | 0 | 13 | 100 | 0 |

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Rialtas na hÉireann
Government of Ireland

# Hen Harrier Conservation and the Wind Energy Sector in Ireland

2022



## Preparation of this Report:

The first draft of this report was commissioned by NPWS (now of the Department of Housing, Heritage and Local Government) to inform the development of the Hen Harrier Threat Response Plan (HHTRP) and was prepared by Marc Ruddock. Information on the distribution and characteristics of turbines installed in Ireland up to June 2016 was analysed for the purposes of this report; meanwhile, policy changes and developments up to March 2022 detailed. Due to the time required to finalise the HHTRP, these final additions and updates were made to the report by NPWS and DECC. Members of the HHTRP Interdepartmental Steering Group and Consultative Committee were also consulted on earlier drafts and their comments taken into consideration.

Energy policy context has been rapidly changing since March 2022 onwards, as has biodiversity policy with the development of the EU's Nature Restoration Law and the agreement of the Convention on Biological Diversity's Global Framework for Managing Nature through 2030. Because of the frequency and regularity of developments and their potential for further change in the near future, this report does not describe those that have occurred post-March 2022. However, they will be taken into account in the finalisation of the Hen Harrier Threat Response Plan itself, as will the results of the 2022 National Hen Harrier Survey.

Through the course of the document's preparation, the Departments referenced within it were re-configured a number of times, so their names change throughout. For the purposes of clarity for the reader, these changes are set out below.

- The Department in which the National Parks and Wildlife Service sits changed from the Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (DAHRRGA) to the Department of Culture, Heritage and the Gaeltacht (DCHG), and, finally, in 2020, to the Department of Housing, Local Government and Heritage (DHLGH).
- The Department of Communications, Energy and Natural Resources (DCENR) changed to the Department of Communications, Climate Action and Environment (DCCAE) and then, in 2020, to the Department of the Environment, Climate and Communications (DECC).
- The Department of the Environment, Community and Local Government (DECLG) changed to the Department of Housing, Planning, Community and Local Government (DHPCLG), then to the Department of Housing, Planning and Local Government (DHPLG) and then to the Department of Housing, Local Government and Heritage (DHLGH) in 2020, (incorporating NPWS at this time).
- The Department of Agriculture, Food and the Marine remained the same throughout.

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National Parks and Wildlife Service 2022

## Preface

Directive 2009/147/EC (the Birds Directive) provides a comprehensive regime of protection for all wild birds naturally occurring in the European Union. The Directive instructs Member States to maintain their populations of wild bird species at a level that corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements. In light of this requirement, Ireland, along with other Member States, shall take the requisite measures to preserve, maintain or re-establish a sufficient diversity and area of habitats for its wild bird species.

The Directive also requires the classification of suitable areas as Special Protection Areas (SPAs) for the protection of certain bird species, including the Hen Harrier. Under Article 6 (2) to (4) of the Habitats Directive, Ireland is obliged to prevent the deterioration of these SPAs (as suitable areas for the species) and only to consent to projects where there is clear scientific evidence that such projects will not lead to an adverse effect on the integrity of the SPA or its qualifying features. The Court of Justice of the European Union, in a number of its findings regarding the interpretation of these Directives, has emphasised the importance of scientific understanding of the impact of proposed interventions, and where there is scientific doubt as to the potential effects on the species or habitats, the precautionary principle must apply.

In growing recognition of the importance of reversing biodiversity decline and its interactions with climate change adaptation and mitigation, international and EU biodiversity policies are being strengthened and Ireland's next National Biodiversity Plan, to be developed in 2022, will reflect these global, European and national contexts.

The Convention on Biological Diversity is currently undertaking negotiations with its Parties to develop the post-2020 global biodiversity framework and move towards achievement of the 2050 Vision of "Living in Harmony with Nature". The EU has also recently adopted its European Green Deal and its constituent element, the EU Biodiversity Strategy to 2030, which is intended to support a green recovery following the Covid-19 pandemic. The Strategy's objective is to put the EU's biodiversity on the path to recovery by 2030 and contains specific actions and commitments, including:

- Establishing a larger EU wide network of protected areas on land and at sea by 2030 (30% on both land and sea, 10% of both being strictly protected)
- Establishing a Nature Restoration Plan, with legally-binding national restoration targets
- Unlocking funding for transformative change and a strengthened governance framework.

The Biodiversity Strategy also includes a requirement that Member States ensure that at least 30% of species and habitats not currently in favourable conservation status achieve that status or show a strong positive trend by 2030, and that none show further signs of deterioration.

At the UN High-Level Summit for Biodiversity in September 2020, An Taoiseach signed up to the Leaders' Pledge for Nature which supports the 30/30 targets and calls for an ambitious and

meaningful post-2020 global agreement that will address the biodiversity crisis and help bring about the transformative change needed to halt biodiversity loss on a global level.

The UN Intergovernmental Panel on Climate Change published its sixth assessment report on 28th February 2022. The report highlighted the increasing impacts of greenhouse gas-induced climate change that are being experienced globally and the diminishing window of opportunity to implement measures to mitigate the worst future impacts. The report noted that the impact of unabated climate change upon ecosystems will lead to species migration and extinction. The primary instrument for the mitigation of climate impacts of fossil fuels is a rapid transition from these to renewable energy. For Ireland, the largest available indigenous renewable energy resource is wind energy.

Under the revised 2018 Renewable Energy Directive, the European Union has committed to delivering 32% of gross final consumption of energy from renewable sources by 2030, as part of the EU objective of reducing greenhouse gas emissions. In July 2021, the European Commission launched the Fit for 55 package to give effect to the climate ambition outlined in the European Green Deal and Climate Target Plan, which would increase the EU 2030 greenhouse gas emissions reduction target from 40% to 55% (on a 1990 baseline). The Commission have proposed a range of legislative amendments to give effect to this step-change in ambition, including a revision to the 2018 Renewable Energy Directive to increase the binding renewable energy target from 32% to at least 40% by 2030.

An accelerated transition to renewable electricity will be key to successfully meeting the ambitious renewable energy and greenhouse gas emission reduction targets outlined in the European Green Deal and Climate Action Plan. Onshore wind energy will continue to be one of the leading cost-effective technologies to achieve these targets, as well as displacing emissions in other sectors, including household heating and vehicle transport.

The Climate Action and Low Carbon Development (Amendment) Act 2021 establishes a system of carbon budgeting with a 'carbon budget programme' comprising three five-year economy-wide budgets that set a limit, on an economy-wide basis, for the amount of Greenhouse Gas (GHG) emissions that can be emitted in that period. The carbon budgets will be supplemented by sectoral emissions ceilings, setting the maximum amount of greenhouse gas emissions that are permitted in a given sector of the economy during each five-year carbon budget.

The Climate Action Plan 2021 now commits Ireland to reducing greenhouse gas emissions by 51% over the decade (2021 – 2030), to achieving net-zero emissions by 2050, and to reaching a target of generating up to 80% of electricity from renewable sources by 2030. The indicative renewable electricity capacity targets for Ireland, as set out in the Climate Action Plan 2021, project up to 8 GW of onshore wind by 2030, an increase of up to 4GW on 2019-installed capacity, with the addition of at least 5 GW of offshore wind. Of this renewable capacity at least 500 MW will be delivered through community-based projects, subject to competition as appropriate.

As of March 2022, the invasion of the Ukraine by Russia has triggered an energy crisis with a rapid inflation of energy prices and a risk of energy security being compromised through a restriction in oil and gas supplies. Increasing the utilisation of indigenous renewable energy resources such as wind energy is the best defence that fossil fuel import-dependant countries have to improve their energy security. Furthermore, given the recent rapid growth in demand for power in Ireland, driven primarily by additional large energy users, preserving current capacity whilst adding further renewable electricity generation will be a critical enabler in achieving energy and emissions targets, as well as to protect against security of supply risks.

Up to 700MW of installed onshore wind capacity, or roughly 16% of the current total installed capacity, located within four of the six Hen Harrier Special Protection Areas will have to renew their planning permission or secure planning permission for repowering within the next two decades. The shutdown of this capacity, upon expiry of planning consent, is projected to result in a loss of output of around 1.7TWh/A, an increase in gas requirements for power generation of around 3.4TWh/A, as well as increased carbon dioxide emissions of 628k$TCO_2$/A. The withdrawal of this capacity from the electricity market is also projected to result in increased prices for consumers and a deterioration in Ireland's security of supply position. A larger number of turbines may in reality be affected, as some wind farms may only partially overlap with an SPA, while the entire wind farm may be denied permission for an extension of duration of planning.

This report specifically examines the interactions between the wind energy sector and Hen Harrier conservation in Ireland. The purpose of this report is to inform the Hen Harrier Threat Response Plan (HHTRP), and its findings will be integrated with those from reports on other key sectors, *i.e.* agriculture and forestry, in order to develop a collaborative cross-sectoral way forward for the conservation of this species.

**Disclaimer:** Some data utilised in the preparation of this report has been compiled from third-party data sources. Whilst every attempt has been made to verify these data and, although the data have been produced and processed from sources believed to be reliable, no warranty expressed or implied is made regarding accuracy, adequacy, completeness, legality, reliability or usefulness of any information. This disclaimer applies to both isolated and aggregate uses of the information.

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# CHAPTER 1: INTRODUCTION

## Background

The National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government and Heritage (DHLGH) is responsible for co-ordinating the conservation of natural habitats and species and the protection of biological diversity in Ireland.

Under Regulation 39 of the European Communities (Birds and Natural Habitats) Regulations 2011-2015, provision is made for the development and implementation of appropriate threat response plans. The purpose of such plans is to cease, avoid, reduce or prevent threats, pressures or hazards that may be having an adverse effect on the conservation status of a species of bird referred to in Article 1 of the Birds Directive, and/or may be causing the deterioration of the habitats of species for which a European Site (or Natura site) has been classified pursuant to the Birds Directive (Directive 2009/ 147/EC).

The Hen Harrier (*Circus cyaneus*) is listed on Annex 1 of the Birds Directive. In 2007, six European Sites (Special Protection Areas (SPAs)) were designated for the conservation of this breeding species. Hen Harriers are also listed for two other SPAs that support important roost sites outside of the breeding season (*i.e.* Lough Corrib SPA and Wexford Harbour and Slobs SPA). A survey of breeding Hen Harrier in 2010 recorded 128 to 172 breeding pairs (Ruddock *et al.*, 2012); this was broadly similar to the totals recorded in the previous survey in 2005 (Barton *et al.*, 2006). However, notable declines were recorded in some of the stronghold SPA sites (Ruddock *et al.*, 2012). The 2015 survey of breeding Hen Harrier (Ruddock *et al*., 2016a) recorded further national declines with 108 to 157 breeding pairs estimated. Further declines were noted within four of the six of the SPAs and overall, the total SPA breeding population of Hen Harriers was shown to have declined by approximately 10% since the 2010 survey and 27% since the 2005 survey.

The results of recent research has raised the possibility that the Hen Harrier may be subject to an ecological trap in Ireland because of its habitat preferences and potential interactions with other land management and land uses. This, coupled with concerns that the extent and rate of change to the Hen Harrier's habitat (due to factors such as continued afforestation, increases in wind energy development and agricultural intensification) were linked to the recently recorded declines, led to the decision to develop a Hen Harrier Threat Response Plan (HHTRP). This document was prepared as part of the HHTRP process and specifically reviews the interactions between the wind energy sector and the conservation of the Hen Harrier population here. Similar reports have been prepared for the forestry and agricultural sectors (NPWS, 2015a and 2015b).

## The Hen Harrier in Ireland

### *A history of the Irish Hen Harrier population (1800s – 1980s)*

The Hen Harrier is a widespread, but patchily-distributed, breeding bird across much of northern and central Europe. This European breeding range equates to less than one quarter of its global range (Cramp and Simmons, 1980; Simmons, 2000). The European breeding population is considered to be relatively small (estimated at 32,000 – 59,000 breeding pairs (Birdlife International, 2004)). As the Hen Harrier underwent a large decline between 1970 and 1990, its European conservation status was regarded as 'unfavourable' (BirdLife International, 2004) but it has since been categorised on the European Red List of Birds as 'Least Concern' (BirdLife International, 2015). In Ireland, it is Amber-listed on the Birds of Conservation Concern (Gilbert, Stanbury and Lewis, 2021). It is migratory in the northern parts of its range in north and northeast Europe and Asia, and partially migratory and dispersive in the rest of its breeding range (del Hoyo *et al.*, 1992). Until recent genomic studies, the (Eurasian) Hen Harrier and the (American) Northern Harrier were understood to be the same species.

From the earliest documented records in the 1850s, Hen Harriers were generally distributed throughout Ireland, with breeding strongholds in Kerry, Wicklow and the Tipperary/Waterford border in the south, and Derry and Antrim in the north (Thompson, 1849). The Hen Harrier was also found breeding in Connemara (Shawe-Taylor in Watson, 1977). By 1900, this species was recorded in counties Kerry, Cork, Limerick, Tipperary, Waterford, Wicklow, Dublin, Offaly, Laois, Galway, Mayo, Fermanagh, Donegal, Derry, Antrim and Down. However, it was noted that the population was in decline and no longer present in some historical breeding areas (Ussher and Warren, 1900). At this time, Hen Harriers were considered to have been widely persecuted in Ireland (primarily through the destruction of young and eggs) throughout the latter half of the 19th century (Usher and Warren, 1900; O'Flynn, 1983). Indeed, this species was considered by some to have become extinct as a breeding species in Ireland altogether by the early 1950s (Kennedy *et al.*, 1954; Bannerman and Lodge, 1956). However, small numbers continued to breed in a few areas such as the Slieve Bloom Mountains in Laois, the Tipperary/Waterford border and the Cork/Kerry border (Watson, 1977). There is no accurate historical estimate of Ireland's total breeding population during the early 1950s but it is considered that the Irish population was at historically low levels with regard to numbers and breeding distribution at that time.

It is considered that a recovery in the population started in the 1950s (Andrews, 1964). In 1956, breeding pairs were found in Waterford, south Kilkenny and Cork (O'Flynn, 1983), re-colonising Wicklow soon after, with seven breeding pairs recorded in the county in 1961 (Scott, 1995). By 1964, at least 35 pairs were known to be breeding in six southern counties (O'Flynn, 1983). In the Atlas of Breeding Birds in Britain and Ireland (Sharrock, 1976), an all-Ireland breeding population estimate of 200 – 300 pairs is given, with confirmed or probable breeding records from 17 counties. The distribution was based on fieldwork which was undertaken during the period 1968 – 72. A slightly increased estimate of 250 – 300 pairs is reported for the period 1973-75 (Watson, 1977).

O'Flynn (1983) considered that the recovery of the Hen Harrier breeding population from the 1950s onwards appeared to have been due to an increased availability of secure nest sites and

passerine prey species. O'Flynn (1983) cites the government's adoption of a long-term afforestation plan in 1947 of circa 400,000ha to be planted over 40 years as the likely driver of this change, with Hen Harriers using the recently afforested (*i.e.* pre-thicket) areas to both nest in and forage over.

In the latter half of the 1970s, O'Flynn (1983) suspected that the population was no longer increasing. After further investigation, he concluded that the population had declined significantly in some areas (*e.g.* Wicklow from over 20 pairs in 1965 to two or three pairs in 1982), with apparent local extinctions occurring in other areas (*e.g.* Slieve Aughty Mountains, the Ballyhoura Mountains, hills of north Tipperary, hills of south Kilkenny and the Comeragh Mountains in Waterford). O'Flynn (1983) noted that, by the mid-1970s, the earlier-planted conifer forests had grown to maturity, resulting in a direct negative impact on the availability of suitable prey. Coincident changes to open, non-forested habitats in Hen Harrier breeding areas were also occurring at this time. These were partly attributed to Ireland's entry into the European Economic Community (EEC) in 1973 and through subsequent changes in land use initiated by significant investment through the Common Agricultural Policy. O'Flynn (1983) considered that tracts of scrub- and gorse-covered marginal land, which had provided a productive hunting habitat for the Hen Harrier, were cleared and transformed into improved grassland. The combination of the maturation of forest estate and the clearance of marginal land was considered by O'Flynn (1983) to be the main reason for the Hen Harrier breeding population decline of the late 1970s.

### *Hen harrier in Ireland 1980s to present*

O'Donoghue (2004) described the modern landscape of the Irish-breeding Hen Harrier as:

- upland, typically above 100m above sea level (asl) and dominated by pastoral-based livestock farming, with holdings often covered in rushes and bordered by hedgerows;
- active and degraded peatland;
- scrub; and
- commercial forestry plantations of different ages.

### Breeding:

Adult birds begin to occupy breeding areas in the uplands in March, with a view to forming pair bonds and to begin nesting. In a two-year study, O'Donoghue (2010) recorded that eggs were laid as early as the 16th of April and as late as the 10th of June, with the median occurring in the first week of May. Incubation per egg is estimated to last 29 – 31 days (del Hoyo *et al.*, 1992). O'Donoghue (2010) noted that the date when chicks fledged ranged from the 18-24th of June to the 6-12th of August, with the fledging peak occurring during the 9-22nd of July.

### Nesting Habitat:

The main nesting habitats selected by Hen Harriers in Ireland are:

- pre-thicket stage of first and, particularly, second rotation plantations;
- heather moorland; and
- scrub habitats (see Norriss *et al.*, 2002; Barton *et al.*, 2006; Wilson *et al.*, 2009; O' Donoghue, 2010; Ruddock *et al.*, 2012; Ruddock *et al.*, 2016a).

Harriers will often nest in rides (typically in heather) between plantation blocks or in gaps within mature plantations where there is a suitable dense growth of mature heather or scrub (Ruddock *et al.*, 2012). Hen Harriers have been recorded nesting in mature trees in Northern Ireland (Scott *et al.*, 1991; Ruddock *et al.*, 2008) but incidences of tree-nesting Hen Harriers have not been documented in the Republic of Ireland (O'Donoghue, 2010). Tree-nesting has been less frequently recorded in Northern Ireland in recent years (Scott *et al.*, 1991; Ruddock *et al.*, 2008; Hayhow *et al.*, 2013).

O'Donoghue (2010) found that the three main habitat categories used by Hen Harriers for nesting were restocked forest (47%), heather/bog (30%), and scrub (23%). Ruddock *et al.* (2016a) indicated that the majority of Hen Harrier breeding pairs occur in second rotation forest (59%); heather moorland (26%); scrub (8%); first rotation forest (6%) and failed forest (1%).

Hen Harrier nesting preferences in Ireland range between 36m and 385m in altitude (O'Donoghue, 2010), are typically between 100m to 400m (Wilson *et al.*, 2009; Ruddock *et al.* 2012), with the majority recorded between 200m and 400m (63%) and the remaining between 100m to 200m (33%).

Breeding Hen Harriers in Ireland typically avoid agriculturally-improved land for nesting (Wilson *et al.*, 2009), although the species will forage along hedgerows and linear features (Madders, 2000; 2003a). Hen Harrier populations in Ireland are now breeding predominantly in forested landscapes (Barton *et al.*, 2006; O'Donoghue, 2010; Ruddock *et al.*, 2012; Ruddock *et al.*, 2016a). These have replaced open heath-dominated upland habitats (O'Flynn, 1983). Conversely, in the UK, the Hen Harrier is recorded more frequently nesting in moorland (Redpath *et al.*, 1998; Sim *et al.*, 2007; Hayhow *et al.*, 2013).

### Foraging habitat and diet during the breeding season

The foraging habitat preferences of Hen Harriers in Ireland are generally biased towards moorland, grassland mosaics and pre-thicket forest habitats (see O'Donoghue, 2004; 2010; Barton *et al.*, 2006; Irwin *et al.*, 2012). Post-thicket or mature forest is generally avoided by Hen Harriers for hunting (Madders, 2000; O'Donoghue, 2004). Several studies (see above) have noted that Hen Harriers in Ireland show a preference for nesting in pre-thicket forest habitats. However, observations of foraging behaviour (Madders, 2003; O'Donoghue, 2012) and pellet analysis of breeding pairs, including those in forested landscapes, show that Hen Harriers also use open heath, scrub and farmland habitats for foraging during the breeding season (O'Donoghue, 2010) and in some cases, preferentially use these open, natural habitats (Barton *et al.*, 2006; Ruddock *et al.*, 2012; 2016).

In Ireland, the diet of Hen Harrier is more restricted than that of birds in Britain due to the absence and/or sparse distribution of some small mammal prey species (Ruddock *et al.*, 2008). In the UK, Hen Harrier breeding numbers are typically correlated with the abundance of small mammals (Redpath *et al.*, 2002a; 2002b; Thirgood *et al.*, 2003). However, this relationship does not appear to exist in Ireland, perhaps due to the absence of short-tailed vole (*Microtus agrestis*) (see O'Donoghue, 2010). Preferred prey species in Ireland are Wood Mouse (*Apodemus*

*sylvaticus*) and small passerines such as Meadow Pipit (*Anthus pratensis*) and Skylark (*Alauda arvensis*) during the breeding season, whilst Meadow Pipit, Brown Rat (*Rattus norvegicus*) and wintering thrushes predominate in winter (O'Donoghue, 2010). Therefore, comparisons of diet between Ireland and elsewhere need to be undertaken with caution.

There are substantial amounts of Irish-based evidence that show the selection and avoidance of habitats used by foraging Hen Harrier:

- Barton *et al.* (2006) found that foraging adult Hen Harriers did not use habitats in proportion to availability. This study found that heath/bog had the highest selection ratio and so was the preferred habitat for foraging. Pre-thicket forest and scrub were important habitats, with rough grassland having a lower selection ratio. Improved grassland and post-thicket forests had the lowest frequency of use by Hen Harrier, although forested habitats accounted for 53% of the total foraging records.
- Ruddock *et al.* (2012) found that almost 40% of all foraging events observed by surveyors and recorded as part of the 2010 national survey were associated with pre-thicket forests and that 49% of foraging was recorded within open habitats (moorland, grassland and scrub), compared to 43% over forested habitats.
- In a study of Hen Harrier in the Duhallow region of north County Cork and east County Kerry, O'Donoghue (2012) recorded that almost 25% of all foraging flight-lines observed were in pre-thicket forest, with a preference (25% of hunting observations) along linear features (hedgerows) and scrub, as well as moorland (23%) and rough grassland (11%). There was apparent avoidance of mature forest habitats and intensively-managed grasslands.
- Using remote tracking technology, Irwin *et al.* (2012) found that Hen Harriers were more frequently recorded in forested (65%) rather than open habitats (35%), although the study area was biased towards forested habitats. Within forested areas, foraging Hen Harriers showed a preference for second-rotation pre-thicket forest, particularly forest that was 6 - 11 years old, with reduced use of forest 12 – 15 years old. This study also corroborated their preference for foraging along linear features (up to 3-4m wide) and their avoidance of intensively-managed grasslands and forests less than 3 years old and greater than 15 years of age.
- Ruddock *et al.* (2016a) reported that Hen Harriers were more frequently recorded in open habitats (51%) compared to forested habitats (41%). Foraging was most frequently recorded over heather moorland (30.0%) and second-rotation forest (18.7%), rough grassland (12.4%) and thicket stage forest (12.4%).

### Population trends since 1990

A second Breeding Bird Atlas was undertaken during the period 1988-91 and an all-Ireland population of 180 breeding pairs was estimated, based on an extrapolation of density estimates across the areas of confirmed or probable breeding (Gibbons *et al.*, 1993). The first national Hen Harrier survey in the Republic of Ireland was conducted during the breeding seasons of 1998 - 2000 and estimated a breeding population of 102 - 129 pairs (Norriss *et al.*, 2002 as described in Barton *et al.*, 2006). A second national survey was undertaken in 2005 and

established that its range was within 66 10km squares, as well as a national population estimate of 132 – 153 territorial pairs. This was an increase in numbers of pairs of over 18% from the first national survey; and could be partially explained by increased survey coverage in 2005 (Barton *et al.*, 2006). Combining the results with comparable surveys undertaken in Northern Ireland (Sim *et al.*, 2001; Sim *et al.*, 2007), Barton *et al.* (2006) established all-Ireland estimates of 130-167 and 190–221 territorial pairs in 1998–2000 and 2005 respectively, equivalent to an increase of over 24% in that period.

The third national survey, undertaken in 2010, estimated a breeding population of between 128 to 172 territorial pairs occurring in 69 10km grid squares. A separate survey in Northern Ireland estimated 59 proven and probable territorial pairs (Hayhow *et al.*, 2013), providing an all-Ireland estimate of 158 to 205 pairs (Ruddock *et al*., 2012). These results indicated that the Hen Harrier population appeared to be stable. However, the ability to directly compare the 2005 and 2010 national estimates was complicated by the more than doubling of the surveyor effort in the 2010 survey (Ruddock *et al.*, 2012). The coverage of the 2010 national survey included the 10km squares surveyed in 2005 and therefore, a more accurate comparison was derived by Ruddock *et al.* (2012) by comparing the number of breeding pairs in this subset. The analysis of 113 10km grid squares surveyed in both survey years indicated a population decrease of 6.4% over that five-year period.

A similar sub-sample approach for 84 10km squares surveyed in 1998-2000 and 2010 showed a short-term national population decline of 11 – 14% and 6% reduction in breeding range over this period (see NPWS, 2013a). The 2007 – 2011 Bird Atlas (Balmer *et al.*, 2013) presents the breeding distribution of Hen Harrier within 99 10km squares in the Republic of Ireland but differences in survey methodology and survey effort complicate the interpretation. A large proportion of the records submitted to this Bird Atlas were derived from the 2010 national survey.

The most recent survey data, from 2015 (Ruddock *et al*., 2016a), with 108 – 157 breeding pairs, revealed a further national population decline. This represents a total population decline of 8.7% since 2010. The overall breeding range was observed to have increased, but only for 'possible' breeding pairs, and Hen Harriers were recorded within 83 10km squares (Figure 1), which was a 20.3% increase from 2010 (69 squares).

Supplementary sub-set analyses of data from 139 10km squares that were surveyed in 2010 and 2015 showed a decline of 21.2% in numbers of confirmed breeding pairs (Ruddock *et al*., 2016a). A further sub-set of 110 squares surveyed in 2005, 2010 and 2015 showed a decline of 9.7% in total numbers of territorial pairs from 2005 to 2015 and 16.7% from 2010 to 2015. There was an 8.3% increase recorded in total numbers of territorial pairs between 2005 and 2010 (see also Barton *et al.*, 2006). To establish a long-term trend, Ruddock *et al.*, (2016a) examined 78 10km squares covered in all national surveys (1998-2000, 2005, 2010 and 2015). This shows an overall decline of 33.5% in numbers of territorial pairs between the first national survey (1998-2000) and most recent survey (2015). The proposed 2020 national survey was unavoidably delayed due to the Covid-19 pandemic, and so the 2015 results remain the most recent.

The observed declines in the abundance of breeding birds in the Hen Harrier strongholds, several of which are designated as SPAs, are of particular concern. Six sites have been designated as SPAs for breeding Hen Harriers in Ireland (Figure 2). The SPAs comprise a combined area of some 167,000 hectares (ha) and consist mainly of non-native coniferous plantation forests, open upland peatland habitats, and a spectrum of agricultural grasslands (from unimproved to improved) (NPWS, 2007; Moran and Wilson-Parr, 2015). It is estimated that approximately 52% of the total land area in these six SPAS is afforested. As of June 2016, there were 308 connected wind turbines within or close to (*i.e.* within 500m of) the Hen Harrier SPAs (NPWS, unpublished). The combined breeding Hen Harrier populations within these SPAs during the 2010 national survey (Ruddock *et al.*, 2012) was 77 territories, a decline of 18.1% compared to the 94 territories recorded in the 2005 survey. In 2015, the SPA population accounted for 44-47% of the national population, with between 51 and 69 breeding pairs recorded (Ruddock *et al*., 2016a). This represents a decline of up to 26.6% in numbers of territorial pairs since 2005. In 2015, whilst the overall SPA network population had declined since 2005, the populations of two of the individual SPAs were recorded to have increased whilst the remaining four had declined (see Table 14 in Ruddock *et al*., 2016a).

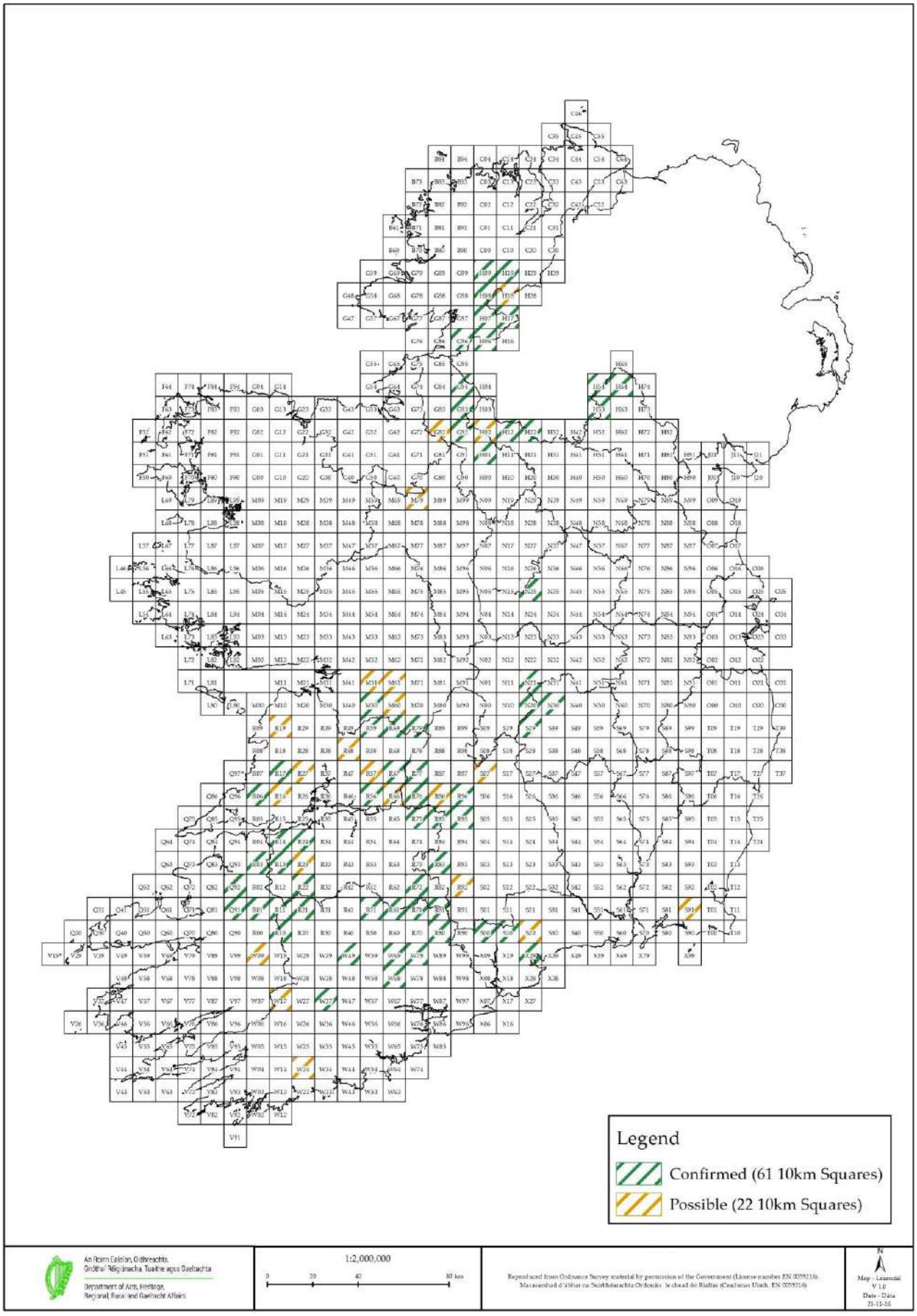



**Figure 1. Distribution of Breeding Hen Harrier in 2015**

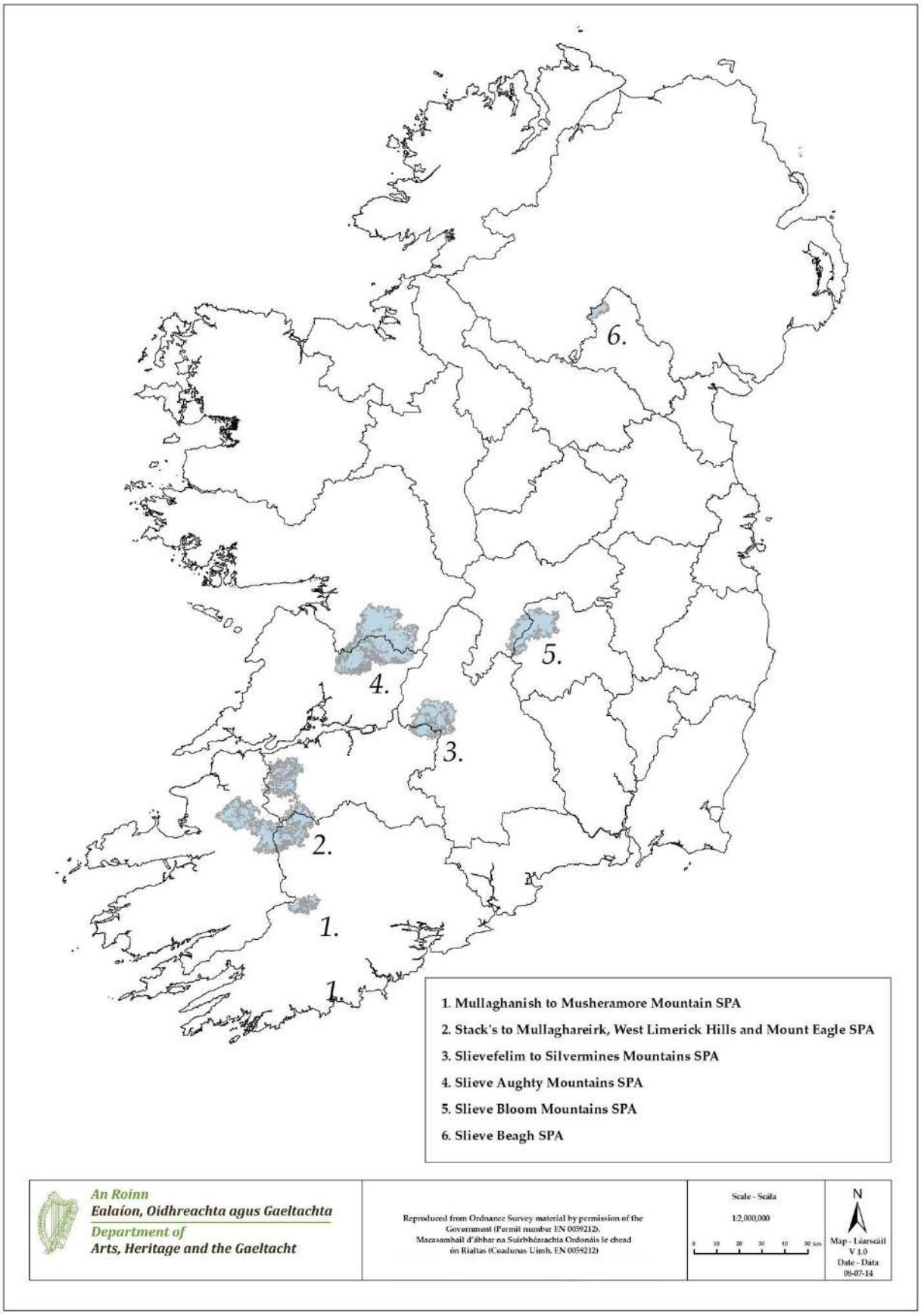



**Figure 2. The SPA Network for breeding Hen Harrier.**

### Outside the Breeding Season (or the Wintering Season)

The winter distribution of Hen Harriers in Ireland differs from that of the breeding season (Figure 3). During the non-breeding season, which can be broadly defined as mid-August to mid-March, Hen Harriers may disperse from the breeding sites, with the majority of marked young birds born in Ireland re-sighted within 150km of their natal site (O'Donoghue, 2010). O'Donoghue (2010) also indicated that Irish Hen Harriers were largely resident, rather than migratory. There are evident population links between Ireland and Britain with records of Scottish-bred birds being re-sighted in Ireland, but the level of cross-over of birds during the breeding and non-breeding periods has yet to be established with certainty (Etheridge and Summers, 2006; O'Donoghue, 2010).

Hen Harrier wintering grounds are reported to typically occur in lowland sites below 100m (Clarke and Watson, 1990; 1997; O'Donoghue, 2010). During the winter, Hen Harrier can gather at communal (frequently used by several birds and other raptors) roost sites at night (Watson and Dickson, 1972). Roost sites may also be solitary (used by individual birds regularly or infrequently) (see Clarke and Watson, 1990). Hen Harriers select roost sites that have suitable cover, low ambient levels of disturbance and are presumably close to suitable foraging areas to roost (O'Donoghue, 2010). In Ireland, the majority of known roosts are located in reedbeds, heather/bog and rank/rough grassland but also in fen, bracken, gorse and saltmarsh (Watson, 1977; O'Donoghue, 2010). Approximately 20% of known roost sites here occur within close proximity to core nesting areas. Only a small number of known roosts are found in forested habitats (O'Donoghue, 2010). The numbers of individual birds occupying each roost site at any one time outside the breeding period are highly variable and patterns of roost site use are poorly understood. In 2014, approximately 96 confirmed winter solitary and communal roosts were known in Ireland, and they were estimated to support between 219 – 313 individuals (B. O'Donoghue, personal communication; see also NPWS, 2015a).

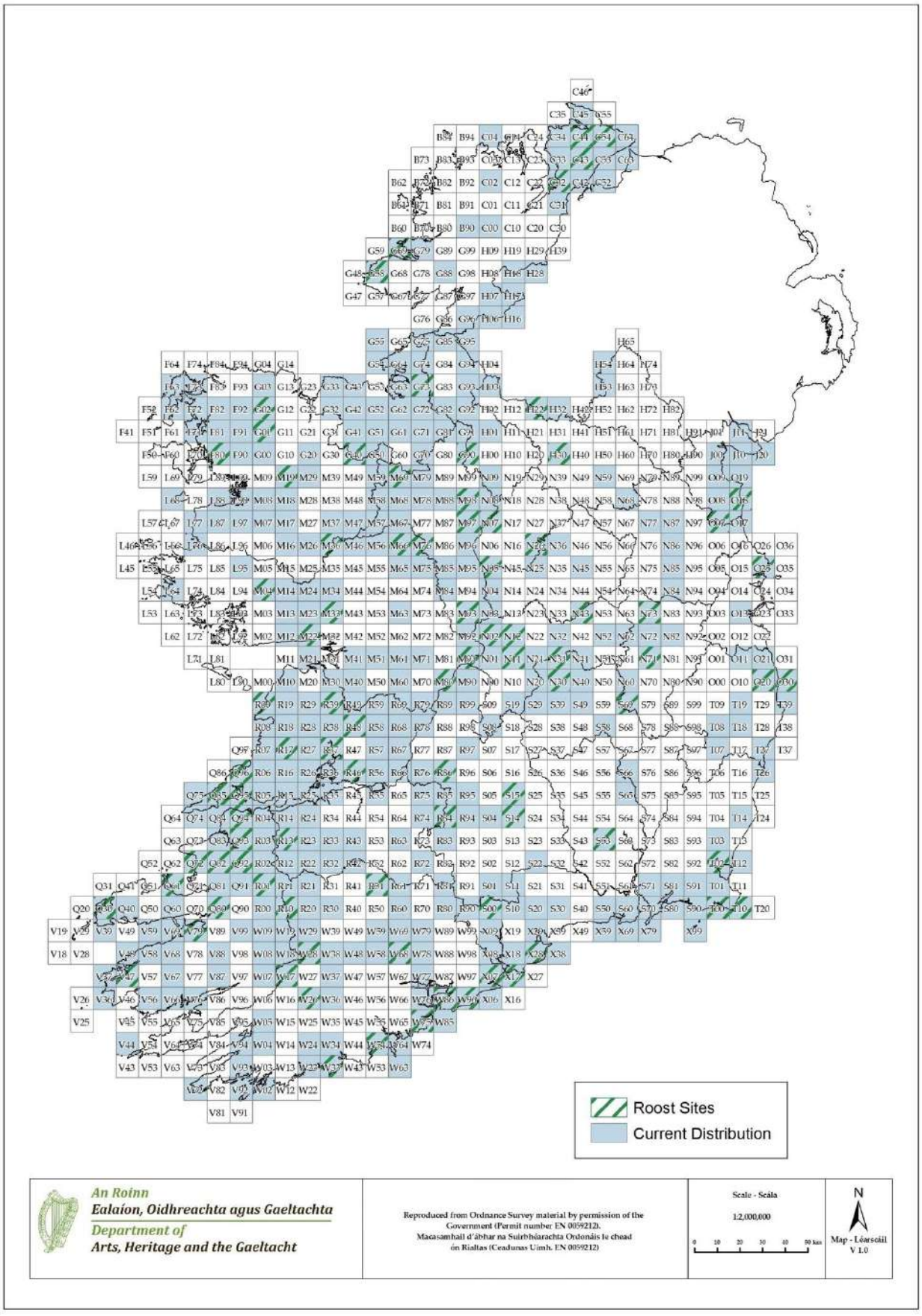



**Figure 3. The distribution of wintering Hen Harrier (Distribution data from the 2007-11 Bird Atlas; Roost site locations from unpublished Irish Winter Hen Harrier Survey data).**

## The Wind Energy Sector in Ireland

The renewable energy sector includes a diverse range of technologies that harness natural energy sources, including solar energy, wind energy, hydro-power (rivers, wave, tidal) energy, geothermal energy and biomass (wood, waste, crops) energy (SEAI, 2016a). Many of these technologies are not considered to be ecologically relevant to Hen Harrier (*i.e.* there are no interactions between them) and thus, are not considered in this review to any degree. This review examines the wind energy sector only (see also Chapters 2 & 3).

### *Stakeholders in the Wind Energy Sector*

Since 2016, DECC (or DCCAE, as it was then) has been responsible for policy and management of wind energy as directed by international and EU obligations. There are a number of commercial, non-commercial and regulatory State bodies under the aegis of DECC that are relevant to the development of wind energy, including the Electricity Supply Board (ESB), EirGrid, Bord na Móna (BNM), the Commission for Regulation of Utilities, and Sustainable Energy Authority of Ireland (SEAI).

SEAI was established as Ireland's national energy authority under the Sustainable Energy Act 2002 and it is central to the delivery of Ireland's renewable energy portfolio, policy and targets. SEAI also has responsibilities with respect to energy efficiency; its "energy efficiency first" philosophy ensures that the reduction of energy demand is considered first in national energy policy, as an alternative to increasing energy supply (*e.g.* SEAI, 2016b).

SEAI has worked in recent years to maintain a database of connected wind turbines and wind energy developments to inform delivery, reporting and analysis of the industry. SEAI also undertakes regular reviews and assessment of energy targets, performance and policy (*e.g.* SEAI, 2011; 2016a) in order to inform government policy, as well as engaging with stakeholders.

SEAI supports also supports relevant research, *e.g.* it has supported BirdWatch Ireland to facilitate work with the International Energy Agency Wind Technology Collaboration Programme (IEA Wind TCP) on WREN (*i.e.* Working Together to Resolve Environmental Effects of Wind Energy). WREN is the leading international forum for supporting the deployment of wind energy technology around the globe, through an improved understanding of environmental issues, efficient monitoring programmes and effective mitigation strategies.

Other Government Departments and agencies may also be considered as stakeholders in the wind energy sector as their plans, programmes, policies and areas of responsibility may be affected by its plans and programmes *etc*. These include, for example, those bodies identified as prescribed bodies in the planning system, such as the National Parks and Wildlife Service (NPWS now sits within the Department of Housing, Local Government and Heritage). NPWS/DHLGH is also an environmental authority, in accordance with the meaning prescribed by the SEA Regulations, and is the lead authority with respect to nature conservation and policy. It is also responsible for the designation of sites for the purposes of nature conservation, including pursuant to the Habitats and Birds Directives, as well as the setting of conservation objectives for same.

DHLGH, through its Planning Section, is also responsible for the development of planning policy and legislation, including the overarching National Planning Framework (NPF) for Ireland's social, economic and cultural development. Local authorities and An Bord Pleanála are also key stakeholders as planning authorities.

The Forest Service of the Department of Agriculture Food and Marine (DAFM) has also become involved in the wind energy sector due to the development of wind energy within afforested sites.

Similarly, academic institutions and non-governmental bodies are involved in undertaking research and providing guidance (*e.g.* Wilson *et al.*, 2015; McGuinness *et al.*, 2015). There are also a significant number of ecologists and environmental scientists engaged in preparing planning applications and the associated ecological assessments for wind energy developments, as well as for relevant plans, programmes and strategies.

Various entities are involved in developing, constructing, operating and maintaining wind turbines or wind energy developments. These include the utility sector, large serial developers, small serial developers, single project developers and asset management companies (International Energy Association, 2015). Examples include State bodies, such as Coillte and Bord na Móna, that develop and operate wind energy developments on state-owned lands, as well as individual landowners or business owners, that may install one turbine in and around their own premises or land-holdings.

There are two representative bodies for the wind energy industry in Ireland:

- Wind Energy Ireland (WEI) (previously the Irish Wind Energy Association or IWEA) has over 150 members and engages laterally with counterparts in the British Wind Energy Association (BWEA; Renewable UK) and the European Wind Energy Association (EWEA). There are also extensive north-south co-operation mechanisms within WEI for consideration of All-Ireland industry issues, as well as an Ireland-UK working group for Northern Ireland, RenewableNI, facilitated by WEI and Renewable UK;
- Meitheal na Gaoithe, the Irish Wind Farmers' Association which is a representative body and lobby group for independent wind energy developers. It has over 70 members.

### *Policy and legislative context for the development of wind energy developments in Ireland:*

The wind energy sector is governed and influenced by a wide range of policy and legislative drivers, including those of the energy sector itself, but also those concerning planning, climate change, biodiversity and the wider environment, heritage as well as other land-use sectors, such as forestry and agriculture. This broad context is described in more detail below.

#### *-Renewable energy context*

The primary global framework governing the development of renewable energy began at the United Nations (UN) Framework Convention on Climate Change (1994). Subsequently, amendments to the UNFCC were adopted through the Kyoto Protocol (1997), the Integrated

Energy and Climate Change Package (2007), and more recently, the Paris Agreement (2016). The Paris Agreement sets out a global framework for the avoidance of dangerous climate change, by the limitation of global warming to well-below 2°C, and by the pursuance of efforts to limit warming to 1.5°C. The EU's contribution, adopted for all Member States under the Paris Agreement, is to reduce greenhouse gas emissions by at least 40% by 2030 compared to 1990.

The EU 2030 Climate and Energy Framework, adopted in 2018, incorporates EU legislative measures to achieve three EU-level key targets:

- at least a 40% reduction in greenhouse gas emissions;
- at least a 32% share for renewable energy; and;
- at least a 32.5% improvement in energy efficiency.

The 32% EU-wide renewable energy target is given effect through the recast Renewable Energy Directive (2018/2001/EU) and the Regulation on the Governance of the Energy Union and Climate Action (EU) 2018/1999 (the Governance Regulation). As part of the Governance Regulation, Member States prepared National Energy and Climate Plans (NECPs) for 2021-2030, outlining the measures they will take to meet the 2030 targets for, *inter alia*, renewable energy and energy efficiency. Ireland's first NECP 2021-2030 (DCCAE, 2020) outlined the policies adopted to deliver on a national target of 34% of gross final consumption of energy from renewable sources by 2030, including a 70% renewable share in electricity production. The first NECP does not take into account the increased EU climate ambitions – for a 55% reduction in greenhouse gas emissions over 2021–2030 – that are outlined in the proposed amendment of the 2018 Renewable Energy Directive.

In December 2019, the European Commission issued a communication on the European Green Deal (EGD), which set an ambition to achieve climate neutrality – or net-zero greenhouse gas emissions - by 2050 and, as an intermediate step, a 50-55% reduction in EU-wide GHG emissions by 2030 (on 1990 baseline levels) (European Commission, 2019). In December 2020, the European Council agreed to adopt a 55% target for 2030. On foot of the EGD Communication and Council's agreement, the Commission will bring forward a range of legislative proposals in 2021 to give effect to this step change in ambition, including a revision to 2018 Renewable Energy Directive to increase the binding renewable energy target. Any increase in the renewable energy target will require the additional deployment of renewable electricity as one of the key mechanisms to decarbonise the wider energy sector (*i.e.* heat and cooling and transport) in the electrification of those sectors.

EU legislation also provides the framework for the regulation and design of the EU internal market in electricity, which was most recently updated through the *Clean Energy for all Europeans* package of legislative measures, including the Directive on Common Rules for the Internal Market for Electricity (EU) 2019/944, the Regulation on the Internal Market for Electricity (EU) 2019/943, the Regulation on Risk Preparedness in the Electricity Sector (EU) 2019/941 and Regulation (EU) 2019/942 which establishes an EU Agency for the cooperation of energy regulators.

*Domestic legislative and policy framework*

Renewable energy, including wind, is a key part of the Irish Government's commitments to a secure, sustainable energy strategy (DCENR, 2012a; 2014a and 2014b; 2016), energy transmission infrastructure (DCENR, 2012b) and low carbon policy (DCENR, 2015). The present policy context is shaped by the 2021 Climate Action Plan (DECC, 2021), which sets out the indicative renewable electricity capacity required to meet the policy of achieving an up to 80% renewable share in electricity by 2030, including an increase in onshore wind capacity from 4.2 GW up to 8GW over the decade 2021 – 2030.

The key Irish legislative instruments governing the renewable electricity sector include the Electricity Regulation Act 1999, which outlines domestic regulatory arrangements for the electricity sector; the Sustainable Energy Act 2002; the Energy Efficiency Directive 2012/27/EU implemented via SI 426/2014 and SI 131/2014; the 2009 Renewable Energy Directive (2009/28/EC), implemented via SI 483/2014 (which will be superseded by the 2018 Renewable Energy Directive from July 2021); and the EU Services Directive 2006/32/EU (via SI 542/2009).

*Future policy development*

Further expansion of renewable electricity will be required to meet Ireland's contribution to the 2030 renewable energy target, particularly in the context of the 2020 Programme for Government commitment to a 7% per annum reduction in greenhouse gases for the period 2021-2030 and the revised EGD greenhouse gas target. The deployment of renewable electricity technologies will be driven by technology costs and competitive auctions under the Renewable Electricity Support Scheme (RESS) as well as major private sector funding through Corporate Power Purchase Agreements.

To date, onshore wind has been the largest driver of growth in renewable energy electricity, primarily due to its cost-effectiveness when compared to other renewable technologies. In order to support the target to generate 40% electricity from renewable sources by 2020, DECC facilitates financial incentivisation of renewable energy generation via the Renewable Energy Feed in Tariff (REFIT). This scheme, funded by the Public Service Obligation (PSO) and paid via electricity consumers, subsidises renewable electricity generators based on electricity output (per kilowatt hour). DECC is currently operating the new Renewable Electricity Support Scheme (RESS). It is aimed at ensuring Ireland meets its 2030 renewable electricity target, providing support to renewable electricity projects and aiming to increase technology diversity and energy sustainability, and help decarbonise the energy sector.

SEAI also provides grants and subsidies to encourage renewable energy research development, demonstration, and energy efficiency.

### - *Biodiversity and Nature policy context*

The renewable energy industry, its policies, planning and implementation, are also subject to, and require compliance with, a number of EU Directives. These include the Strategic Environmental Assessment (SEA) Directive (2001/42/EC); Environmental Impact Assessment Directive (2014/52/EU); Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC)

(see also EPA, 2001; 2004a; 2004b; SI 435/2004; SI 436/2004). Under the SEA Directive, an SEA is mandatory for all energy plans and programmes. The sector must also comply with any and all relevant national transposing legislation, such as the European Communities (Birds and Natural Habitats) Regulations 2011- 2015 as well as relevant national biodiversity and nature conservation legislation including the Wildlife Act, 1976 and the Wildlife (Amendment) Act, 2000.

*Developing policy and legislative context:*
Biodiversity policy is rapidly developing at the international and European levels to respond to the biodiversity and climate emergency (Dáil Éireann, 2019), and Ireland's next National Biodiversity Plan, to be developed in 2022, will reflect these global, European and national contexts.

The Convention on Biological Diversity is currently undertaking negotiations with its Parties to develop the post-2020 global biodiversity framework and to move towards achievement of the 2050 Vision of "Living in Harmony with Nature". The EU has also recently made calls for a Paris-style (*i.e.* target-driven, legally binding) agreement for biodiversity (European Commission, 2021), and as part of its Green Deal, has adopted its Biodiversity Strategy to 2030, which is intended to support a green recovery following the Covid-19 pandemic. The Strategy's objective is to put Europe's biodiversity on the path to recovery by 2030 and so contains specific actions and commitments, including:

- Establishing a larger EU wide network of protected areas on land and at sea by 2030 (30% on both land and sea, 10% of both being strictly protected)
- Establishing a Nature Restoration Plan, with legally-binding restoration targets
- Unlocking funding for transformative change and a strengthened governance framework.

The Biodiversity Strategy also includes a requirement that Member States ensure that at least 30% of species and habitats not currently in favourable conservation status achieve that status or show a strong positive trend by 2030, and that none show further signs of deterioration.

To support the EU Biodiversity Strategy 2030 and to complement the Protected Areas targets, the European Commission is developing overarching restoration targets that would be legally binding for all Member States. These targets are to enable tangible, measurable and concrete actions that contribute to achieving the overarching goal of halting biodiversity loss and restore degraded ecosystems. Such measurable and time-specific targets for restoration to favourable conservation status for protected habitats and species are not explicit in the Nature Directives; these targets will also encompass habitats and species not protected under the Nature Directives. It is expected that long-term protection of the restored areas will be necessary. These restored areas could therefore contribute towards the EU targets on protected areas.

At the UN High-Level Summit for Biodiversity in September 2020, An Taoiseach signed up to the Leaders' Pledge for Nature which supports the 30/30 targets and calls for an ambitious and meaningful post-2020 global agreement that will address the biodiversity crisis and help bring about the transformative change needed to halt biodiversity loss on a global level.

Ireland has also signed up to the High Ambition Coalition for Nature and People (HAC). The HAC, chaired by France and Costa Rica, builds on the UN Summit for Biodiversity and aims to maintain momentum in mobilizing political will for biodiversity in the lead-up to the next CBD Conference of the Parties (COP15, October 2021). One of the key aims supported by the HAC is the 30/30 target.

### *- Planning and Development context*

This section sets out relevant planning and development policies, legislation and guidance to the wind development sector.

*Spatial planning and policy*

Adopted in 2018, the National Planning Framework (NPF) is a national planning policy framework that guides Ireland's high-level strategic planning and development, with the aim that population growth will be sustainable, environmentally, socially and economically. Together with the National Development Plan, it guides strategic development and infrastructure development nationally and set the context for the development of the Regional Spatial and Economic Strategies (RSES) by the three Regional Assemblies. These, in turn, take account of and co-ordinate local authority Development Plans, so that all three levels (national, regional and local) align. Local Authority Development Plans, in turn, are required to include Wind Energy Strategies and Local Authority Renewable Energy Strategies. Following the adoption of all three RSES by January 2020, the statutory review process of local authorities' County or City Development Plans was commenced, overseen by the Office of the Planning Regulator. When complete, this process will ensure that all City or County Development Plans are consistent with the national and regional development objectives of the NPF and the relevant RSES.

The Planning and Development Act 2000 (as amended) is the primary planning legislation that influences the sector, setting requirements for regional guidelines, forward planning at the local authority level and development control. The Act sets out requirements for:

(i) regional planning guidelines;
(ii) development plans;
(iii) local area plans;
(iv) Ministerial guidelines;
(v) the process of applying for and obtaining planning permission;
(vi) special requirements for protected structures, conservation areas and areas of special planning control;
(vii) housing supply;
(viii) the Office of the Planning Regulator
(ix) An Bord Pleanála and the planning appeals process;
(x) planning enforcement processes;
(xi) strategic development zones and processes;
(xii) requirements for Environmental Impact Assessment (EIA);
(xiii) requirements for appropriate assessments;
(xiv) substitute consent;

(xv) local and State development processes;
(xvi) compensation,
(xvii) amenities;
(xviii) acquisition of land and
(xix) other particular types of development, *inter alia*.

In accordance with section 28 of the Planning Acts, local authorities are required to have regard to any Guidelines issued by the Minister under that section. The Wind Energy Development Guidelines 2006, issued under section 28 of the Planning Acts, advise local authorities to plan for wind energy through the development plan process and to include a statement of its "*policies and objectives in relation to wind energy development and matters it will take into account in assessing planning applications for specific wind energy development proposals*". This plan-led approach also requires the identification of areas considered suitable or unsuitable for wind energy development, and is to be used to inform decisions on such applications.

The guidelines also provide advice on the determination of applications for planning permission (addressed below). In 2013, with input from a range of government department and bodies, SEAI published its Methodology for Local Authority Renewable Energy Strategies (LARES) (SEAI, 2013a) to assist local authorities in the preparation of their renewable energy strategies. The aim of the methodology was to facilitate a consistency of approach in the preparation of LARES, and to assist local authorities in developing robust, co-ordinated and sustainable strategies in accordance with national and European obligations.

Development plans can help to avoid or minimise conflicts, and in particular, to encourage appropriate siting of wind energy developments in areas of potentially low or no conflicts for wildlife, including Hen Harrier strongholds and protected sites. As part of the plan process, local authorities may identify European 2000 sites as "*less favoured areas*" or areas of high sensitivity for wind development in their Wind Energy Strategies, and may discourage wind energy development or consider it to be "*not normally permissible*" within the sites. It should be noted that these categories are indicative and that every wind energy development planning application is to be assessed on its merit, regardless of the categorisation that has been applied to the area within which the development is proposed.

As a result of the consideration of suitable areas for wind energy developments as part of the development plan process, information has been generated regarding the relative sensitivity of constituent parts of each county, as well as county-by-county maps for favoured and less favoured zones for wind energy developments (see individual Local Authority Development Plans). DHLGH has developed Myplan.ie, in collaboration with all planning authorities, to make a wide range of spatial information related to the planning process available to all, including census data, heritage sites and patterns of housing development. SEAI have also funded AIRO (All-Island Research Observatory at NUI Maynooth) to consolidate wind energy maps into an online interactive mapping toolkit, and at the time of writing, a follow-on project is being explored by SEAI to incorporate this resource within a LARES mapping web tool and online viewer.

The Planning Acts also require local authorities, when varying or reviewing Development Plans and the associated land-use/zoning policies, to carry out Strategic Environmental Assessments (SEA) and Appropriate Assessments (AA) of the Plans, as may be required. They transpose the obligations of the EU Habitats Directive (Articles 6(3) and 6(4)) for an Appropriate Assessment (AA) to be carried out where a plan or project is likely to have a significant impact on a European 2000 site. Guidelines on Habitats Directive Articles 6(3) and 6(4) were published by the European Commission (EC, 2001; EC, 2010; EC, 2007/2012) and on the appropriate assessment process by the then Department of Environment, Heritage and Local Government (DoEHLG, 2009; updated in 2011).

*Development Control (*i.e. *planning for individual wind energy developments)*
As mentioned above, the Planning Acts and Regulations set out the legislative context for planning permissions for individual wind energy developments.

To obtain consent for individual wind energy developments, applicants need to submit a Natura Impact Statement (NIS) (DoEHLG, 2009), if one is deemed necessary by the planning authority. *i.e.* if they have determined that significant effects may arise on a European site as a result of the proposed development. An NIS is to be prepared by ecological experts in order to allow the planning authority to complete the AA process and their determination as to whether adverse effects on the integrity of European sites may or will arise.

The need to apply the precautionary principle in appropriate assessments has been enshrined in ECJ case law (*e.g*. where effects may arise but have not been proven) (*e.g.* Waddenzee Judgment (ECJ, 2004). Public authorities shall give consent to a plan or project, or adopt a plan or project, under Article 6 (3) of the Habitats Directive, only after having determined that it shall not adversely affect the integrity of a European site; furthermore, appropriate assessments should "*include complete, precise and definitive findings and conclusions that are capable of removing all scientific doubt as to the effects of the proposed development on … [sites] concerned*" (High Court, 2014).

If adverse effects are predicted or cannot be excluded, (even with proposed mitigation), the plan or project may proceed under Article 6(4) of the Habitats Directive, but only where there are:

- Imperative Reasons of Over-riding Public Interest (IROPI), including those concerning human health, public safety and beneficial consequences of primary importance for the environment, or those of a social or economic nature
- Where there is an absence of alternative solutions, and
- Where compensation measures for the adverse effects arising have been identified and put in place (DoEHLG, 2009; EC, 2007/2012).

Decisions of the local planning authorities to grant permission for wind energy development may be appealed to An Bord Pleanála. 'Strategic' developments must seek planning consent directly from An Bord Pleanála, through the Strategic Infrastructure Development (SID) process, rather than from the relevant local authority. This may include some wind energy developments *e.g.* installation of a wind energy development with more than 25 turbines or

having a total output greater than 50MW (Schedule 7 of the Planning and Development Regulations, 2001).

On those occasions where planning permission or development consent is not required for the construction or reconstruction of a generating station to supply electricity to final customers, the Commission for Regulation of Utilities (CRU) grant or refuse authorisations, following the assessment of an associated application. In such cases, the CRU is responsible for the undertaking of any required appropriate assessment (CRU, 2020).

*Guidance to support the development and assessment of wind energy developments*

The then Department of Environment, Heritage and Local Government published extensive guidelines for the development of wind energy developments (DoEHLG, 2006) which includes natural heritage considerations. The guidelines set out a framework for wind energy development and planning related matters including, among other things, environmental impacts, and recommend early identification (via GIS mapping) of natural heritage designations. Such designations do not necessarily preclude wind energy development applications, but require that obligations under the EU Birds and Habitats Directives must be met, including that the planning authority is satisfied that there will be no adverse effects on the integrity or conservation objectives of any designated site from any proposed development, prior to consent.

In accordance with planning legislation, it is also requirement for an EIA to be undertaken for wind energy developments that will have more than five turbines, or a total output greater than 5MW. Certain sub-threshold developments also require an EIA wherever the planning authority or An Bord Pleanála considers that the development would be likely to have significant effects on the environment. In 2018, the then Department of Housing, Planning and Local Government published updated section 28 Guidelines for planning authorities and An Bord Pleanála on carrying out EIAs (DHPLG, 2018), to take account of the 2014 amendments to the EIA Directive (Directive 2014/52/EU). The 2014 EIA Directive retained wind energy development in its Annex II which means that the requirement for an EIA is determined at the national level, either on the basis of thresholds/criteria or a case by case examination, having regard to the criteria set out in Annex III. In addition, Recitals 7 and 13 of the EIA Directive now oblige the consideration of the impacts of climate change on a project as well as the impacts of a project on climate, as well as on biodiversity.

In June 2017, DHPLG and DCCAE published a "preferred draft approach" to the Review of the 2006 Wind Energy Development Guidelines. This approach focused on issues relating to Sound/ Noise, Visual Amenity Setback, Shadow Flicker, Consultation Obligations, Community Dividend and Grid Connections. DHPLG and DCCAE then published draft Wind Energy Development Guidelines, incorporating the "preferred draft approach", for public consultation in December 2019. Following consideration of the submissions received, and any further revisions to the draft as required, the finalised Guidelines will be published.

Informed by the DoEHLG guidelines (2006), WEI (then IWEA) produced their own industry guidelines for the sector which focus on all stages of the development process from initial

feasibility studies to operational, decommissioning and repowering (IWEA, 2012). These guidelines are not required to be taken into consideration by a developer or a consenting authority.

Locally and at a European level, additional supporting guidance on the preparation of EIA and AA has also been published which ensures regular updates to practitioners (*e.g.* EPA, 2002; EPA, 2003; EU, 2010 – 2016). Most recently, the European Commission has produced an extensive revision of its guidance document on wind energy developments and EU nature legislation, in recognition of the need to tackle climate change, to address growing pressures on and loss of biodiversity, to reflect most recent insights and to develop good practice so that respective policy goals and targets can be reconciled (European Commission, 2020b).

In Ireland, the Forest Service (2011) has also published ancillary guidance for wind energy development in afforested sites, and departmental policy statements show general support for renewable energy policy; *e.g.* the Department of Agriculture, Food and the Marine has published its Climate Change Sectoral Adaptation Plan for the Agriculture and Forest sectors (*e.g.* DAFM, 2019a and 2019b).

There are no specifically Irish-prepared ornithology guidelines to inform surveys for the development of wind energy in Ireland. Specific direction has been provided by NPWS (2002) for Hen Harrier surveys to inform impact assessments for wind energy development. This included the recommendations for 500m wind energy development buffers and wider hinterland surveys up to 5km for Hen Harriers. Furthermore, recommendations for systematic sampling to quantify site usage between April and August via vantage point observations were given (based on Madders, 2002), as well as consideration of cumulative effect of other wind energy developments in the area. Further guidance will be prepared by NPWS as an action of the HHTRP.

Percival (2003) reviewed available knowledge on the effects of wind energy developments on birds, particularly in relation to potential issues in Ireland, including disturbance-related research. This work also set out to provide a methodology for assessing the effects of wind energy developments on bird species. It addressed:

- baseline data collection,
- evaluation of sensitivities,
- establishing the magnitude of possible impacts,
- determination of significance of possible impacts,
- mitigation and
- cumulative assessment.

The review recommended the adoption of British Wind Energy Association (BWEA) and Scottish Natural Heritage (SNH, now known as NatureScot) guidance with Ireland-specific adaptations. This study also set out a number of criteria which could be used to assess the ornithological sensitivity the site being assessed and the species involved *e.g.* it considered that SPA selection species (or Species of Conservation Interest/SCI) should be considered 'very high' sensitivity. On the basis of its ecological characteristics (where it is not an SCI species), Hen

Harrier was classified as 'high' sensitivity. Thus, in Ireland, in the SPAs for which Hen Harrier is an SCI species, it would be considered to be 'very high' sensitivity, and where it occurs outside the SPA Network, 'high' sensitivity.

There is also a suite of published research on wind energy developments and birds (see Chapter 2) and Wilson *et al.* (2015) has reviewed guidelines in use in the UK and elsewhere in Europe. In Scotland, a detailed framework for ornithological interactions has been set out (SNH, 2000; 2006; 2011) and frequently, independent ecologists operating in other jurisdictions, including other constituent parts of the UK (England, Wales and Northern Ireland) and in Ireland, may use or adapt SNH (now known as NatureScot) guidelines during their assessment and implementation of wind energy development planning processes. In addition to best practice guides for construction and decommissioning, these guidelines include recommendations on specific surveys, methods, seasons, assessment, avoidance, disturbance, repowering, habitat management, cumulative assessment, SPA connectivity, carcass searches, power lines, meteorological masts and are available online on the NatureScot website (see also review in Wilson *et al.*, 2015).

In the absence of specific Hen Harrier (or ornithological) guidelines in Ireland, the generic ornithology guidance provided by DoEHLG (2006) and IWEA (2012) and on appropriate assessments required for development within SPAs (DoEHLG, 2009; EU, 2011), along with the EU's guidance on wind energy developments and Natura 2000 (European Commission (EC), 2010), most recently updated in late 2020 (European Commission, 2020b) comprise best available guidance in Ireland.

Further to statutory and other guidance, there are also ancillary guidance tools available that can be used to inform wind energy development planning and associated ornithological requirements. These include the wind energy development sensitivity mapping tool, available via the National Biodiversity Data Centre's Biodiversity Maps portal and funded by SEAI. The primary research for this tool was undertaken in 2012, with an outline method and policy development protocol (Tierney *et al.*, 2012). The more detailed secondary report and assessment tool (McGuinness *et al.*, 2015) also provided a research output (and spatial planning tool) to inform wind energy development sensitivity for Hen Harriers and 21 other bird species for which spatial data were available. It has been developed into an AA and SEA screening tool by AIRO/NIRSA at NUI Maynooth, and SEAI is also funding its further development into the LARES data viewer and web tool.

### *Ireland's wind energy resource*

Ireland has a relatively high wind resource that typically increases with increasing altitude (SEAI, 2013b; SEAI online Wind Atlas). Therefore, turbines have perhaps, historically, been more likely to be located in upland areas. Wind energy developments can theoretically be developed spatially anywhere in Ireland although spatial optimisation, particularly for wind output (Rasuo and Bengin, 2010) and other environmental constraints, is desirable. Because of dispersed historical development in Ireland and rural settlement patterns in particular, as well as related considerations that require wind energy development to be set away from settlements, very large swathes of the country are considered to be effectively unsuitable for wind energy development.

Newer and larger turbines may be less restricted by altitudinal requirements (*i.e.* installation in windier, upland areas) as they are now larger and can exploit wind resources at lower levels more easily. Thus, they can (theoretically) be installed at lower elevations and still harvest wind resources previously only obtained at higher elevations. However, similarly-sized turbines at lower levels will, on average, deliver lower energy yields than those in upland locations (SEAI online Wind Atlas; J. McCann, pers. comm.).

At the time of designation (2006), wind energy developments were located within the boundaries of four of the six Hen Harrier SPAs) and as of 2016, turbines had also been permitted in or in proximity to three SPAs post-designation (see Chapter 3). There are currently no explicit prohibitions on wind energy development within SPAs. However, as already mentioned, there is a requirement to undertake an appropriate assessment to ensure the development does not affect the integrity of the SPA.

A database of spatial and descriptive statistics of wind turbines greater than 0.1MW in Ireland (SEAI, unpublished; J. McCann, pers. comm.) confirms that the first wind energy development was erected in Ireland in 1992 (Co. Mayo; Figure 4). After a short hiatus between 1993 and 1996, the number of turbines increased annually, although the numbers of turbines connected varies between years (Figure 5). The average capacity installed annually between 2008 and 2017 was 258 MW. More recently, in 2019 alone, 461 MW was installed, bringing the total installed wind capacity to 4,137 MW (SEAI, 2020).

There are two databases in which information on wind energy in Ireland is collated *i.e.* the Transmission System Operator (TSO) database held by Eirgrid and the Distribution System Operator (DSO) database held at ESB Networks. WEI and SEAI present information on wind power in Ireland, informed, in part, by these databases. At the global level, there are also sources of relevant data (*e.g.* The Wind Power website). Both the TSO and DSO databases have two separate sub-databases for the connected (or energised) wind energy projects, as well as the contracted projects that have grid connection offers but have not yet been constructed, energised or connected. These databases do not necessarily provide information on the numbers of installed turbines or individual turbine capacity but rather the Maximum Export Capacity (MEC) upon which connection agreements are made. A single wind energy development may have several connection agreements and associated reference numbers for

energy export. Figure 5 illustrates the connected wind-energy resources in Ireland up until 2016 (2,780MW).

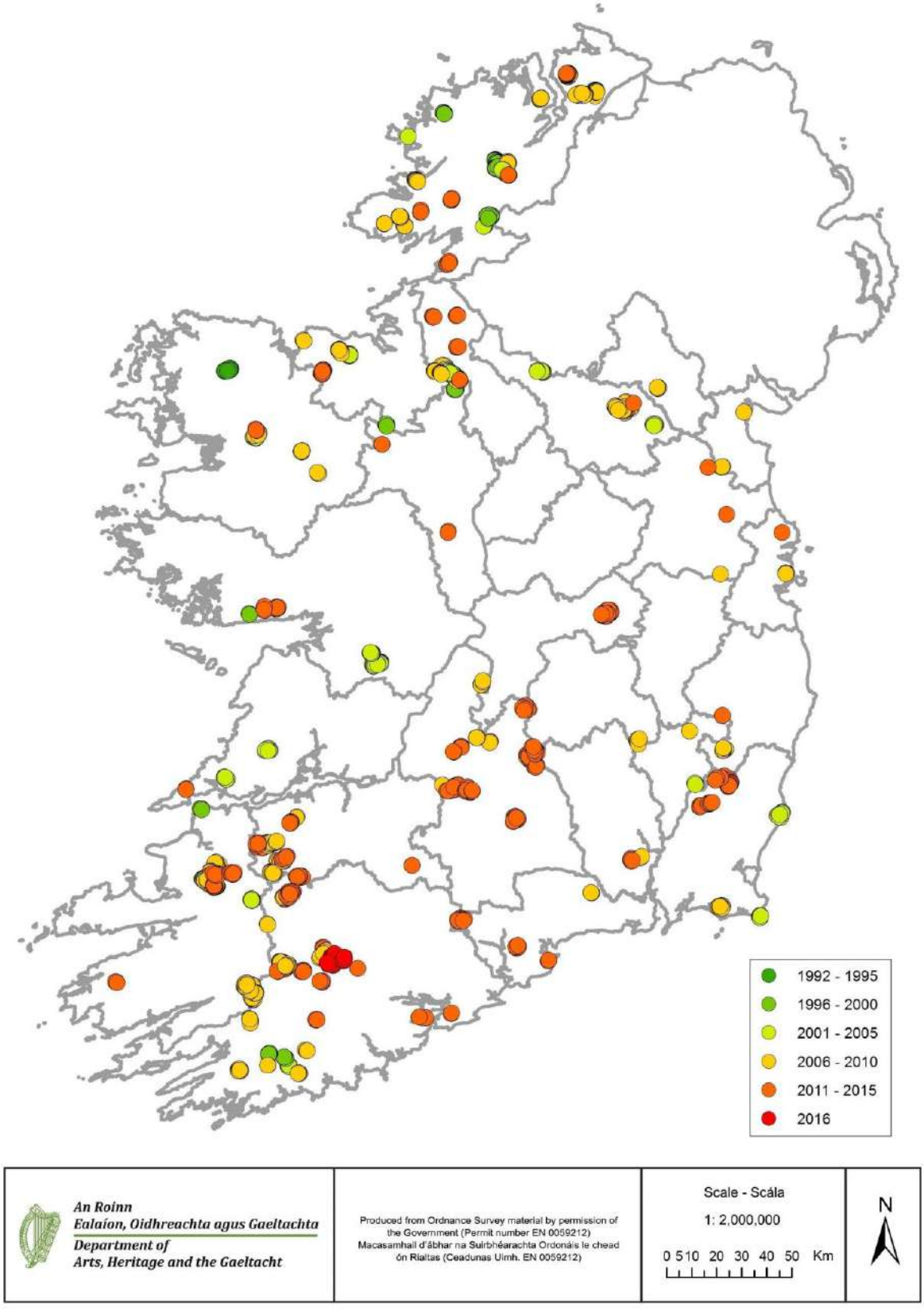



**Figure 4. The cumulative distribution of terrestrial turbines connected in Ireland (1992 – 2016).**

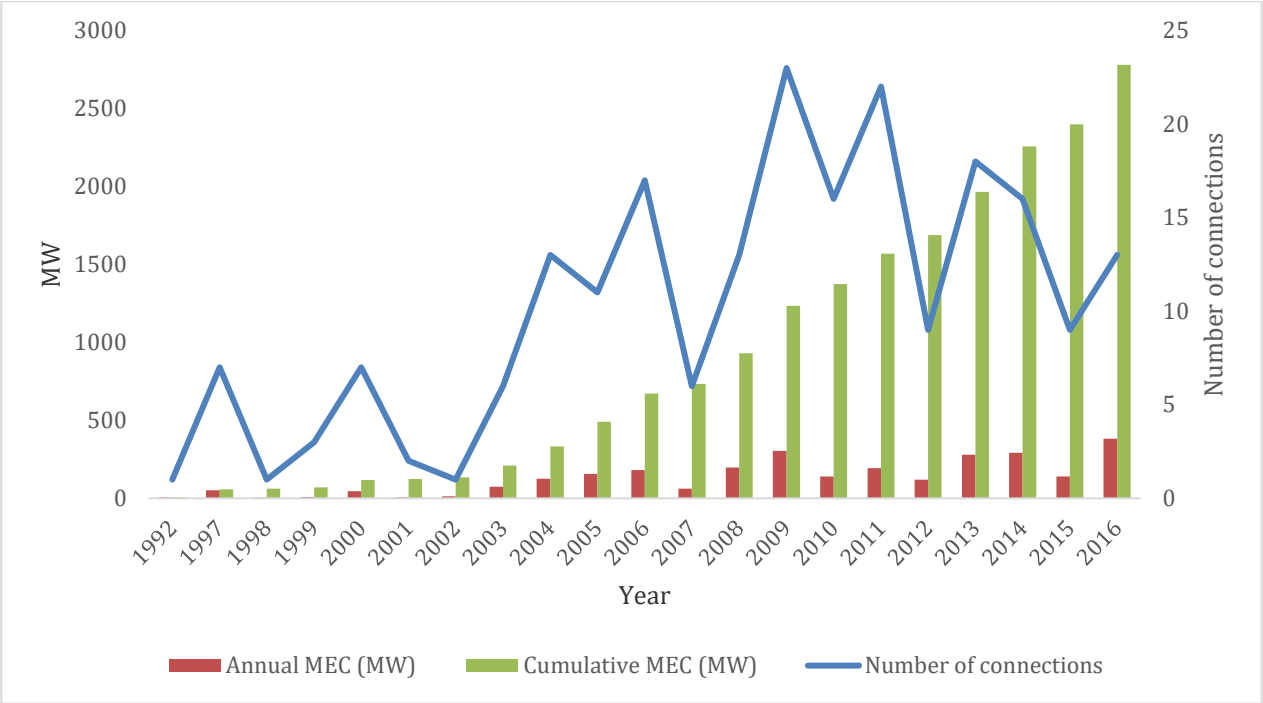



**Figure 5. The annual and cumulative connected MW in Ireland between 1992 and 2016 (derived from statistics collated by ESB and TSO).**

The NECP, submitted in Summer 2020, outlines estimated trajectories for the deployment of renewable energy technologies in Ireland, including renewable electricity technologies, taking into account the policies outlined in the 2019 Climate Action Plan (the With Additional Measures, or WAM, scenario) (DCCAE, 2020). In this scenario, the deployment of onshore wind is estimated to increase to 7.5GW by 2030 and to 8GW by 2040. The NECP trajectories will be reviewed in light of the policies adopted pursuant to the 2020 Programme of Government and ambitions of the European Green Deal, particularly the commitment to increased deployment of offshore wind and the increased ambition for greenhouse gas reductions and renewable energy penetration.

The overall trend of increasing power supply to meet renewable electricity targets takes into account the repowering of existing onshore wind energy developments (SEAI, 2011). The repowering of wind energy developments is expected to become increasingly relevant in coming years given the 20-30 year life-span of earliest developments. It also receives particular attention in the recast Renewable Energy Directive (2018/2001/EU) and the Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action, which requires Member States to facilitate the repowering of existing renewable energy plants with simplified and swift permitting processes that take no longer than one year (Article 16 (6)).

Wind energy development performance declines with age, and the rate of decline may be influenced by a number of factors, including terrain, weather, fleet vintage, as well as regulatory, policy and contractual factors (Hamilton *et al.*, 2020). The repowering of existing sites, where permissible, will be able to capitalise on recent technological advances, efficiency and increased power output of newer turbines (Herbert *et al.*, 2007; Sarkar and Behera, 2012). This will likely mean installation of larger and greater-output turbines over time, although the

largest turbines (>7.5MW, with the largest offshore turbine 12MW, as of 2020) are proposed primarily for offshore use. Maximum onshore turbine height will be influenced by the establishment of a setback distance, set at four times tip height, subject to a mandatory minimum of 500m, as set out in the "preferred draft approach" and the Draft Wind Energy Development Guidelines (DHPLG, 2019).

### *Developing a Wind Energy Development Application*

The installation of wind energy development in Ireland typically involves several phases:

(i) pre-application feasibility and suitability;
(ii) research and assessment;
(iii) planning application and decision-making;
(iv) construction;
(v) operation and
(vi) decommissioning, renewal (*i.e.* life extension) or repowering.

*Stage (i) Pre-application feasibility and suitability:* It is recommended that an extensive suitability and feasibility assessment be undertaken before a planning application is submitted (known as the "pre-application stage") (DoEHLG, 2006). Such assessments are a judicious use of resources to explore technical, economic and site-specific options, and involve early screening of high-risk or poorly-sited developments before any further financial investment is committed.

*Stage (ii) Research and assessment:* It is likely to be necessary to undertake research, survey and assessment in order to prepare for, amongst other things, the requirements of an Environmental Impact Assessment (EIA) and/or for an Appropriate Assessment.

*Stage (iii) Planning application and decision-making:* The applicant submits their application to the relevant planning authority, along with the Environmental Impact Assessment Report and Natura Impact Statement, if required. Applications are examined with reference to, *inter alia*, their impact on designated sites, nature conservation and taking into account the provisions of domestic and European legislation. The planning authority must refer all planning applications that might have significant effects in relation to nature conservation to NPWS-DHLGH. NPWS prepares and submits observations to the planning authority, which then concludes its Appropriate Assessment, and makes a decision on the application. The findings of the Appropriate Assessment must be taken into account in its decision-making.

The planning authority may set a series of planning conditions, including risk mitigation measures as part of the planning consent. Provided sufficiently robust information is available to inform the assessment and review by the planning authority, these conditions should provide for mitigation for any residual risk at all stages of wind energy development construction, operation and decommissioning.

In addition to planning consent, it is necessary to secure a grid connection (in order for a wind energy development to be able to export power to the national grid) and to agree the route and type of transmission (*e.g.* underground cables or overhead power lines). Details of the grid

connection must also form part of the planning approval process, where EIA/AA is required, in order to ensure that the impact of the whole project is considered. Connection offers from grid operators can be obtained prior to planning consent. Grid connection contracts are typically in place prior to commencement of construction.

*Stage (iv) Construction:* Construction can involve the creation of roads (typically hard-fill or floating road designs); turbine bases and hard-standings; erection of turbine towers, nacelles and blades; construction of operation/control rooms; construction/erection of grid connection infrastructure (*e.g.* underground cabling or overhead power lines). Planning consents also have specific requirements pertaining to the management of environmental risk during construction. For example, there may be a requirement to manage temporal constraints such as bad winter weather, with the elevated risk of siltation (run-off), or disturbance to breeding birds during the summer, or to have an Ecological Clerk of Works on site, to oversee the works and to ensure compliance with ecological mitigation measures.

Construction activities typically involve a relatively large work force and associated vehicles, cranes and other machinery to build the necessary infrastructure. Construction activities may also require the creation of borrow-pits, quarries, sediment ponds and temporary compounds; road widening and improvement works on the approaches to the site; installation of drainage infrastructure and waste disposal locations for material such as spoil from excavation works. Construction activities may also include habitat modification such as felling of trees (*e.g.* key-hole felling), habitat creation or restoration. Direct land-take by wind turbines may be relatively small compared to the entire wind energy development site, but the ecological impacts arising from the entirety of the development, *e.g.* through construction activities *etc.*, may affect a much wider area. The impacts of all these activities are to be assessed in the relevant ecological assessments.

*Stage (v) Operation:* The primary operational phase of a wind turbine or wind energy development may extend to 20-30 years, as directed by the planning consent. The scope of a full operation and maintenance contract includes the generating plant (*i.e.* turbines) and the entire wind energy development site, including access tracks, auxiliary buildings and electrical infrastructure. For the most part, day-to-day maintenance and operation of the site is undertaken either remotely and/or by a small number of site personnel and associated vehicles. Site operation involves one or a limited number of personnel attending the site on a daily basis, or occasionally, in order to undertake routine site and/or infrastructure inspections or condition assessments. Some site compounds may be used as operational bases for regional staff and thus, regular activity may occur. This may present other novel sources of disturbance to wildlife. For many wind energy developments, controls rooms are located at the electrical substation, commonly close to the entry point to the development, at a lower elevation, and not within the wind array. Remote monitoring involves only intermittent visits by personnel, when operational issues require their attendance.

Operations staff or technicians may need to respond either remotely or locally to maintenance notifications in order to diagnose the cause of the notification and reset, if needed. Such responses may be required around the clock, depending on its cause, though it is understood

that most can be addressed remotely. There may be human and vehicular activity associated with scheduled (*e.g.* quarterly or annual) maintenance inspections, service monitoring and repairs. There may also be a requirement for attendance of heavy goods vehicles or cranes in order to undertake more substantial repairs or maintenance; these are most likely to be required when major turbine components reach "end-of-life" (typically, more than 10 years into service). Larger scale operations, *e.g.* to remove/ replace turbines or extensive road repairs, may cause disturbance to species or habitats outside the primary construction periods.

The operational phase may also include ongoing or intermittent monitoring, reporting and management activities *e.g.* bird surveys, collision mortality (carcass searches), environmental management (*e.g.* habitat management). This phase may also be subject to environmental, health and safety and operational guidelines, which may vary between sites and operators.

*Stage (vi) Decommissioning, Renewal or Repowering:* Decommissioning may be included as a planning condition for a wind energy development but increasingly, repowering of existing sites may extend its lifetime. Factors that may drive the requirement for decommissioning include time-bound constraints on manufacturer warranties (and the associated risks), reliability (which may decrease over time), maintenance issues and efficiency (Verma *et al.*, 2015).

Following the cessation of a wind energy development operation, decommissioning involves the dismantling and removal of above-ground equipment (masts, turbines and foundations) from the site and all associated structures (including any access roads) are removed and vegetation reinstated. These activities are usually conditioned to be undertaken within three months of decommissioning (*e.g.* An Bord Pleanála, 2016). There is, as yet, little experience of this in Ireland but more detailed studies and reviews have been undertaken in Scotland (Welstead *et al.*, 2013).

Wind energy developers may also apply for permission to renew permission for a wind energy development. Renewal entails the seeking of planning permission to continue using the wind energy development as constructed, beyond the time limit specified in the original planning permission (if such a condition is in place) and may include replacing components (up to and including a wind turbine/s) of the wind energy development on a like-for-like basis.

Repowering entails entails the removal of the existing equipment and the seeking of planning permission for the installation of new wind turbines and any ancillary works required within the wind energy development site. As existing wind energy developments near the end of their operating lives, applications for repowering are steadily increasing. In some cases, the wind energy developments will be repowered due to rapidly evolving technology and changing financial incentives. In many cases, applicants will seek to install larger turbines when repowering an existing site.

Applications for repowering will need to be accompanied by further and more up-to-date surveys and ecological/environmental assessments in order to inform the associated planning decisions. The effects arising may differ to those of the original project as risks may shift from

one receptor group to another (European Commission, 2020b). Specific guidance on the approach to be used in the ecological assessment of repowering to inform AAs and EIAs may also be of benefit. Applications for repowering should be considered on a case-by-case basis by the planning authority taking into account all relevant legislation, policy and guidance, including the updated Wind Energy Development Guidelines to be issued by DHLGH.

# CHAPTER 2: INTERACTIONS BETWEEN WIND ENERGY DEVELOPMENT & THE HEN HARRIER IN IRELAND

## Introduction

This chapter outlines the potential interactions between wind energy development and the Hen Harrier in Ireland. It provides an overview of such interactions with birds generally, as well as the breeding and non-breeding Irish Hen Harrier population, within and outside the SPA network. It sets out the variety of interactions that may arise and then relates these to various aspects of Hen Harrier ecology. This review is largely based on scientific publications and reports, the majority of which are from peer-reviewed sources.

## Wind energy development -bird interactions

Wind energy development interactions with birds can have lethal or non-lethal effects. Wind turbine construction and/or development work present three main risks to birds (Desholm, 2006), namely:

1) direct mortality due to collision with the turbine blades, nacelles, towers and/or ancillary wind energy development infrastructure (*e.g.* overhead power lines, if used; meteorological masts) (Barrios and Rodriguez, 2004; Band *et al.*, 2007; Drewitt and Langston, 2008; Bellebaum *et al.*, 2013);

(2) loss of breeding and/or foraging habitat, due to the footprint of construction, or fragmentation of breeding, wintering or foraging habitats (de Lucas *et al.*, 2008; Pearce-Higgins *et al.*, 2009a; Fijn *et al.*, 2012; Zimmerling *et al.*, 2013), and

(3) displacement of birds as a result of increased disturbance (Devereaux *et al.*, 2008; Fielding and Haworth, 2010; Fijn *et al.*, 2012), and/or loss of suitable habitat, and barrier effects caused by turbine arrays (Barrios and Rodriguez, 2004; Desholm and Kahlert, 2005; Masden *et al.*, 2009).

These potential effects are not mutually exclusive and may interact with one another to increase or decrease the severity of the overall effect. For example, reduced occurrence of a species on a site, caused by habitat loss, may decrease their risk of collision. Similarly, the absence of an avoidance response in some species or in individual birds may increase their collision risk (Drewitt and Langston, 2006; McGuinness *et al.*, 2015), and subsequent mortality.

There are a number of research studies and reviews available on the interactions between wind energy developments and raptors, in particular arising from studies over the last 25 years in Spain, USA, the Netherlands, Germany and Belgium (Crockford, 1992; Langston and Pullan, 2003; Stewart *et al.*, 2007; Carrete *et al.*, 2009; Wang and Wang, 2015; Schaub *et al.*, 2020).

### *Wind energy developments and collisions*

The key concern of direct mortality and injury to birds through wind energy development-mediated collision is widely studied. The mortality effects on birds can be variable and may be affected by:

- season (Barclay *et al.,* 2007; Minderman *et al.*, 2012);
- topography (de Lucas *et al.,* 2012; Katzner *et al.*, 2012);

- turbine metrics such as height, design and age (Orloff and Flannery, 1992; Osborn *et al.*, 2000; Smallwood & Thelander, 2004; de Lucas *et al.*, 2008);
- spatial arrangement of the wind energy development (Ferrer *et al.*, 2012; Zwart *et al.*, 2016; Schaub *et al*., 2020);
- weather conditions (Winkelman 1992; Drewitt and Langston, 2006; Kunz *et al.*, 2007; Larsen and Guillemette, 2007; Lawrence *et al.*, 2007; Drewitt and Langston, 2008; Farfán *et al.*, 2009);
- repowering (SNH, 2014);
- specific species' vulnerability or morphology (Barrios and Rodriguez, 2004; Smallwood *et al.*, 2009);
- species' abundance and distribution (Fielding *et al.*, 2006; Douglas *et al.*, 2011; Carrete *et al.*, 2012); and
- value or attractiveness of surrounding habitats (Larsen and Madsen, 2000; Walker *et al.*, 2005; Martinez-Abrain *et al.*, 2012).

The statistical relationship between bird mortality and turbine design is complex (Hötker *et al.*, 2006; Barclay *et al.*, 2007; Stewart *et al.*, 2007; Pearce-Higgins *et al.*, 2009a; 2012; Ferrer *et al.*, 2012; Thaxter *et al*., 2017). It is also widely recognised that a species' population dynamics can be affected by mortality that may be additive (*i.e.* adding to natural mortality) or compensatory (*i.e.* substituting for natural mortality) (Cole and Dahl, 2013; Dahl *et al.*, 2013). Wind energy development collisions may operate in combination with other mortality factors, thereby exacerbating population declines or low/declining rates of population growth. This is of particular concern given the likelihood of extensive increases in numbers of turbines, both nationally and globally, in order to meet growing renewable energy targets.

Overhead lines may also elevate collision risk and/or occurrence of collisions (Hagen *et al.*, 2007; Doherty *et al.*, 2008) and may cause avoidance or displacement over a wider area *e.g.* declining habitat use over 600m, as recorded by Braun (1998). Overhead power lines and associated infrastructure (*i.e.* pylons or poles) may also act as perching locations for some species (Manosa, 2001; Smallie and Virani, 2010), including nest predators such as corvids (Lammers and Collopy, 2005), as well as causing electrocution (Tryjanowski *et al.*, 2013).

Poorly-sited developments can result in extensive mortality *e.g.* Smóla (Norway), Altamont Pass (California) and Tarifa (Spain) (Osborn and Schillinger, 1996; Hunt, 2002; Follestad *et al.*, 2007; de Lucas *et al.*, 2008; Telleria, 2009a; b). Whilst site-specific mortality can be increased by poorly-sited turbines, it may be lower than other types of mortality such as persecution (*e.g.* shooting or poisoning), predation or other types of collisions (*e.g.* vehicles, towers, buildings, power lines) (Langston and Pullan, 2003). However, impacts at the population level may be more marked in the cases of poorly-manoeuvrable, rare, long-lived species (Carrete *et al.*, 2009; Cole and Dahl, 2013). Effects may be particularly marked in those species which have low breeding productivity (Carrete *et al.*, 2009; Cruz-Delgado *et al.*, 2010), of which the Hen Harrier is one. There may also be a higher likelihood of effects on migrants (Masden *et al.*, 2009; Telleria, 2009b), particularly where mortality occurs in one part of the migratory or seasonal

range. This, then, may have effects well beyond the site of the actual collision (Katzner *et al.*, 2015).

The potential effects of repowering on bird mortality rates appears to be variable (Stewart *et al.*, 2007; Drewitt and Langston, 2008 contra Smallwood and Thelander, 2004; Barclay *et al.*, 2007). Some studies have concluded that there is no compelling evidence that repowering (*i.e.* increasing the capacity) of older turbines will change the collision risk for birds (Stewart *et al.*, 2007; Drewitt and Langston, 2008). Thaxter *et al*. (2017) conclude from their review study across a range of bird species, that, per energy output, collision risk may be reduced, if fewer larger turbines are installed, rather than many smaller ones. They highlighted that more research is needed to understand the relationship between collision risk and turbine size, and its variation between the habitats in which the turbines are located. The ecological effects of repowering will need to be considered on a site-by-site and species-by-species basis (European Commission, 2020b) as to whether it would result in a change to predicted collision risk.

Collision risk at wind energy developments is therefore a complex interaction between various species' characteristics and occurrence, and environmental and wind turbine/wind energy development factors (see Wilson *et al.*, 2015).

### Hen Harriers and collisions

While low-medium risks of collision mortality has been identified by Whitfield and Madders (2006), Hen Harrier collisions have been reported, including in Spain (Lekuona and Ursúa, 2007 (n = 1); Northern Ireland (Scott and McHaffie, 2008; Co. Antrim; n = 1); Scotland (RSPB, 2012, Perthshire; n = 2) and Ireland.

In Ireland, as part of their review and study of flights behaviour, Wilson *et al.* (2015) recorded that:

(i) during sky dancing displays, Hen Harriers achieved flight heights that put them at potential risk from wind turbines;
(ii) average flight heights of adult Hen Harriers did not change in response to wind turbine presence, although it is possible that birds altered their flight height in the proximity of individual turbines;
(iii) adult male Hen Harriers spent up to 12% of their flight time at wind turbine rotor swept height; and
(iv) newly-fledged juvenile Hen Harriers spent the majority of their time below turbine rotor sweep height, in and around the nest area.

Overall, it was concluded that the risk of direct collision with wind turbine rotors was low (Wilson *et al*., 2015). However, since that study's conclusion in 2015 and even in the absence of robust carcass searches, NPWS-DHLGH has received reports (including photographic evidence)

of one "possible" case and three "probable/confirmed"[1] incidences of Hen Harrier mortality caused by turbine strike.

Mortality of the allied Northern Harrier (*Circus hudsonius*) (Etherington and Mobley, 2016), (which was until recently considered to be the same species as the Hen Harrier) has also been recorded, with six collisions reported at Altamont Pass Wind Resource Area (APWRA), California (situated on a major bird migratory route with high concentrations of raptors) and Foote Creek Rim, Wyoming (Erickson *et al.*, 2001; Johnson *et al.*, 2001; Kingsley and Whittam, 2005). There were three recorded by Smallwood and Thelander (2004) over five years, and seven reported between 1989 and 2007 by Smallwood and Karas (2008), although some of these studies appear to report on the same data over different time periods. Three Northern Harrier collisions were also reported by Derby *et al.* (2008) at Buffalo Ridge, Dakota, USA.

In addition to the relatively small number of collisions occurring, many studies show that there does not appear to be a link between Hen Harrier abundance and collision levels, or those of Northern Harriers (Johnson *et al.*, 2000; Stewart *et al.*, 2005; Mabey and Paul, 2007; Whitfield and Madders, 2006). Mortality of harriers may also be disproportionately lower than other raptors (Drewitt and Langston, 2008). Hen Harriers may be at lower risk of collision due to the majority of low-elevation flights undertaken by the species (Madders, 2000; Whitfield and Madders, 2006; Band *et al.*, 2007), which does not normally predispose them to flying within the rotor swept zone, and avoidance responses (Garvin *et al.*, 2011). Wilson *et al.* (2015) suggested that collision risk may be affected by the proximity of the nest and during breeding displays.

A recent study examining flight behaviours of Montagu's Harriers, using three-dimensional GPS tracking data to investigate collision risk of breeding males with wind turbines, found that only 7.1% of flights were within the average rotor height range (RHR; 45-125m), with birds spending as much as 8.2 h per day in flight, more than Hen Harriers in the same study area (4-6 h/day for males during the breeding season) (Schaub *et al*., 2020). Avoidance of turbine towers was demonstrated, with a distinct reduction of flight activity near turbines. This analysis estimated that any repowering of wind energy developments in the study area (where tracked birds visited nine wind energy developments in total), using low-reaching modern turbines (RHR 36-150m), could more than double the risk of collision for Montagu's Harriers.

With respect to Hen Harrier, repowering of old wind turbines with larger models may move the rotor swept area above their typical foraging altitude. Between 1992 and 2014, the average height of the lower edge of the rotor swept area doubled. Thaxter *et al.*'s (2017) review study

[1] A determination of cause of death of any remains discovered near a turbine or wind energy development footprint is made based on a review of the available evidence. This includes:
- proximity of the specimen when found, relative to a wind turbine;
- a detailed physical examination of the remains by an expert *e.g.* veterinary surgeon and x-rays to ascertain whether injuries sustained would be consistent with a turbine collision.
Such cases where the nature of the physical trauma *i.e.* fractures and/or severed body parts are consistent with a turbine strike are deemed 'probable/confirmed' for reporting purposes. Where a turbine strike cannot be discounted as cause of death, such incidents are recorded as 'possible'.

identified a strong positive correlation between turbine capacity (MW) and bird collisions per turbine, indicating that fewer larger turbines should be installed to minimize collisions.

### *Wind energy developments and habitat loss and fragmentation*

Construction of hard surfaces, *e.g.* for roads and turbine foundations *etc.,* cause direct habitat loss. The construction of access roads may also increase fragmentation of habitats (Trombulak & Frissel, 2000) that may be important for bird species but it may also attract other species *e.g.* by providing novel linear features which harriers may utilise for foraging (M. Ruddock, personal observation). Overhead power lines and any associated vegetation clearance can similarly influence small mammal (prey) populations (Osbourne *et al.*, 2005) and create fragmentation or barriers to movement (Andrews, 1990; Pruett *et al.*, 2009a and 2009b; Hagen *et al.*, 2011).

### *Wind energy developments and displacement of bird species, including Hen Harrier*

Displacement and/or disturbance can potentially occur in three phases of the wind energy development's lifespan: firstly, during construction phase; secondly, during the post-construction phase and finally, in the decommissioning or repowering phase. The former and latter will occur over a short temporal period (weeks – 18 months) whilst the operational phase will occur over several years *i.e.* the period for which it is operational (20-25 years). Issues are also most likely to arise where spatial and/or temporal interactions occur between nesting, foraging or roosting habitats and wind energy developments and activities.

Displacement from breeding, wintering or foraging areas (effectively, a loss of habitat) can occur as a result of both direct and indirect effects at wind energy developments. Direct bird displacement may be caused either through direct habitat loss, perturbation or changes to habitats *i.e.* loss of nesting or roosting habitat. Indirect displacement by wind energy development can be manifested through behavioural avoidance by birds because of associated disturbance (Langston and Pullan, 2003; Dahl *et al.*, 2013) and/or modification of foraging habitats, thereby affecting their utility (Arroyo *et al.*, 2009).

Operations (once-off or recurring) that have the potential to disturb nesting Hen Harrier (see Chapter 1) during pre-construction, construction and operational phases of wind energy developments include the following, though not every wind energy development will involve all those listed (*e.g*. tree felling, overhead power lines):

(i) mechanical site (vegetation) clearance;
(ii) timber felling (clearfell), extraction and removal;
(iii) mechanical extraction and drilling for cabling;
(iv) mechanical extraction for creation of foundations;
(v) road construction (and associated developments);
(vi) mechanical piling / drilling for turbine bases;
(vii) the erection of fences;
(viii) the erection of power lines, poles and associated rigging;
(ix) operational site monitoring activities;
(x) operational site maintenance activities; and
(xi) operational habitat management activities.

Indirect effects can also be due to behavioural avoidance of actual turbines at a small scale (*i.e.* individual turbine) or a wider 'barrier effect' at wind energy development(s) level (Hotker *et al.*, 2006; de Lucas *et al.*, 2004; Sugimoto and Matsuda, 2011; Plonczhier and Simms, 2012; Humphreys *et al.*, 2015), where preferred flyway routes may be altered, particularly for migrating birds (Masden *et al.*, 2009; Telleria, 2009a).

A wide range of conclusions have been drawn in relation to wind energy developments and their displacement effects on birds, including that:

- it does not occur or its effects are negligible, acting at a small-scale (Madders and Whitfield, 2006; Devereux *et al.*, 2008; Douglas *et al.*, 2011; Haworth and Fielding, 2012);
- it has negative impacts (Pearce-Higgins *et al.*, 2009b); and
- the direction of observed or predicted effects are complex interactions between site-specific and species-specific metrics (Drewitt and Langston, 2006; Pearce-Higgins *et al.*, 2009a; 2012; Garvin *et al.*, 2011; Dahl *et al.*, 2013; Thaxter *et al.*, 2015).

The direct habitat loss due to the footprint of construction is likely to be a relatively small area of land, with a wider behavioural effect caused by avoidance likely across a greater area (*i.e.* the zone of influence). The key metric for displacement is a spatial response *i.e.* avoidance of wind energy developments or turbines by a specified distance (Whitfield *et al.*, 2008), although it is recognised that this spatial response can be highly variable between species (Marques *et al.*, 2014) and may be highly individualistic.

Reviews and empirical studies, measuring pre- and post-construction abundance and distribution, show that displacement exhibits considerable intra-specific variation, and where it does occur, it may range from 50m to 1,000m. Some species may not be affected (Douglas *et al.*, 2011) but the effects on others may, however, extend to a much greater distance (see Ruddock and Whitfield, 2007; Whitfield *et al.*, 2008).

In their field study, Fernández-Bellon *et al.* (2019) found that total bird densities were lower at wind energy developments than at control sites, and that the greatest differences occurred close to turbines. In addition, it was found that the scale and intensity of the displacement effects of wind energy development on upland birds depends on bird species' habitat associations and that the observed effects are mediated by changes in land use associated with wind energy development construction.

Pearce-Higgins *et al.* (2009) found in field experiments that there was no relationship between displacement and turbine size (range 30m – 70m; 8.4 MW – 97 MW) or power, whilst in their meta-analysis review, Stewart *et al.* (2005, 2007) found that there does not seem to be an inter-relationship between bird abundance and wind turbine number; only a weak, but statistically significant, relationship with power output was observed, with lower power-rated turbines resulting in greater declines in bird abundance than higher-rated turbines. This study also found that bird abundance was significantly affected by the life-span of the wind energy

development operation, with those that had been operational for longer time periods having higher effects on abundance.

Spatial avoidance can operate at the individual bird level, where an individual foraging or nesting bird locates itself further from the wind energy development and, subsequently, at a localised population level *i.e.* reduction in abundance and/or density (Pearce-Higgins *et al.*, 2009a; Marques *et al.* 2014). Displacement may have associated indirect 'cascade' responses (Schmidt and Ostfeld, 2003; Salo *et al.*, 2010), whereby some species are affected and that, in turn, affects other species. For example, wind energy development-mediated changes in prey species density or abundance may affect foraging predators, such as raptors (Pearce-Higgins *et al.*, 2009a; Wilson *et al.*, 2015). That is, habitat quality may be compromised to such an extent that indirect changes result in the avoidance of those habitats because of a reduction in their suitability and/or profitability for the species in question.

It has been suggested that displacement may affect breeding success in raptors (Bright *et al.*, 2008a; Carrete *et al.*, 2009) and displacement from suitable habitat has been suggested as causing a decline in the breeding success of two large raptors, White-Tailed Eagles and Griffon Vultures (Dahl *et al.,* 2012), although several studies show no detectable effects (see review in Wilson *et al.*, 2015). There is mixed evidence of habituation, with some reviews (Stewart *et al.*, 2005, 2007) suggesting that effects will persist throughout the operational period. Others suggest that this may vary between species (Marques *et al.*, 2014), but few studies have demonstrated this empirically (see Madsen and Boertmann, 2008).

Several studies attribute much of the perturbation caused by wind energy developments to the construction phase (Garvin *et al.*, 2011; Pearce-Higgins *et al.*, 2012; Campedelli *et al.*, 2013; Hull *et al.*, 2013; Stevens *et al.*, 2013) and associated disturbance and displacement effects. However, for some species (particularly seabirds, waders and raptors), long-term population effects have been shown to be more likely (Bevanger *et al.*, 2010; Nygard *et al.*, 2010; Dahl *et al.*, 2012). Conversely, some studies show that there are no detectable population level impacts (Devereaux *et al.*, 2008; Pearce-Higgins *et al.*, 2009a; Fielding and Haworth, 2010; Haworth and Fielding, 2012; Douglas *et al.*, 2011), particularly during the operational phase, although some species may be vulnerable to longer-term effects than others (Pearce-Higgins *et al.*, 2012).

The WINDHARRIER project reviewed wind energy interactions with Hen Harriers, as well as carrying out a series of Hen Harrier/wind energy development research packages in Ireland (Wilson *et al.*, 2015). It examined:

- population trends in relation to wind energy developments;
- the effects of wind energy developments on breeding bird communities;
- interactions with Hen Harrier breeding parameters;
- Hen Harrier flight behaviour in relation to wind energy development;
- Hen Harrier foraging behaviour; as well as
- wind energy development assessment guidance and recommendations for mitigation.

In its review of bird communities in and around wind energy developments, it was found that:

(i) bird densities were lower within 100m of wind turbines compared to control areas, particularly forest bird species;
(ii) differences in bird densities (within 100m) were related to habitat changes caused by wind energy development construction;
(iii) the extent of differences in bird densities depends on the extent of areas affected by changes in habitat during wind energy development construction;
(iv) the species of birds affected by these differences depends on which habitats are modified during wind energy development construction; and
(v) open-country bird species' densities were lower at wind energy development sites.

These may be due to large-scale effects of wind energy developments, landscape differences in habitats, or differences in management practices, but further research is required to determine the cause of these patterns.

The infrastructure associated with wind energy developments may also have additive effects. In particular, the requirement for both access (*i.e.* roads) and a distribution network (*i.e.* overhead power lines, if used) may cause other effects for birds (Drewitt and Langston, 2008; Martin and Shaw, 2010). Wind energy developments may also facilitate recreational access to previously inaccessible areas (Andrews, 1990; Trombulak and Frissel, 2000) via wind energy development roads and tracks, for vehicles such as scramblers or motorbikes, or for other activities such as turf extraction (see Ruddock *et al.*, 2016a).

Displacement may occur where birds avoid areas around wind energy developments; they may also be affected by habitat modifications that consequently decrease their abundance in the area. Stewart *et al.*, (2005) and Whitfield and Madders (2006) indicated that nesting Hen Harriers are one of the least affected bird species with respect to displacement, and have one of the highest rates of avoidance in raptors (Garvin *et al.*, 2011). That is, this species will avoid wind turbines generally and they are considered to be less vulnerable to displacement. Madders and Whitfield (2006) reviewed several studies and found little evidence of large-scale displacement, ultimately suggesting that foraging avoidance mostly extended to approximately 100m, while nest displacement was reported at 200m to 300m. Bright *et al.* (2008a) and McGuinness *et al.* (2015) both considered in their respective sensitivity models that Hen Harriers were sensitive to wind energy developments at 2km.

Displacement of Hen Harrier can occur through displacement from nesting or roosting locations, and/or displacement from foraging areas. The key field study that examined displacement in Hen Harriers (Pearce-Higgins *et al.*, 2009a) found that avoidance extended to 250m from turbines, with reduced flight activity, and that breeding density would be consequently reduced by 52.5% (range -1.2% to 74.2%). This study also found that risk exposure of Hen Harriers was unrelated to flying height and that there was no significant reduction in abundance from wind energy development tracks or transmission lines. Pearce-Higgins *et al.* (2009a) have recognised that the avoidance rates recorded in their study may be highly site-specific. Haworth and Fielding (2012) concluded from a review of UK wind energy developments that harriers are displaced at relatively small scales of between 0-100/200m.

In Scotland, nests have been recorded at one site, Cruach Mhor, where there was an inclusive habitat 'enhancement area', between 131m and 476m (average = 284m) from turbines (SPR, 2009; Robson, 2011). Elsewhere in Scotland, nests have been recorded 110m from turbines, where disturbance exclusion zones were used (Forrest *et al.*, 2011, as cited in *Wilson et al.*, 2015), with a similar density of nesting pairs recorded in pre- and post-construction (2.6 pairs pre-construction phase; 2.4 pairs operational phase; with 4.5 pairs construction phase) (Forrest *et al.*, 2011, as cited in AEC, 2012). Both of these sites also recorded Hen Harriers nesting within a few hundred metres during construction phases. McMillan (2014) reports that, whilst breeding activity was recorded close to turbines in the year of construction (following cessation of construction in March), a nest was located at around 800m away from the wind energy development, although it is not clear if this refers to the same breeding pair (*i.e.* which would indicate displacement). This same study reports nesting Hen Harriers 500m from turbines and less than 200m from access tracks. During wind energy development construction, displacement has been suggested to potentially occur for up to 500m around construction sites, with some disruption up to 1km, depending on the line of visibility (Madders, 2004; Bright *et al.* 2006).

These studies show that individual responses vary (see review in Wilson *et al.*, 2015) but typically extend from 50m to 800m. Several reviews have recommendations for set-back distances. For instance, in their reviews of Hen Harrier disturbance zones, Currie and Elliot (1997), Petty (1998) and Ruddock and Whitfield (2007) suggested buffers of 500–600m, 500–1000m and 500–750m respectively. Such metrics are frequently applied to wind energy development developments (Obermeyer *et al.*, 2011).

Johnson *et al.* (2000) recorded relatively high abundance of Northern Harrier utilising a Before-After-Control-Impact (BACI) study and found that there was a decline in abundance in the first year after construction but that this displacement was different between years. This study also found that avoidance was small-scale, less than 100m from turbines, and may have been related to the associated habitat changes (Madders and Whitfield, 2006; Whitfield and Madders, 2006). Garvin *et al.*, (2011) found from observations of abundance that, for Northern Harriers, there was a temporal lag in observed displacement (*i.e.* later in the operational phase) with 100% avoidance observed, which extended to around 100m from turbines.

Studies in Ireland show that Hen Harriers may relocate their breeding sites at increasing distances from turbines following construction, *e.g.* a 200–300m average increase in distance away from turbines was observed at a site that had been a Hen Harrier territory for more than 20 years (O'Donoghue *et al.*, 2011). That study observed total displacement during the year of construction; after construction, average set-back distance of nests was 501m (range 140m – 760m) from nearest turbines. O'Donoghue *et al.* (2011) also noted that the breeding Hen Harrier territories examined had significantly different breeding success, with 79.2% breeding success in areas where there were no proposed wind energy developments, compared to 16.7% in areas with energy development proposals - this was not directly linked to extant wind energy development sites but may be indicative of (unconfirmed) persecution or accidental disturbance during the early/pre-construction phases of wind energy development.

In a study at Derrybrien (Co. Galway), Madden and Porter (2007) compared pre- and post-construction survey results and found that one pair of Hen Harriers was recorded nesting within 1km of the wind energy development in the two years after construction, although most pairs were located between 1km and 5km away (9 – 10 pairs). The study also showed that Hen Harriers continued foraging near operational turbines and were recorded between 10m and 100m away from turbine bases. They concluded that absolute or total displacement was not evident, at least in the short-term, post-construction.

In certain circumstances, noise disturbance can originate from wind turbines, including mechanical noise derived from turbine components such as the gearbox and generator in the nacelle, as well as aerodynamic noise caused by the rotation of turbine blades. There are few studies of wind energy developments and the impacts of noise (see Ruddock and Reid, 2010). However, since Hen Harriers hunt largely by auditory means (Simmons, 2000), it is conceivable that foraging efficiency and prey detection may be compromised when they are in close proximity to turbines (see Wilson *et al.*, 2015). The width of the zone of influence may vary, depending on how far the noise travels. Noise modelling, which takes the turbine model into account, can be carried out to inform the scale and extent of increases to noise that can be anticipated around operational turbines.

Another study, Madders (2004), (cited in Wilson *et al.*, 2015), reports that some disruption may occur up to 1km from a construction disturbance, along the Hen Harrier's line of sight.

Volunteer surveyors conducted field observations as part of the 2010 National Hen Harrier Survey; subsequently, Ruddock *et al.*, 2012 reported wind energy development-related disturbance as the suspected reason for Hen Harrier breeding failure at five separate locations in Co. Cavan, Co. Kerry, Co. Cork and Co. Limerick. In the 2015 survey (Ruddock *et al*., 2016a), disturbance was examined in greater detail; at the national level, reports of wind energy developments as pressures were relatively infrequently recorded (*i.e.* the 11$^{th}$ most frequently recorded pressure within 500m and 2km of Hen Harrier territories). However, it was the 4$^{th}$ most frequently recorded pressure within four of the six SPAs.

Fieldworkers did not record any wind energy development pressures in the Slieve Blooms or Slieve Beagh SPAs in the most recent (2015) national survey but Ruddock *et al.* (2016) outlined that wind energy developments may have been a causal factor in recent declines in Mullaghanish to Musheramore Mountains SPA and also in West Limerick. Ruddock *et al*. (2016a) recommended that further spatial analyses of wind energy developments and Hen Harriers within the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA complex and the Slieve Aughty Mountains SPA be undertaken, as these sites have a relatively large number of turbines within the SPAs (see Chapter 3).

Comparing data from 36 of the 10km squares with breeding pairs during the 2000 survey revealed a marginally non-significant negative relationship between wind energy development presence and changes in the number of breeding pairs between 2000 and 2010 (Wilson *et al*., 2016). There was a 28% spatial overlap of the 69 10km squares which held breeding Hen Harriers in the 2010 national survey and the presence of wind energy developments (Ruddock

*et al.*, 2012). In areas between 200m and 400m asl, a considerable overlap exists (28% in the 69 10km squares which held breeding pairs in 2010) between Han Harrier breeding distribution and the location of wind energy developments in Ireland (Wilson *et al.*, 2016). This relationship was found to be only weakly significant and linked to the interaction between wind energy developments, Hen Harriers and altitude (200 – 400m) but interactions with other factors (*e.g.* habitat, disturbance, persecution) could not be excluded.

In relation to Hen Harrier breeding parameters, Wilson *et al.* (2015) and Fernández-Bellon *et al.* (2015) conducted a field study as part of the WINDHARRIER project. The field study examined the proximity of turbines in relation to breeding parameters of Irish Hen Harriers, including metrics for:

(i) nest success (the proportion of nests that fledged one or more young);
(ii) fledged brood size (*i.e.* the average number of fledged chicks per successful nest); and
(iii) over-all productivity of breeding pairs (*i.e.* the average number of fledged chicks across all nesting attempts).

There were no statistically significant relationships found between these breeding parameters and nest distance from the nearest wind turbine. However, observed lower nest success within 1 km of wind turbines, compared to the success of all nests more than 1km from wind turbines, was close to statistical significance, *i.e.*

- breeding success was statistically non-significantly lower within 1000m of wind turbines, although sample sizes were relatively small; and
- based on composite considerations of findings, it is possible that lower breeding success recorded within 1000m of wind turbines reflects a biologically relevant pattern.

These findings concur with similar maximum direct disturbance or indirect displacement distances recorded in other field studies (Ruddock and Whitfield 2007; Pearce-Higgins *et al.*, 2009a).

### Cumulative Effects and mitigation

As outlined above, during the various phases of wind energy development, risks may arise to Hen Harrier for a variety of reasons. In addition to individual or population-level effects, there may also be cumulative effects, with the effects arising from any one wind energy developments combining with those arising from others to create a much more significant effect. There have been numerous concerns raised about this in the scientific literature, but few studies have found explicit results or negative associations (Fielding *et al.*, 2006; Telleria, 2009a).

## Effects of wind energy developments on Hen Harriers

The impacts described above could affect both Hen Harrier breeding (nesting and foraging) or wintering (roosting and foraging) habitats. The severity of such impacts may be more pronounced during the breeding season (O'Donoghue *et al.*, 2011), particularly when there are dependent young in a nest, compared with during the non-breeding/winter season, when

individual birds can move away from adverse impacts that arise. Depending on the scale and direction of impacts, if any, there may be wider cumulative or population-level effects arising.

It is a conceivable risk that wind energy development mortality and/or displacement is additive to existing habitat displacement (*e.g.* via forestry related habitat constraints or recreational disturbance) and other mortality factors (*e.g.* illegal killing or disease). The Hen Harrier has also been noted to be at risk of collision mortality during migratory (passage) movements at offshore wind energy developments (Wright *et al.*, 2012; see Katzner *et al.*, 2016).

### Impacts on Hen Harrier Ecology from Wind Energy Development

The impacts as they relate to various aspects of Hen Harrier ecology are set out below.

### Potential impacts on foraging habitat and behaviour

As noted previously, generally, foraging Hen Harriers prefer open habitats. In particular, heath/bog, low intensively farmed grassland and semi-natural open habitats with well-established hedgerows, pre-thicket forest and areas of scrub are the main habitats used by foraging harriers (Irwin *et al.*, 2012; O'Donoghue, 2012). Therefore, loss, change, degradation or fragmentation of these types of habitats as a result of wind energy developments, particularly the preferred habitats, could affect foraging Hen Harriers through direct loss or changes to habitats.

- Wilson *et al.* (2015) completed a strategic vantage point study of Hen Harrier habitat usage at wind energy developments and control sites. This found that Hen Harriers foraged preferentially over peatland and pre-thicket habitats, while avoiding closed canopy and natural and semi-natural open habitats. At wind energy development sites, Hen Harriers preferentially foraged in peatland and also avoided closed canopy forest. Hen Harriers at wind energy developments did not use thicket areas for hunting, but preferentially used areas of natural and semi-natural open habitats. The study highlights the importance of open habitats (rough grassland, natural grasslands, scrub and peatland) for foraging Hen Harriers in Ireland.
- Further GPS tracking of a single female (Wilson *et al.*, 2015) found that habitat selection in relation to wind energy developments indicates that natural and semi-natural open habitats, peatland and clear fell were flown over more frequently than expected, and improved grassland was used less frequently than expected.

Direct foraging habitat losses could result from the footprint of development but also if wider habitat alteration is undertaken (Wilson *et al.*, 2015; SNH, 2016). Further to this, indirect effects could occur whereby prey species are affected (*e.g.* reduced density of prey species near wind energy developments (Pearce-Higgins *et al.*, 2009a; Wilson *et al.*, 2015; Fernández-Bellon *et al.,* 2019)) or during key periods of activity, such as construction (Pearce-Higgins *et al.*, 2012), which may have consequential effects on harrier foraging efficiency and subsequent breeding success and/or productivity. However, contrary to potential negative impacts, the reduced suitability of wind energy development areas may lead to avoidance and therefore, a reduced collision risk (SNH, 2016).

Previous research has indicated that avoidance of wind energy developments by breeding Hen Harriers may occur within 1km of turbines (Pearce-Higgins *et al.*, 2009a) and that foraging behaviour of breeding pairs can be influenced by habitat changes at distances up to 3km from the nest (Amar *et al.*, 2004, Arroyo *et al.*, 2009). Based on an analysis of foraging spatial data derived from the remote tracking of three individuals from one study site (the Ballyhouras), Irwin *et al.* (2012) noted that the maximum distance travelled from the nest was 7.5km (female) and 11.4km (male). These are significantly further than the estimates for Scottish breeding birds (2.5km (female) and 9km (male)) (Arroyo *et al.*, 2009; Arroyo *et al.*, 2014). This may be because Irish Hen Harriers breeding in forested landscapes have to forage over larger areas in order to provision broods (at least, in the Ballyhouras) or it may be a reflection of the relatively lower potential prey availability in Ireland (O'Donoghue, 2010; Ruddock *et al.*, 2012; Wilson *et al.*, 2015). These larger potential foraging ranges of Hen Harriers in Ireland mean that the potential for wind energy development-induced habitat management or changes may impact Hen Harriers at a relatively greater range (distance) than is predicted elsewhere.

### Potential impacts at the nest site

A disturbance event that causes the incubating female to flee the nest or that deters the return of provisioning parents can expose eggs and chicks to cold, rain or lack of food (Hamerstrom, 1969; Scharf and Balfour, 1971; Picozzi, 1980). Mammalian predators may be attracted to nests by visual cues such as the presence of humans, trampling of vegetation, increasing activity of parent birds in response to disturbance events, as well as by olfactory cues (Whelan *et al.*, 1994; Skagen *et al.*, 1999).

### Potential impacts at winter roost sites

As already mentioned, birds frequent roost sites outside the breeding season (broadly defined as mid-August to mid-March), probably for shelter and protection (O'Donoghue, 2010). Roosts function as foci from which the Hen Harriers radiate out and forage in the local landscape (O'Donoghue, 2010). Currently, two SPAs are listed for non-breeding Hen Harrier and, based on the published data available, the majority of the known wintering roost sites occur outside of the SPA Network (Figure 3).

The main threats and pressures on Hen Harriers at winter roost sites have been identified to be predominantly agricultural reclamation (roost loss and associated habitat loss); timing of cultivation practices such as ploughing and spraying (reduction in prey availability and disturbance); renewable wind energy development (displacement and direct disturbance); and human disturbance (NPWS, 2013). Forestry-related activities may potentially cause disturbance events at a small number of known roosts (NPWS, 2015a).

Where there is a requirement to avoid disturbance to breeding birds, the construction activity is more likely to be undertaken during the wintering season. This temporal consideration may thus have a greater potential impact on winter roosts rather than nests. In those breeding sites, and indeed outside of breeding sites, where suitable winter roost habitats also occur, it is important that impacts are mitigated to also avoid disturbance and prevent loss of winter roost sites.

## Potential impacts on winter foraging habitat

Wilson *et al.* (2015) focused on the breeding season and there are no documented studies of Hen Harrier foraging behaviour in the non-breeding seasons. It is conceivable that, where wind turbines occur in foraging habitats used by Hen Harriers during the non-breeding period, these may influence their use by the bird. Similarly, loss or changes to habitats that hold abundant food supplies for prey species may affect Hen Harrier foraging efficiency, as has been noted for breeding season foraging habitats. That is, since passerine bird species, particularly thrush species, have been identified to be a frequently-recorded prey-item in the winter diet of Hen Harriers (see O'Donoghue, 2004; 2010), habitats with high abundance of such prey species will be a valuable resource to the birds and they may be impacted by any associated changes.

O'Donoghue (2010), however, found that Hen Harrier diet varied geographically, with more wading birds and small mammals recorded in the diet of birds associated with the lowlands of southern and eastern areas; therefore, diet could be affected in the wider countryside in different ways. There is little detailed information available on the types of habitats utilised by Hen Harriers for foraging over the winter season, but the species is generally more widespread then and thus, may be vulnerable to disturbance over a wider area during the winter. This vulnerability may be increased if construction takes place during the winter, but also in the long-term, they may be vulnerable to indirect displacement due to their avoidance of wind energy development sites in the wider countryside.

## Mitigating the Effects from Wind Energy Developments

Mitigation measures to reduce direct mortality to birds from wind energy developments have included various methods including:

- temporal cessation of turbines during high risk periods (de Lucas *et al.*, 2012; Smallwood, 2013; European Commission, 2020b),
- removal of specific turbines (Martinez Abrain *et al.*, 2013; Smallwood, 2013),
- changing turbine design and spacing (European Commission, 2020b) and
- repowering to reduce overall number of turbines and risk (Smallwood, 2013; Warren and Birnie, 2009).

Mitigation to reduce the effects of disturbance to bird species have been suggested, though with varying levels of supporting evidence. They include:

- restricting construction during the breeding season (Pearce-Higgins *et al.*, 2012; European Commission, 2020b),
- erection of physical screens during the construction phase (Pearce-Higgins *et al.*, 2012);
- use of alternative construction methods (European Commission, 2020b).

The creation of habitat to offset Hen Harrier habitat loss has been determined not to be mitigation (in the meaning of a Habitats Directive Article 6(3) assessment), but is rather a measure to be assessed pursuant to Article 6(4) (*i.e.* compensation) (Supreme Court, 2016; ECJ, 2018).

There are a number of identified research priorities (Wang and Wang, 2015) that, if fulfilled, would enable a better understanding of the sector and its interactions with birds, in light of developing technologies, equipment and particularly, with regard to repowering operations in the future (Hotker, 2006; Smallwood and Karas, 2008; Warren and Birnie, 2009; SNH, 2014; Northrup and Wittemayer, 2016).

# CHAPTER 3: POTENTIAL POPULATION LEVEL IMPACTS OF WIND ENERGY-RELATED ACTIVITIES ON THE HEN HARRIER IN IRELAND

## Introduction

This chapter builds on the description of the overlaps and potential interactions between wind energy developments, their associated management and the ecology of Hen Harrier. This examination of the potential population level impacts on Hen Harrier by the wind energy sector in Ireland is framed by first quantifying the spatial and temporal extent of these interactions.

This review obtained a database from SEAI of individual turbines from 1992 to (June) 2016 for analysis. SEAI have been systematically obtaining details of individual wind turbines (>100kW) from planning files and ortho-photography sources across Ireland for a number of years (J. McCann, pers. comm.). The database captures information on individual turbines and includes site name, spatial co-ordinates (easting/northing), power output (MW), hub height (m), rotor diameter (m), county and connection reference number.

As part of this review, the SEAI database was standardised, and spatially checked and verified against ortho-photographs. The connection year and month were derived from separate publicly available databases (Eirgrid's TSO & ESB respectively) using the unique connection reference numbers. A number of spatial anomalies were rectified and a number of additional turbines were digitised from the ortho-photographs. Altitudes (metres above sea level) were calculated for each individual turbine from a digital elevation model (ASTER) of Ireland. This resource is now known and referred to as the Review Turbine Database 2016 or RTD (NPWS, unpublished) throughout this report.

## Potential interactions of wind energy and Irish Hen Harrier breeding populations

As previously discussed, where there is a contiguous spatial overlap between wind energy developments and Hen Harrier breeding habitats, there may be both a direct loss of habitat (Madders and Whitfield, 2006) and a displacement effect (Pearce-Higgins *et al.*, 2009a; Pearce-Higgins *et al*., 2012) which may occur spatially at the small (wind energy development) scale and within a wider associated zone of influence (Madders and Whitfield, 2006; Pearce-Higgins *et al.*, 2009a; O'Donoghue *et al.*, 2011; Fernández-Bellon *et al.*, 2015; Wilson *et al.*, 2015).

Similarly, Hen Harriers are known to be affected by direct collision mortality (Lekuona and Ursúa, 2007; Scott and McHaffie, 2008; RSPB, 2012; this study). All of these impacts may have consequences for individual birds but they also, depending on the number of collisions, may have wider population level effects. It is conceivable too that the occurrence of wind turbines may affect breeding parameters such as:

- abundance (Usgaard *et al*., 1997; Pearce-Higgins *et al.*, 2009a);
- density close to turbines <500m (Pearce-Higgins *et al.*, 2009a);
- breeding success (Fernández-Bellon, 2015);
- brood sizes; and/or
- productivity (O'Donoghue *et al.*, 2011; Hatchet *et al.*, 2013; Bennett *et al.*, 2014); and
- mortality (Carrete *et al.*, 2009).

### *Co-occurrence of wind turbines and breeding Hen Harriers*

Wilson *et al.* (2015; 2016) quantified the spatial overlap with wind energy developments (up to and including 2012) at 10km resolution, using WEI data on wind energy developments, and Hen Harrier data from the 2000 and 2010 breeding surveys (Norriss *et al.*, 2002 and Ruddock *et al.*, 2012 respectively). This study found that there was a 28% overlap (n = 19 of 69 squares) at the 10km resolution, based on 2010 breeding data (Ruddock *et al.*, 2012); there are similar metrics recorded for elevation data of breeding Hen Harriers and wind energy developments, with the majority of wind turbines (67%) and Hen Harriers (62%) occurring at 200m to 400m asl.

These studies indicated that there was a weak negative relationship between wind energy development presence and Hen Harrier breeding populations between 2000 and 2010, with an approximate average loss of one pair in squares with turbines, compared to squares without turbines. This was more strongly observed at 200m to 400m elevations. There were no observed relationships in that study between the number of turbines built and population changes (Wilson *et al.*, 2015). The WINDHARRIER study also indicated that other factors (*e.g.* forest habitat changes) may also be interacting with the observed pattern of Hen Harrier declines and that further research was required.

Wilson *et al.* (2015; 2016) analysed data at a 10km resolution, including for altitudinal data and interpretation of ortho-photography for analysis of change between surveys. The RTD (NPWS, unpublished) now enables a more fine-scale resolution for this review so that spatial interactions with Hen Harriers and wind turbines can be further examined.

As explained earlier in the report, the analysis reported on here was undertaken in 2017, based on available wind turbine data (up to June 2016). The timing of this analysis was designed to allow contemporaneous analysis with the results of the 2015 National Hen Harrier Survey (Ruddock *et al.*, 2016). Due to the Covid-19 pandemic, the anticipated 2020 National Hen Harrier Survey was not undertaken and so, turbine data presented here has not been updated, as there is no corresponding update of Hen Harrier data. As of 2016, there were 1,502 turbines recorded in the database as having been connected since 1992 (*i.e.* 1992-2016) (Figure 6). Those turbines connected in 2016 (n = 25) were not excluded since these were commissioned in 2015 and were considered to have been present at the time of the 2015 Hen Harrier survey. Turbines in the database (*i.e.* from that time period 1992-2016) range in size from 0.05MW to 3MW, with the majority of turbines in Ireland being 0.85MW (22.1%) and 2.3MW (15.3%) machines. Hub heights ranged from 25m to 100m and blade diameters from 15m to 117m (NPWS, unpublished). Generally, the lower rotor-swept areas ranged from 19 to 50m above ground level (with a small number of "outlier" turbines with a lower rotor-swept height of just 10m), whilst the rotor swept heights ranged from 25 to 156m above ground level (NPWS, unpublished). More recent information is available from IWEA's online data viewer.

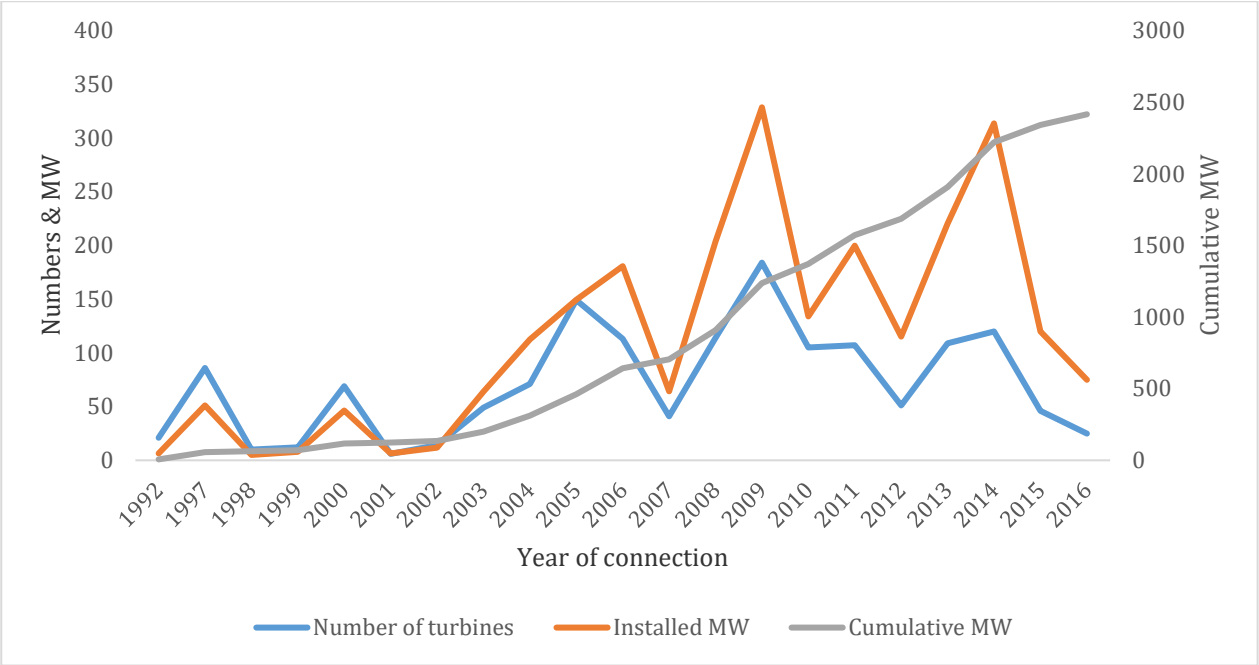



**Figure 6. Numbers of turbines installed and power output 1992 - 2016**

These 1,502 turbines were recorded in 120 10km squares across Ireland, which equates to 13.8% of the 869 10km squares that cover the national land territory. Between one and 75 turbines have been installed per 10km square, ranging in cumulative power from 0.16MW to 111.8MW per 10km square. Turbines in Ireland were recorded at altitudes ranging from 2.9m asl and 510m asl (average 253m ± 108.7m). Turbines were most frequently located in the 300 – 350m and 200 – 250m ranges (Figure 7).

Confirmed 2010 breeding Hen Harriers territories (see Ruddock *et al.*, 2016a for definitions) were located between 71m and 452m asl (average 243.8m ± 88.5m) and were most frequently located between 150m and 300m *i.e.* 22% were located between 150 and 200m, 19% between 200 and 250m, and 20% between 250 and 300m (Figure 7). 81.9% of turbines were located in the 100 – 400m range whilst 92.6% Hen Harriers were located in the same range. 66.7% of turbines and 59.3% of Hen Harriers occurred between 200 – 400m. Earlier survey data (Table 1) found a similar range of altitudes for confirmed pairs during 1998-2004 (range 72 – 495m, average 257.1m); 2005 (range 87 – 401m, average 227.9m) and 2010 (61 – 423m, average 239.6m).

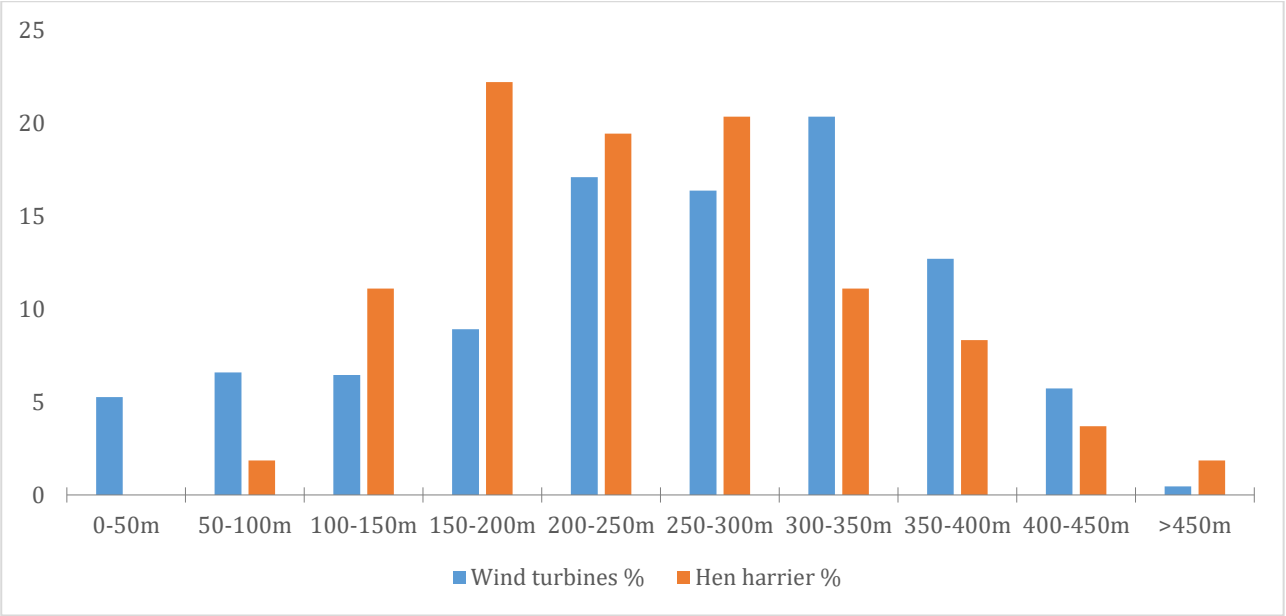



**Figure 7. The elevation (m asl) of both wind turbines and % (y axis) of confirmed breeding Hen Harriers territories in Ireland, 2015.**

From the 2015 Hen Harrier survey data, turbines were recorded in 21.6% of the 10km squares surveyed (n = 58 of 269 squares); and turbines were present in 32.5% (n = 27) of the 10km squares with either confirmed or possible breeding territories (n = 83) (Figure 8). Most turbines (n = 420) were recorded in the 10km squares that had *confirmed* breeding Hen Harriers (Table 1 and Figure 9).

**Table 1. Hen Harrier 10km survey squares in 2015 and their spatial overlap with wind turbines.**

| Details from 2015 survey (Ruddock *et al.* 2016a) | Confirmed breeding | Possible breeding | Seen | Not seen/Vacant |
|---|---|---|---|---|
| Number of survey squares | 61 | 22 | 55 | 130 |
| Number of squares with turbines | 22 | 5 | 13 | 18 |
| Percentage of squares with turbines | 36.1 | 22.7 | 23.6 | 13.8 |
| Total number of turbines | 420 | 100 | 150 | 196 |

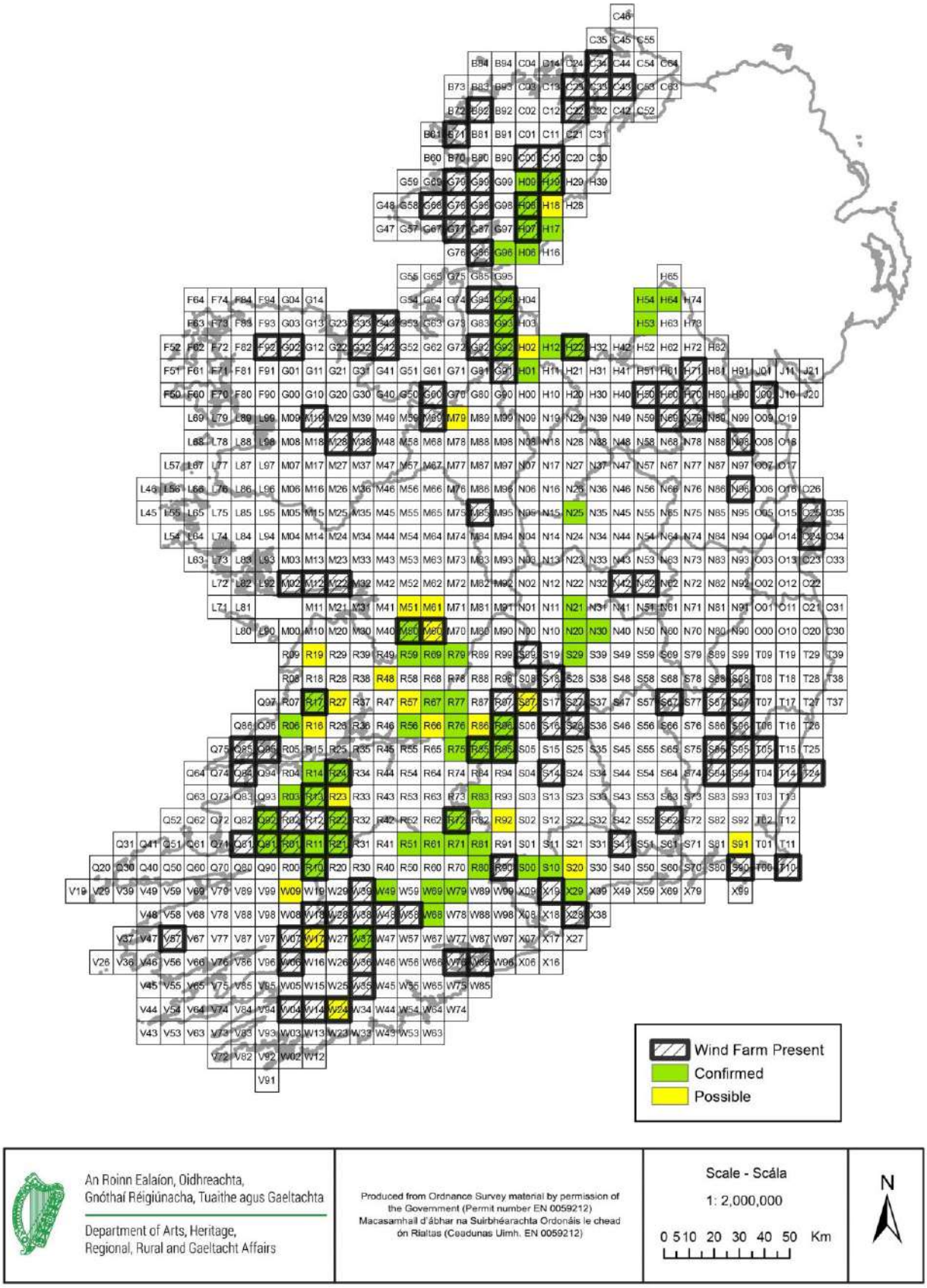



**Figure 8. The distribution of wind turbines from 1992 – 2016 and Hen Harrier confirmed and possible breeding 10km distribution in 2015 (Ruddock *et al.*, 2016a).**

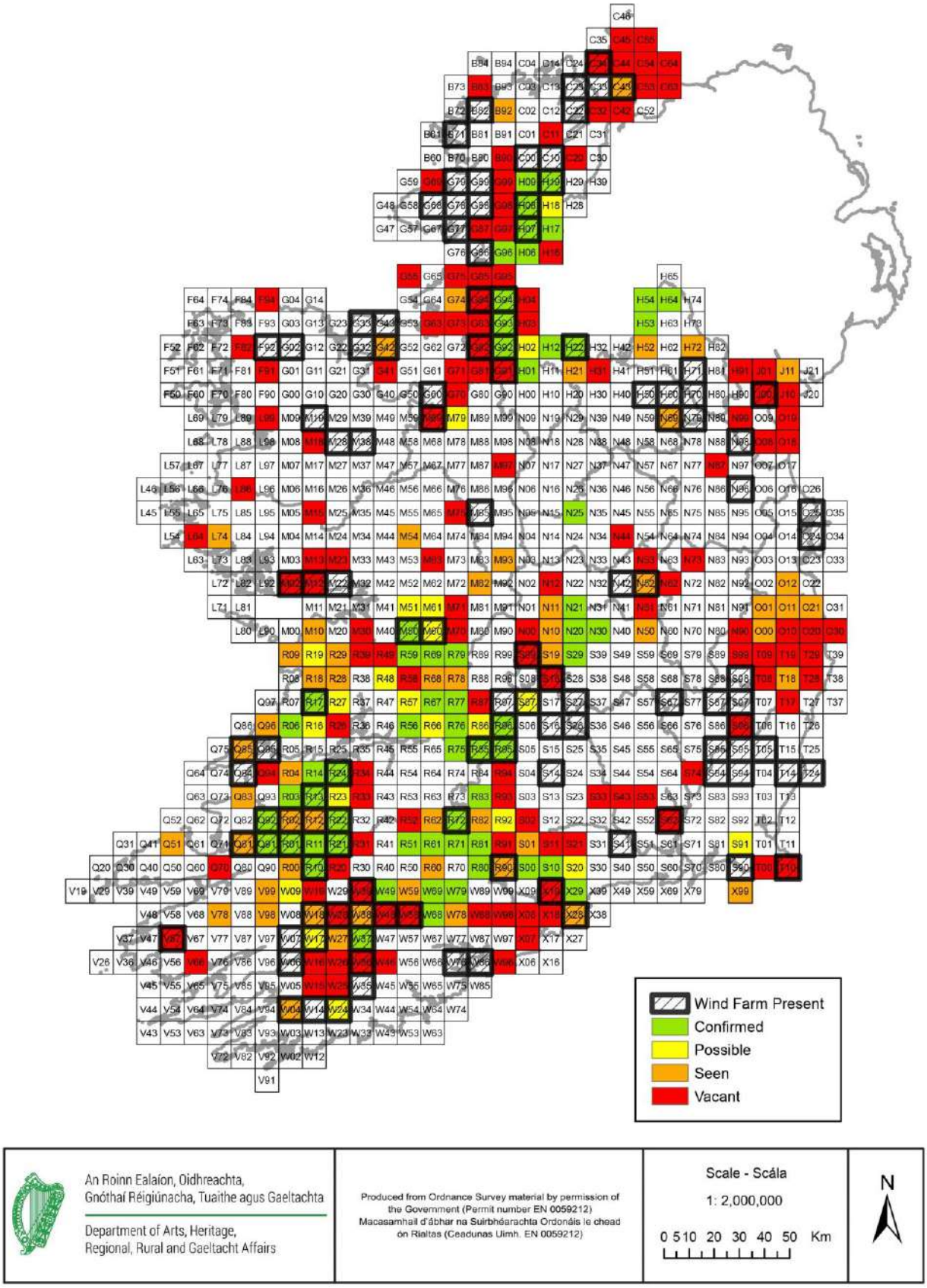



**Figure 9. The distribution of wind turbines from 1992 – 2016 and Hen Harrier Confirmed, Possible, Seen and Vacant 10km breeding distribution in 2015 (Ruddock *et al.*, 2016a).**

Since the first national survey, the proportion of spatial overlap with wind energy development has increased, particularly within the confirmed Hen Harrier breeding range (Table 2).

**Table 2. The results of breeding 10km survey squares in 1998-2000, 2005 & 2010 and spatial overlap with wind turbines.**

| | 1998 - 2000 | | 2005 | | 2010 | |
|---|---|---|---|---|---|---|
| Details from national survey | Confirmed | Possible | Confirmed | Possible | Confirmed | Possible |
| Number of squares | 42 | 17 | 60 | 6 | 62 | 7 |
| Number of squares with turbines | 3 | 1 | 11 | 2 | 18 | 0 |
| Percentage of squares with turbines | 7.1 | 5.9 | 18.3 | 33.3 | 29.0 | 0 |
| Total number of turbines | 54 | 10 | 168 | 29 | 313 | 0 |

### *Displacement of Hen Harriers and wind energy in Ireland*

Using details of all turbines (up to and including 2016) and historical Hen Harrier databases (1998 – 2004; 2005; 2010 and 2015), there is a decreasing number of confirmed and possible Hen Harrier territories located within 500m and 1km of turbines over time (Figures 10 and 11). This may be suggestive of some small-scale avoidance by Hen Harriers close to turbines (up to 500m as described in Pearce-Higgins *et al.*, 2009a; up to 1km from turbines as described in Fernández-Bellon *et al.*, 2015). As detailed earlier in Chapter 2, this may be an artefact of the decreasing Hen Harrier population as well as being compounded by other factors not examined in this desk-review *e.g.* habitat composition or changes (see Wilson *et al.*, 2015; 2016). However, it may also indicate genuine avoidance behaviour of Hen Harriers with respect to wind turbines in Ireland (as in other harrier species – see Schaub *et al.,* 2020) and warrants further statistical examination, alongside other potential compounding factors.

This analysis of turbine distances also indicates that turbines have been built within 1km of at least 50 historically confirmed or possible breeding territories since 1998. Over time, the distance from turbines to confirmed breeding sites has decreased (Figure 12; Table 3). The average distances in 2015 were 10.7km to 9.3km for confirmed and possible pairs respectively (Table 3) which may concur with the possible displacement of 5km to 10km (Figure 10 and 11). Whilst some pairs of Hen Harriers will nest close to turbines (see minimum distances in Table 3), these locations almost exclusively occur within the Stack's SPA which has a relatively high number of turbines.

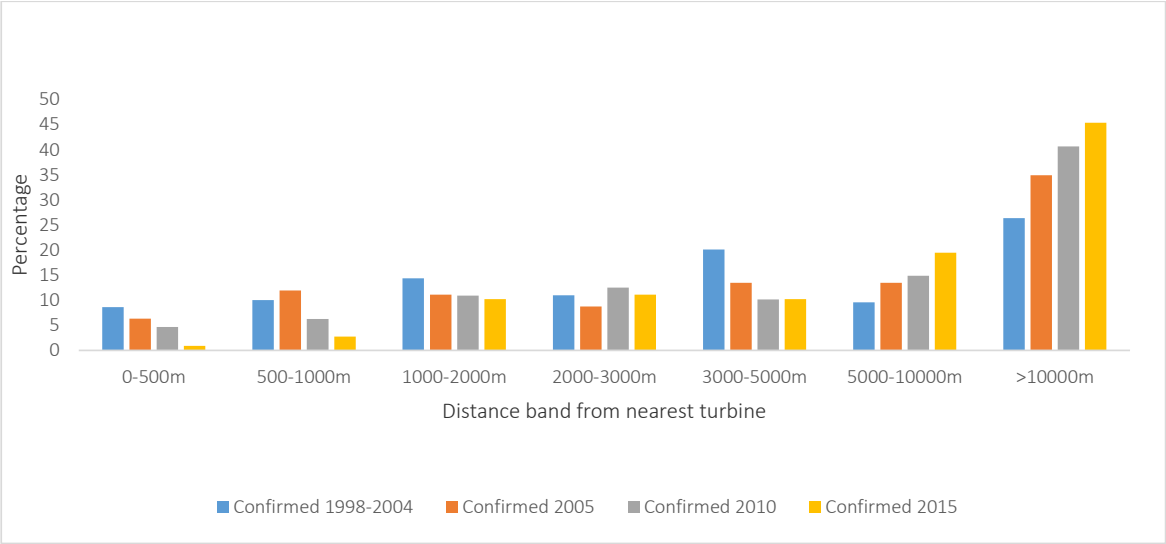



**Figure 10. The percentage of confirmed breeding Hen Harrier territories occurring per distance band from nearest turbine (from national surveys 1998-2004, 2005, 2010 and 2015).**

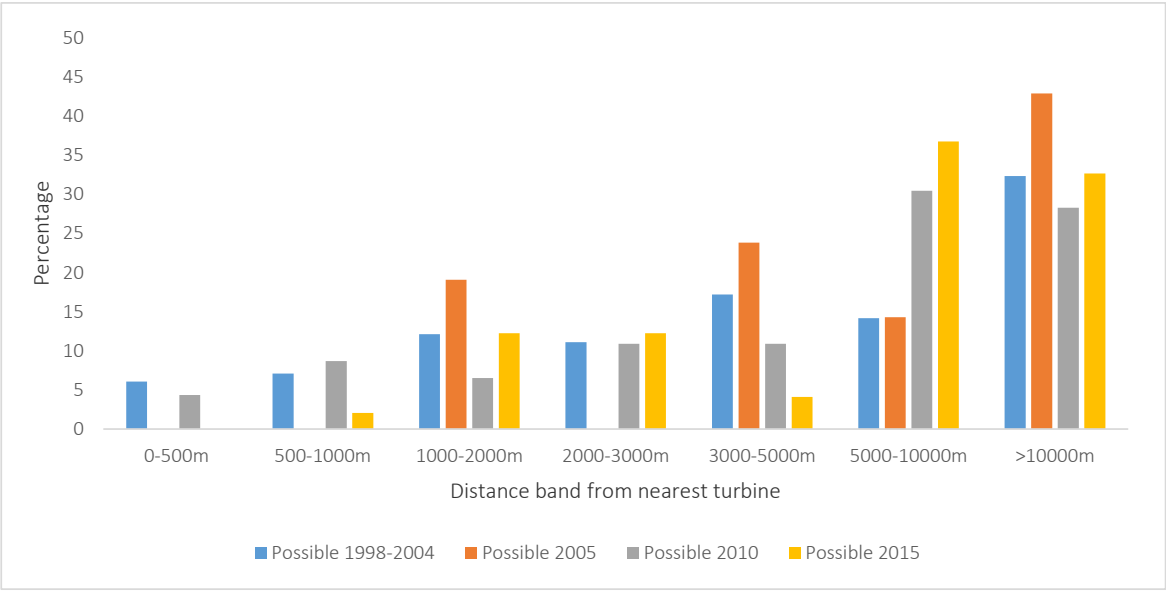



**Figure 11. The percentage of possible breeding Hen Harrier nests occurring per distance band from nearest turbine (from national surveys 1998-2004, 2005, 2010 and 2015).**

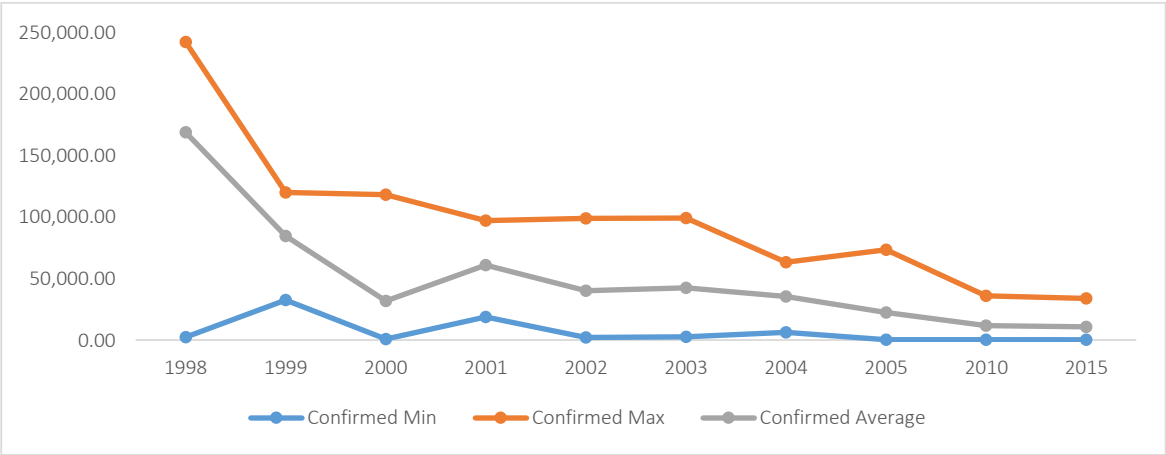



**Figure 12. Turbine distance (m; y-axis) from confirmed breeding Hen Harrier territories in national survey years 1998 – 2015.**

**Table 3. Turbine distances from locations of breeding Hen Harriers in national survey years, based on all turbine data, up to and including 2015.**

| | Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Confirmed** | 39 | 48 | 26 | 11 | 31 | 29 | 25 | 132 | 128 | 108 |
| | **Possible** | 16 | 17 | 12 | 6 | 13 | 24 | 11 | 21 | 46 | 49 |
| | **Total** | 55 | 65 | 38 | 17 | 44 | 53 | 36 | 153 | 174 | 157 |
| | | | | | | | | | | | |
| Confirmed | **Min** | 2,400.4 | 32447.6 | 770.9 | 18,744.1 | 1,972.4 | 2628.8 | 6128.8 | 252.4 | 300.6 | 231.0 |
| | **Max** | 241,924.6 | 119,825.2 | 117,910.6 | 97,073.0 | 98,734.8 | 98,997.3 | 63,057.6 | 73,400.9 | 35,897.3 | 33,786.9 |
| | **Average** | 168,557.9 | 84,427.8 | 31,746.7 | 60,782.4 | 39,954.7 | 42,365.5 | 35,391.1 | 22,308.7 | 11,705.2 | 10,714.0 |
| | **<1km** | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 17 | 41 | 16 |
| | **1-2km** | 0 | 0 | 33 | 0 | 1 | 0 | 0 | 98 | 195 | 90 |
| | **2-3km** | 8 | 0 | 62 | 0 | 16 | 16 | 0 | 202 | 426 | 257 |
| | **3-5km** | 25 | 0 | 100 | 0 | 25 | 36 | 0 | 654 | 943 | 732 |
| | **>5km** | 25 | 0 | 203 | 0 | 63 | 116 | 1 | 1781 | 2025 | 2116 |
| | **Altitude min** | 22 | 22 | 97 | 34 | 123 | 76 | 161 | 87 | 61 | 71.2 |
| | **Altitude max** | 495 | 495 | 361 | 432 | 418 | 422 | 388 | 401 | 423 | 452.4 |
| | **Altitude ave** | 274.3 | 275.1 | 242 | 232.2 | 249.5 | 221.4 | 272.7 | 238.8 | 239.6 | 243.8 |
| | | | | | | | | | | | |
| Possible | **Min** | 118,239.30 | 57,969.30 | 22,152.7 | 31,813.3 | 20,630.7 | 6,579.2 | 2,536.3 | 1,972.4 | 316.4 | 959.8 |
| | **Max** | 240,584.3 | 118,502.8 | 70,465.8 | 88,771.3 | 100,994.0 | 99,995.7 | 56,794.9 | 50,343.3 | 32,257.6 | 33,231.2 |
| | **Average** | 189,895.4 | 80,999.9 | 51,864.8 | 59,735.4 | 62,744.6 | 35,857.2 | 25,134.8 | 25,709.3 | 9,410.2 | 9,330.6 |
| | **<1km** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1 |
| | **1-2km** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 39 | 43 |
| | **2-3km** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 | 65 | 141 |
| | **3-5km** | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 66 | 205 | 358 |
| | **>5km** | 0 | 0 | 0 | 0 | 0 | 62 | 3 | 127 | 1129 | 1094 |
| | **Altitude min** | 229.2 | 99 | 35 | 133 | 76 | 13 | 185 | 69 | 49 | 67.5 |
| | **Altitude max** | 13 | 378 | 287 | 374 | 360 | 392 | 422 | 471 | 431 | 488.3 |
| | **Altitude ave** | 409 | 235 | 189 | 213 | 252.9 | 203 | 309.5 | 259.2 | 234.1 | 252.9 |

### *Pressure records in Hen Harrier breeding areas from wind energy in Ireland*

Fieldworkers for the 2015 national survey were requested to record the threats or pressures observed, if any, within 500m and within 2km of the survey area in order to facilitate a strategic assessment of these metrics at the regional and national levels, using the EU's Birds Directive Article 12 pressures and threats (further details in Ruddock *et al*., 2016a). "Pressures" are current, while and "threats" are in the future, and include the collection of information on wind energy production (see European Environment Agency (2018) for more information on pressure codes) (Figure 13).

At the time of the survey, wind energy developments were present in 120 10km squares across Ireland, while wind energy development pressures were recorded in 33 10km squares, of which only 63.6% are noted to actually contain wind turbines (Figure 13). Therefore, it appears that fieldworkers were either aware of impending wind turbines, perhaps from wind energy road development, and/or that they considered the pressure arose from turbines they could observe within adjacent squares (and within 2lkm of the survey area as per the methodology), and reported accordingly. There were also power line (D3) pressures recorded at 26 squares, 57.7% (n = 15) of which also had wind energy development (C3) pressures recorded, and 38.5% (n = 10) of which had wind turbines present. This indicates that power lines occur more widely than wind energy developments, but also that they may not be located in and/or around existing wind turbines, as underground cables may be used by wind energy developments instead, and, in fact, the power lines may not be related to the wind energy development at all.

### *Breeding population changes and wind energy in Ireland*

Ruddock *et al.* (2012; 2016a) suggested that wind turbines and associated mortality and displacement warranted further investigation. As noted above, Ruddock *et al*. (2016a) also reported that, in some areas, Hen Harriers were perceived by surveyors to be under pressure from wind energy developments. Based on data derived from the 2000 and 2010 national surveys, Wilson *et al.* (2015; 2016) found evidence that population decline may be associated with the presence of wind turbines. However, that study found that there were also interactions evident with both altitude and habitat changes and wind energy developments. The mechanism for this decline is not clearly defined and could relate to either direct or indirect disturbance sources that result in displacement of territorial birds during the breeding season. The relationship between wind turbines and Hen Harriers may therefore be a complex one, and minimization of spatial conflict in order to reduce the likelihood of effects would be desirable (see Chapter 4).

The number of turbines in those squares in which Hen Harrier declines (1 to 6 pairs) had been recorded between 2010 and 2015 increased by 131 (281 turbines to 412; 46.6%). Conversely, for squares where population increases were recorded (+1 to +3 pairs), turbines increased by 51 (109 to 160; 46.8%). This indicates that the proportional increase of turbines may not affect rates of population change, since both percentage increases in turbines were similar. Rather, the density of existing and installed turbines may be driving the change. However, it is recognised that other factors may also be interacting (such as forestry and agricultural activities) and they are not analysed further here (see NPWS reports on Hen Harrier and these sectors- NPWS, 2015a and 2015b).

Similarly, between 2005 and 2010, in those squares where Hen Harrier numbers declined (by 1 to 4 pairs), turbine numbers increased from 109 to 194 (70.2% increase), whereas for squares in which Hen Harriers increased (by 1 to 6 pairs), there was an increase of 56 to 119 turbines (112% increase). This further indicates that the rate of turbine increase may not be driving population change since there was a higher proportional increase in turbines in squares where Hen Harriers increased. It is therefore conceivable that a turbine density threshold may be a driver of population change.

### *Breeding parameters and wind energy in Ireland*

Fernández-Bellon *et al.*'s (2015) analysis showed no significant differences between the breeding outputs of Hen Harrier nests that were located at different distances from wind turbines. However, non-statistically-significant lower nest success rates and productivity were observed within 1km of active wind turbines. Thus, there may be a negative effect on nest success extending to approximately 1km (see also Wilson *et al.*, 2015).

Monitoring carried out between 2008 and 2010 revealed a breeding success rate of 79.2% for Hen Harriers in territories where no wind energy developments were planned (n=53), compared with a success rate of just 16.7% in territories where wind energy developments were planned (n=18) (O'Donoghue *et al*., 2011). The outcome of this research suggests that harriers associated with wind energy development proposal areas have a significantly higher failure rate than harriers nesting elsewhere. Productivity may also be reduced, as shown by O'Donoghue *et al.* (2011), at a single Hen Harrier territory when comparisons are made between pre- and post-construction periods (average of 2.63 young reduced to 1.27 young) over a 22 year period.

Breeding outcome (nest success or failure) may be impacted by the occurrence of turbines, as indicated by Fernández-Bellon *et al.* (2015), although the mechanisms for this are not clear. Empirical data from the RTD (NPWS, unpublished) and outcomes of breeding records from national surveys in 2005, 2010 and 2015 indicate that successful nests were up to 20% (average 12.9%; range 0.3 – 20.1%) further away from turbines than failed nests (Table 4). This also indicates that only a small number of either failed or successful nests are located within 1km of a turbine in each survey year (Table 4), which means that effects, if any, are either occurring at greater distances or, perhaps, are unrelated to turbines in the landscape. It is notable perhaps that nearly 14% of failures in 2010 surveys were within 1km of turbines (average 5.9%; range 0 – 13.6%) (Table 4).

**Table 4. Turbine distance from breeding Hen Harrier locations in recent national survey years, based on all turbine data up to and including 2015 and breeding outcomes**

| | Survey year | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| **Successful pairs** | **Average distance (metres)** | 23,551.50 | 13,432.60 | 11,054.20 |
| | **Number of records** | 56 | 50 | 49 |
| | **Number within 1km** | 2 (3.6%) | 3 (6.0%) | 1 (2.1%) |
| **Failed pairs** | **Average distance (m)** | 18,790.10 | 10,990.90 | 11,019.10 |
| | **Number of records** | 6 | 44 | 48 |
| | **Number within 1km** | 0 (0%) | 6 (13.6%) | 2 (4.2%) |
| | **Proportional difference in distance between successful and failed pairs** | 20.1% | 18.2% | 0.3% |

Note: Survey data in 1998-2000 was extracted on a year-by-year basis as examination of trends with multi-year data is confounded by the repeated sampling of same locations in different years.

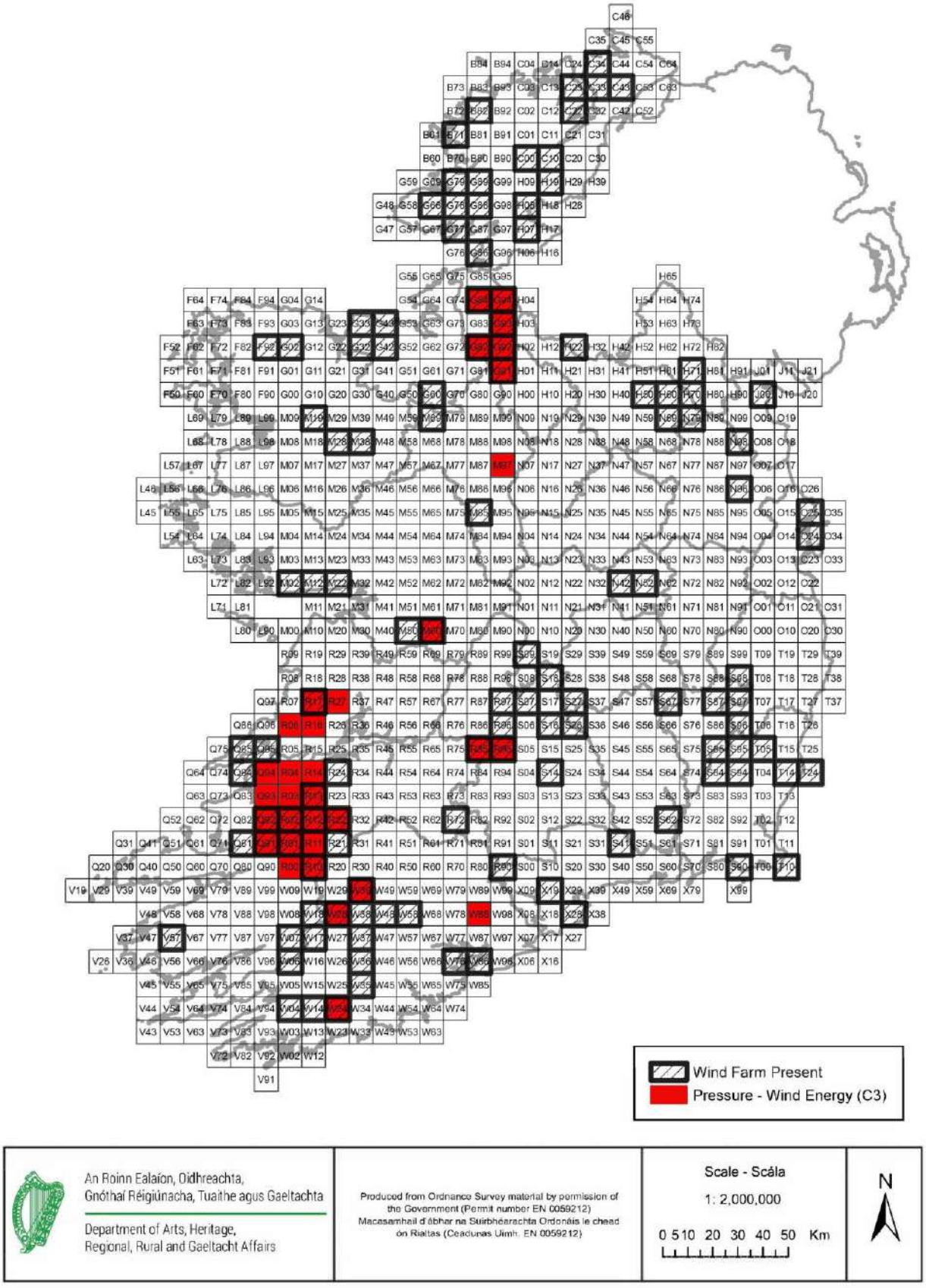



**Figure 13. The presence of wind turbines (as derived from the RTD (NPWS, unpublished) and wind energy development pressure (C3, in accordance with Birds Directive Article 12 reporting) as recorded by surveyors (Ruddock *et al.*, 2016a)).**

### *Collision risk and wind energy in Ireland*

A small number of suspected Hen Harrier collisions have been documented in Ireland, (see Chapter 2) although it is also recognised that relatively few wind energy developments in Ireland have formal carcass-searching protocols (Fennelly, 2015). Therefore, collision incidences may well be under-recorded. Several studies elsewhere indicate that harrier species mortality at wind energy developments is relatively low (Smallwood and Thelander, 2004; Madders and Whitfield, 2006; Derby *et al.*, 2008) and not typically linked to bird abundance (Johnson *et al.*, 2000; Stewart *et al.*, 2005; Madders and Whitfield, 2006; Mabey and Paul, 2007), although Wilson *et al.* (2015) suggest that collision risk may be affected by proximity to nest sites. The spatial distribution of wind energy developments has a larger influence on the estimated number of collisions compared with the design of turbines, and therefore precluding wind energy developments from core breeding areas remains the most important mitigation measure (Schaub *et al.*, 2020). The cumulative effect of the existing turbine network as well as potential future wind energy development in Ireland (SEAI, 2011) may lead to an increasing collision risk over coming years; this will be influenced by a range of factors including the level, nature and effects of repowering, and the scale of ambition for the expansion of the sector

Wilson *et al.* (2015) used observed Hen Harrier flight data to calculate an arbitrary 'typical' collision risk and estimated mortality for the 'average' wind turbine in Ireland with a rotor swept range of 25m (floor height) to 125m (ceiling height). The average breeding season collision estimate of Wilson *et al.* (2015) was between 0.778 and 2.477 birds over a 25 year wind energy development lifespan. It is not currently possible to draw a more robust generic conclusion for a national collision estimate using estimates of the number of wind energy developments or numbers of turbines since it is recognised that:

(i) not all turbines occur in Hen Harrier areas which may lead to an over-estimation of collision; but also

(ii) no estimates are available for the non-breeding season which may under-estimate mortality; and

(iii) collision risk can be highly site-specific and may be related to proximity of nest sites (Wilson *et al.*, 2015). There are 520 turbines (34.6% of 1,502 turbines) within the 2015 Hen Harrier breeding range and therefore, this would reduce overall estimated collision during the breeding season.

Wilson *et al.* (2015) reported Hen Harrier observations were below rotor height (25m) 83% of the time but within rotor-swept areas (25m – 125m) for 11.8% and above rotor height (>125m) for 5.4% of the time. Based on RTD (NPWS, unpublished), there were no recorded turbines of 25m floor and 125m ceiling height, and average floor height was 29.7m and ceiling 96.3m. 0.6% of turbines (n = 10) have a 25m rotor floor and 7.2% of turbines (n = 109) have a 125m ceiling height. Therefore, the rotor-swept area of Wilson *et al.* (2015) is larger than actual average rotor-swept areas and may be overly precautionary, although rotor swept areas generally ranged from 19m to 156m. Estimates of cumulative mortality in Ireland, based on the height bands of Wilson *et al.* (2015), may require re-analysis on the basis of observed flying heights from that study, actual turbine metrics now available (NPWS, unpublished; this study; and

installations since 2016) and preferably, the inclusion of site-specific collision estimates (see Chapter 4).

A composite review of all available data may facilitate further analysis of cumulative collision mortality risk estimates for Ireland. By utilising and updating the turbine database now available (NPWS, unpublished; this review), it would be possible to produce a national collision risk model to establish the level of wind energy development -mediated mortality (see O'Donoghue, 2011; Ruddock *et al.*, 2012; 2016). It is noted, however, that collision mortality and risk estimates can be highly site-specific and may not be linked to abundance or detection rates from pre-construction surveys (Haworth and Fielding, 2012; see also Chapter 2), although such an estimate would be useful to inform indicative cumulative risk in Ireland and also allow assessment of future projects. Two suspected collisions in Ireland have occurred in the non-breeding season and there is an absence of flight data available for that time of the year, although it is suspected that flights may be routinely lower during it, due to the lack of higher elevation display flights that occur in the breeding season (O'Donoghue 2011; Wilson *et al.*, 2015).

### Potential interactions of wind energy and Irish Hen Harrier SPA breeding populations

It has previously been reported that there were 17 extant wind energy developments within the SPAs, with a further 10 proposed in 2015 (Wilson *et al.*, 2015). Ruddock *et al.*, 2016a reported that four of the six SPAs held a total of 236 turbines within the boundaries and a further 44 were located within 500m of them. As noted earlier, wind energy development (C3) and power line (D3) pressures were reported (Figure 13) for four of the SPAs, Mullaghanish to Musheramore; Stacks, Stack's to Mullaghareirk, West Limerick Hills & Mount Eagle; Slievefelims to Silvermines Mountains and Slieve Aughties had. In the Slieve Blooms SPA, whilst no turbines were recorded within it, power lines (D3) were recorded as a pressure (Ruddock *et al*., 2016a).

This review estimates that, as of 2016, there were 319 turbines inside four of the six SPAs and 58 turbines within 1km of the SPAs (Table 4). Two SPAs, Slieve Beagh and Slieve Blooms, did not have any turbines in 2016 nor are there turbines within 1km of their boundaries. Neither were there turbines within 28.7km and 2.1km distance of these two SPAs, respectively, but there has been an increasing number of turbines within the other four SPAs over time (Table 4).

Prior to the Hen Harrier SPA designation process in 2007, there were already turbines located within the boundaries of two of the SPAs, namely Slieve Aughty Mountains SPA and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle. Mullaghanish to Musheramore Mountains SPA had no turbines present until after 2010 (Table 4), although three turbines were located within 1km of the boundary between 2005 and 2010. As of 2016, there remain a small number of turbines within the SPA boundary and there have been an increasing number of turbines adjacent to it (within 1km of its boundary). Despite only a small number of turbines inside the boundary, nearly 10% of the SPA area was within a kilometre of one, at that time.

The Slieve Aughty Mountains have had the same number of turbines present from 2005 to 2016 *i.e.* prior to SPA designation. Therefore, it is unlikely that Hen Harrier declines in the Slieve Aughties in recent years (2005 – 2010 = 14.8% decline; 2010 – 2015 = 39.1% decline) are related to pressure from increasing numbers of turbines, although those present were installed in close proximity to a number of Hen Harriers territories at the time (Madden and Porter, 2007). A spatial redistribution and avoidance of this general area by Hen Harrier may have consequently occurred but further analysis is required to understand the reason/s behind the observed decline in numbers of breeding pairs in this area.

Similarly to Mullaghanish to Musheramore SPA, in the Slievefelim to Silvermines SPA there were a small, but increasing, number of turbines, both inside the boundary (covering a relatively small area of the site) and within 1km of it (Table 5), as of 2016. Between 2010 and 2015, there was an increase from four to 11 turbines within this SPA and an increase from one to six turbines within 1km of the boundary. With regard to the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA, nearly 20% of the area within the SPA boundary was within 1km of a turbine (Table 5) by 2016. There was also a 428% increase in the number of turbines between 2005 (pre-designation) and 2015 (post-designation), with a total of 227 turbines inside the boundary and a further 39 turbines within 1km.

As indicated by Fernández-Bellon (2015) and Wilson *et al.* (2015; 2016), if effects on Hen Harrier breeding success or breeding numbers may occur up to 1km from the nest site, then turbines beyond the SPA boundaries may be affecting the species within the designated sites, if there is suitable nesting habitat within this distance. Therefore, consideration of such *ex-situ* impacts is necessary. As of 2016, this *ex-situ* impact could be occurring at three SPAs, Mullaghanish to Musheramore; Slievefelims to Silvermines and at the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle complex (Table 5). Also as of 2016, one hundred and sixteen other turbines occured across 14 other designated sites in Ireland. This includes six Natural Heritage Areas (NHAs; 83 turbines), one potential or potential NHA (3 turbines), and six SACs (30 turbines). Several other turbines occur in close proximity to some wetland SPAs (*e.g.* Cork Harbour SPA and Cahore Marshes SPA).

**Table 5. The zone of potential influence & number of turbines at Hen Harrier SPAs at the time of National Surveys**

| | 2000 | | 2005 | | 2010 | | 2015 | |
|---|---|---|---|---|---|---|---|---|
| Special Protection Area | Area (ha) of SPA within 1km of turbines | Number of turbines within SPA | Area (ha) of SPA within 1km of turbines | Number of turbines within SPA | Area (ha) of SPA within 1km of turbines | Number of turbines within SPA | Area (ha) of SPA within 1km of turbines (%) | Number of turbines within SPA |
| Mullaghanish to Musheramore Mountains 004162 (4,975.6ha) | 0 | 0 | 0 | 0 | 7 (0.1%) | 0 (3) | 485 (9.7%) | 2 (13) |

| | 2000 | | 2005 | | 2010 | | 2015 | |
|---|---|---|---|---|---|---|---|---|
| Special Protection Area | Area (ha) of SPA within 1km of turbines | Number of turbines within SPA | Area (ha) of SPA within 1km of turbines | Number of turbines within SPA | Area (ha) of SPA within 1km of turbines | Number of turbines within SPA | Area (ha) of SPA within 1km of turbines (%) | Number of turbines within SPA |
| Slieve Aughty Mountains 004168 (59,435.65ha) | 0 | 0 | 2,059 (3.5%) | 79 | 2,059 (3.5%) | 79 | 2,059 (3.5%) | 79 |
| Slieve Beagh 004167 (3,455ha) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Slieve Bloom Mountains 004160 (21,761.25ha) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Slievefelim to Silvermines Mountains 004165 (20,909ha) | 0 | 0 | 12 (0.1%) | 0 (1) | 323 (1.5%) | 4 (1) | 752 (3.6%) | 11 (6) |
| Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161 (56,627.2ha) | 1,139 (2.0%) | 29 | 1,765 (3.1%) | 43 | 6,201 (10.9%) | 131 (23) | 10,895 (19.2%) | 227 (39) |
| Inside SPA | 1,139 (0.7%) | 29 (0) | 3,836 (2.3%) | 122 (1) | 8,590 (5.1%) | 214 (27) | 14,191 (8.5%) | 319 (58) |
| Outside SPA | 8,806 | 169 | 22,115 | 365 | 54,829 | 830 | 86,268 | 1,183 |
| Total | **9,945** | **198** | **25,951** | **487** | **63,419** | **1,044** | 100,459 | **1,502** |

Ruddock *et al*. (2016a) identified areas in which wind energy development pressures were recorded across 268 surveyed 10km squares. Of the 55 10km squares within which the SPAs occur, there are 21 (38.2%) that contain wind turbines (NPWS, unpublished) and 16 (29.1%) that were considered to be under pressure from wind energy developments (Figure 13; Table 6). Four of these latter squares do not contain turbines (Figure 13) and as noted earlier, fieldworkers may have taken into account pressure from turbines in adjacent squares and near the SPA boundaries and/or may been aware of proposed wind turbines in those areas during their field surveys, potentially from preparatory works.

**Table 6. The no. and % of 2015 10km survey squares and their breeding status with regard to turbine presence.**

| | SPA Status | Confirmed | Possible | Seen | Not seen | Total |
|---|---|---|---|---|---|---|
| Turbines | SPA | 13 (61.9%) | 2 (14.3%) | 5 (23.8%) | 1 (4.8%) | 21 |
| C3 Pressure | SPA | 11 (68.8%) | 1 (6.3%) | 3 (18.8%) | 1 (6.3%) | 16 |

## Potential interactions of wind energy and Irish Hen Harrier breeding populations outside of SPAs

Wilson *et al.* (2015; 2016) quantified the spatial overlap at the 10km square resolution based on the 2010 breeding survey (Ruddock *et al.*, 2012) and found that 28% of the range overlapped with Hen Harriers' breeding range, but no distinction was made between designated and non-designated areas. The majority of wind turbines (n = 1,183; 78.8%) in Ireland (NPWS, unpublished) are located outside the SPAs (Table 5; Figure 8).

## Potential interactions of wind energy across the wider countryside

NPWS (2015a) defined a method by which important spatial clusters (or regional zones) of breeding Hen Harriers were identified, using the 2010 Hen Harrier survey data. These were subsequently updated by Ruddock *et al.* (2016b), using 2015 Hen Harrier locations (Figure 14). This method defined a series of polygons that were classified as either designated (contiguous with SPAs) or non-designated (beyond SPAs) regional breeding populations. There were fewer turbines (n = 42) recorded within the non-designated areas than the designated areas (n = 250; Table 7), with between 0% and 6.8% (average 1.7%) of the non-designated areas within 1km of turbines compared to 0% to 16.7% (average 6.9%) at SPAs (Table 7).

Within some of the SPAs, a relatively high percentage of turbines were noted (Table 7). Consequently, a relatively lower percentage of turbine coverage within non-designated areas and a greater number of pairs of Hen Harriers in these zones, when compared to the proportional turbine coverage, is noted (Table 7; Figure 15).

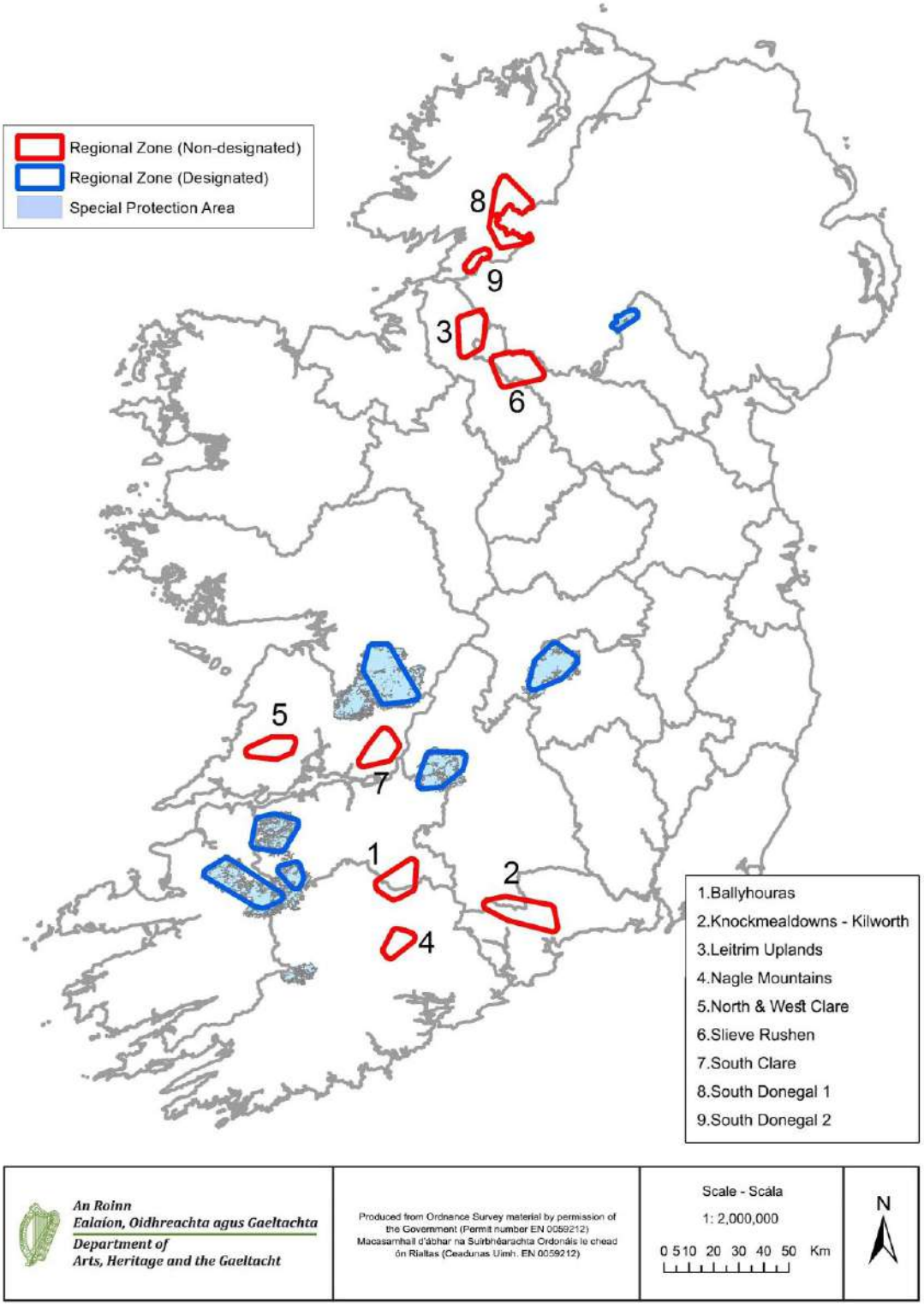



**Figure 14. The distribution of relatively important breeding populations of Hen Harriers (*i.e.* designated and non-designated regional zones), as defined by Ruddock *et al.* (2016b), using 2010 and 2015 survey data.**

**Table 7. The characteristics of turbines located within the 2015 Hen Harrier important breeding population areas (or zones), and size (ha) of associated turbine buffers.**

| Zone (number of pairs) | Zone Area (ha) | Turbine Count | Sum Mw | Ave Mw | Ave Hub Height (m) | Ave Rotor Diameter (m) | Area (ha) covered by 2015 Turbine 1km Buffer | % of Regional Zone Covered |
|---|---|---|---|---|---|---|---|---|
| SPAs | | | | | | | | |
| Aughty 1 (12) | 33677.6 | 79 | 67.2 | 0.9 | 49.0 | 52.0 | 2059.6 | 6.1 |
| Slieve Beagh (3) | 4439.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Slieve Blooms (12) | 21564.7 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Slievefelim 1 (10) | 20821.9 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 171.4 | 0.8 |
| Stacks North 1 (14) | 21163.1 | 41 | 91.5 | 2.2 | 65.7 | 72.9 | 3210.0 | 15.2 |
| Stacks North 2 (5) | 7322.5 | 6 | 12.5 | 2.1 | 78.0 | 81.7 | 685.8 | 9.4 |
| Stacks West & South (12) | 30171.5 | 124 | 147.9 | 1.2 | 58.8 | 56.7 | 5035.2 | 16.7 |
| Non-designated | | | | | | | | |
| Ballyhouras (12) | 16801.4 | 2 | 4.6 | 2.3 | 64.0 | 71.0 | 200.5 | 1.2 |
| Knockmealdowns – Kilworth (7) | 25234.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Leitrim Uplands (7) | 16443.9 | 4 | 9.2 | 2.3 | 64.0 | 71.0 | 521.2 | 3.2 |
| Nagle Mountains (5) | 9175.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| North & West Clare (8) | 13154.0 | 13 | 11.1 | 0.9 | 65.0 | 70.0 | 893.2 | 6.8 |
| Slieve Rushen (7) | 21302.1 | 2 | 3.0 | 1.5 | 65.0 | 70.0 | 314.1 | 1.5 |
| South Clare (7) | 14952.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| South Donegal 1 (11) | 24337.2 | 21 | 12.6 | 0.6 | 40.0 | 39.0 | 735.1 | 3.0 |
| South Donegal 2 (3) | 4532.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

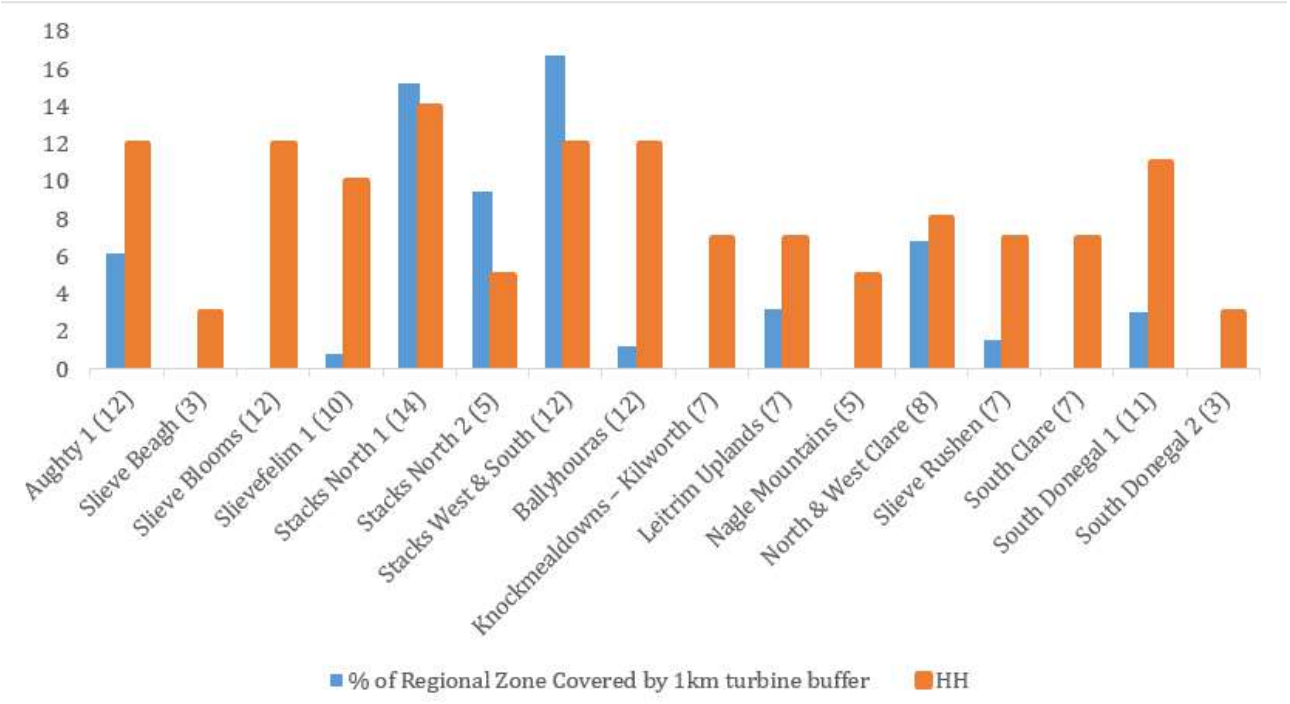



**Figure 15. The number (y axis) of breeding Hen Harrier within designated and non-designated important regional breeding areas and the proportional areas within 1km of turbines.**

## Direct disturbance during the breeding season

During the 2010 and 2015 National Hen Harrier Surveys, both wind energy developments and power lines (which may or may not be related to the wind energy developments) were recorded by surveyors as sources of disturbance to breeding Hen Harrier. In 2010, there were five records of disturbance attributed to wind energy developments by surveyors in Cavan, Kerry, Limerick and Cork, and implicated in the outcome of those territories (Ruddock *et al.*, 2012). None of these five territories were reported as successful and two pairs were explicitly reported to have failed due to wind energy development-related factors. Construction, operational or decommissioning works may cause disturbance to Hen Harriers (see Chapter 2). O'Donoghue *et al.* (2011) also report disturbance (and displacement) due to wind energy developments.

Using empirical data, best practice and/or expert recommendations, avoidance distances have been defined with a view to minimising effects of wind energy developments and other potential sources of disturbance (see review by Ruddock and Whitfield, 2007). They ranged from <10m to 1,500m, indicating a wide variation in individual responses by Hen Harriers. It was also recognised that close-range reactions may be a result of Hen Harriers only flushing at close range to an observer but that the disturbance may have been detected by the harrier in advance of flushing; also, that some birds, *e.g.* non-habituated pairs or individuals, may respond to disturbance at very large distances.

There are a number of studies that recorded empirical data or made disturbance buffer recommendations for Hen Harriers, which ranged from 30m to 1,000m (Table 2). A summary of these studies is provided in Table 8 below. The majority of expert opinions (80%) suggested

that significant disturbance responses were likely to occur within than 750m and thus, recommended a buffer of 500 – 750m. Taking the mean of these minimum and maximum figures equates to 475m – 670m and a median of 500 – 750m. Therefore, the recommendations of Whitfield *et al.* (2008) for a buffer of 500 – 750m seem pragmatic in order to provide protection from direct disturbance, although a wider buffer, >1km, to avoid direct disturbance may be practicable in order to reduce long-term effects on breeding parameters (Fernández-Bellon *et al.*, 2015) and mitigate potential population effects (Wilson *et al.*, 2015; 2016). Buffer distances should also take into account lines of sight from a nest and areas of flight activity, rather than being applied solely as radii from the possible sources of disturbance.

**Table 8. Summary of literature that identifies displacement or disturbance distances and/or buffer recommendations for Hen Harrier.**

| **Disturbance source** | **Distance (range) (m)** | **Effect** | **Reference** |
|---|---|---|---|
| Forestry activities | 500-1000m | Buffer recommendation | Currie and Elliott, 1997 |
| Forestry activities | 500-600m | Buffer recommendation | Petty, 1998 |
| Observer | 300-1000m | Disturbance | Garcia and Arroyo, 2002 |
| Observer | 100m | Mobbing | Garcia, 2003 |
| Wind energy development | 500-1000m | Displacement | Madders, 2004 |
| Wind energy development | 200-300m | Displacement | Madders and Whitfield, 2006 |
| Wind energy development | 500-1000m | Displacement | Bright *et al.*, 2006 |
| Various | 500-750m | Disturbance/buffer recommendation | Ruddock and Whitfield, 2007; Whitfield *et al.*, 2008 |
| Wind energy development | 500-1000m | Disturbance | Bright *et al.*, 2008a |
| Wind energy development | 500m (52%)/ c1000m | Displacement (foraging) | Pearce-Higgins *et al.*, 2009a |
| Observer | 30 -120m | Mobbing | Irwin *et al.*, 2012 |
| Wind energy development | 140 – 1,280 (median 537m) | Displacement (1 pair) | O'Donoghue *et al.,* 2011 |
| Wind energy development | 2,000m | Wind energy development sensitivity | Bright *et al.*, 2008a |
| Wind energy development | 2,000m | Wind energy development sensitivity | McGuinness *et al.*, 2015 |

There are only a small number of analyses that examine or report on the effects of specific construction, operational or decommissioning wind energy development activities on Hen

Harriers. O'Donoghue *et al.* (2011) reports that a single territory was abandoned during the year of construction, that breeding success and breeding activity were reduced post-construction, and that avoidance distance increased.

## Potential interactions of wind energy developments and Hen Harrier populations outside the breeding season

### *Habitat loss and disturbance at roost sites*

There are few studies of the interactions between wind energy developments and wintering species (Devereux *et al.*, 2008), and particularly for Hen Harriers, although such an interaction may cause direct disturbance and/or indirect displacement and/or collision, similar to those that may occur during the breeding season. Human activities can cause abandonment of Hen Harrier roosts (Clarke and Watson, 1990; O'Donoghue, 2010).

The Irish Winter Hen Harrier Survey (IWHHS) is the main source of survey and monitoring data for Hen Harrier during the non-breeding period in Ireland, collecting information on the distribution and occupancy of roosts across the country since 2005. O'Donoghue (2010) reports a predominance of reedbeds and heather/bog habitats for winter roost sites up to 238m asl but the majority were less than 100m asl and more than half (53%) were less than 30m asl. O'Donoghue (2010) also reports a mean of 44.3 ± 8.3m asl for winter roost sites which is considerably lower than the turbine altitudes found in this review (253 ± 108.7m asl). There were 82 turbines (5.4%) recorded at less than 53m asl which indicates a relatively low altitudinal overlap with roost sites. It is also recognised that many of the breeding sites may remain occupied as wintering roost sites (B. O'Donoghue, pers. comm.) and the recent mean altitudes at which turbines occur may now be higher since winter roost data was last published (O'Donoghue, 2010). That study did not explicitly identify wind energy developments or turbines as a threat or pressure on roosts at that time, although they were listed as a general threat to Hen Harriers in Ireland (see also O'Donoghue *et al.*, 2011).

Wintering harriers were recorded across 403 10km squares (Balmer *et al.*, 2013) which equates to 46.4% of the 869 squares in Ireland. 88 of these 10km squares were known to contain winter roost sites (NPWS, 2015). An analysis of the RTD (NPWS, unpublished) shows that 1,036 turbines occur within 66 squares (16.4% of squares) within the species' known wintering range. Of the 88 squares known to contain winter roost sites, 22.7% of these contained between two and 43 individual turbines. That is, at the 10km grid level, nearly a quarter of the known winter roost distribution in Ireland contains wind turbines (Table 9; Figure 16).

NPWS (2015a) reports that the IWHHS had identified 96 confirmed roost sites and a further 13 suspected roost sites at that time. A more detailed analysis of roost sites would provide more relevant metrics to aid understanding of the interactions between wind turbines and wintering Hen Harriers. There would be particular value in the following:

(i) a spatial analysis of turbine proximity to winter roost sites and
(ii) establishment of the altitudinal overlap of winter roost sites with turbines; and
(iii) a comparison of winter roost and turbine habitats.

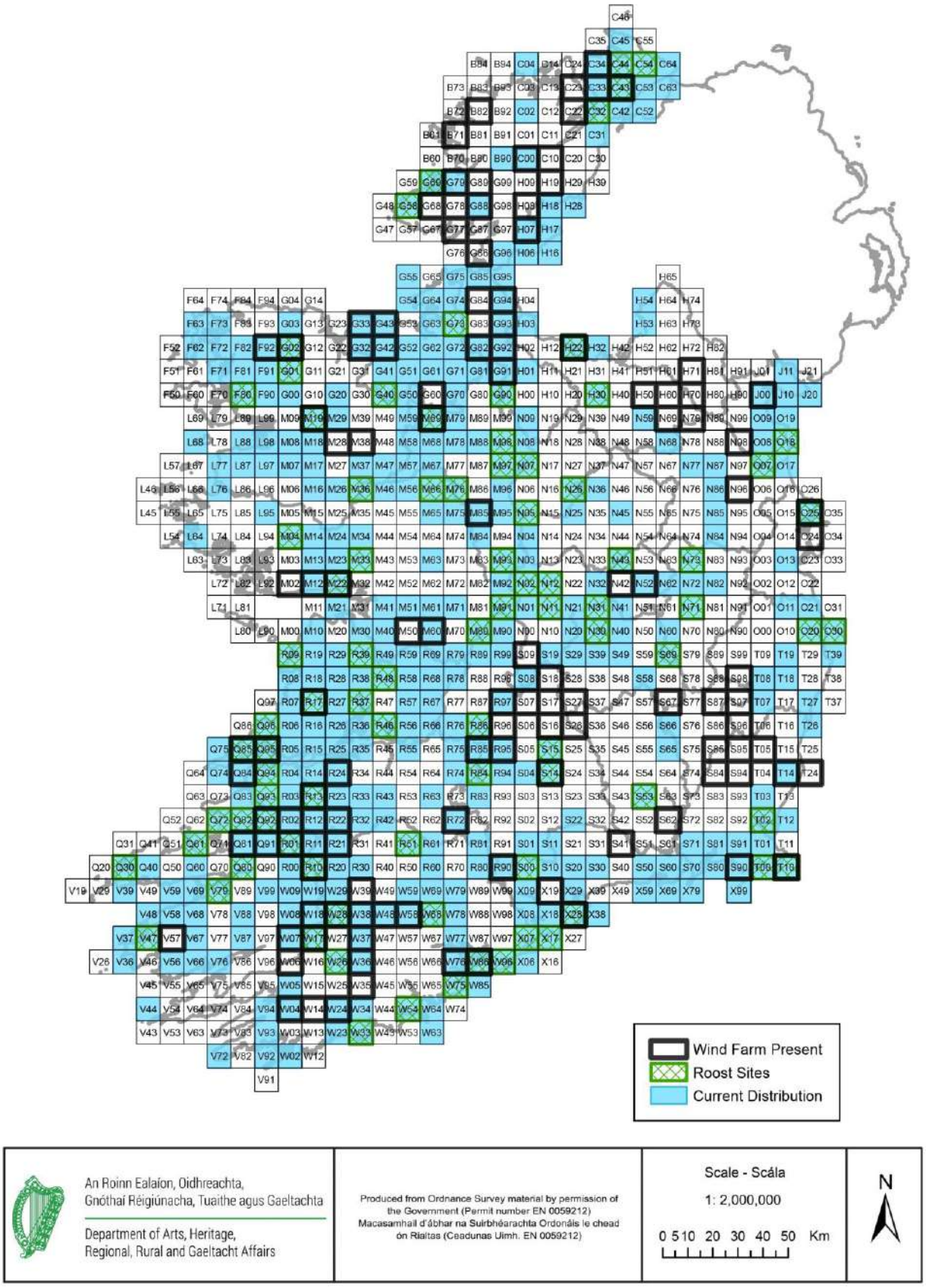



**Figure 16. The distribution of wind turbines (2016), Hen Harrier winter roost sites and Hen Harrier winter records (Balmer *et al.*, 2013).**

**Table 9. Spatial overlap of Hen Harriers and numbers of turbines per 10km resolution, within winter distribution and winter roost range.**

| | Number of squares | Number of squares with turbines | Percentage of squares with turbines | Number of turbines | Average number of turbines | Min | Max | MW |
|---|---|---|---|---|---|---|---|---|
| **Within winter range** | 403 | 66 | 16.4 | 1036 | 15.7 | 1 | 75 | 1698.9 |
| **Within winter roost range** | 88 | 20 | 22.7 | 306 | 15.3 | 1 | 43 | 446.1 |
| **Outside winter range** | 466 | 54 | 11.6 | 466 | 8.6 | 1 | 61 | 716.8 |

### *Loss of foraging habitat outside the breeding period*

It is known that a proportion of the overwintering population of Hen Harrier in Ireland either remain on or transiently use the breeding uplands for foraging and roosting. Therefore, similar sources of habitat loss that have been identified for the breeding population (*e.g.* displacement from foraging habitat; see Pearce-Higgins *et al.*, 2009a) are also relevant to the species during the winter season, although they can more readily move away from the affected area during the winter.

Although studies that examine winter foraging habitat preferences are limited, it is likely that closed canopy forest and improved pastures that are actively avoided by foraging Hen Harrier during the breeding season are also of negligible importance for this species outside the breeding season. The pressure caused by wind energy developments on individual Hen Harriers outside the breeding season may be less obvious due to the perceived movement of birds to less exposed and lowland areas in winter, where fewer turbines occur (Figure 7). The magnitude of this pressure may not be as severe because (i) Hen Harrier are more widely distributed in the winter (Figure 3) and may be less dependent upon the breeding sites; and (ii) Hen Harrier are known to use a wider variety of habitats, including tillage, during the winter months. Further analysis of altitudinal overlap of wintering Hen Harriers and turbines would allow for an examination of the levels of spatial conflict.

While these pressures may be less pronounced outside the breeding season, the higher occurrence of turbines in non-breeding areas, or in habitats used in the winter, may still affect Hen Harrier. Satellite-tracking studies in Ireland and the UK have shown that birds will disperse up to 20km from roost sites during the day to forage on upland heath and rough grassland, often returning to the same areas frequently over a period of days, weeks and months (B. O'Donoghue and S. Murphy, pers. comm., cited in NPWS, 2015a). These patterns of dispersal may indicate that the dependence on foraging quality away from roosts, in areas of lowland and upland heaths, and marginal farmland, could be as important for winter survival as they are for reproductive success during the breeding season. Therefore, the avoidance of, or barrier effect response to, optimal habitats due to the presence of turbines may compromise winter foraging

efficiency and thus over-winter survival. The effects of disturbance are likely, however, to be less constrained than they would be during the nesting period, although this could be exacerbated by disturbance at the roost sites.

## Other potential interactions of wind energy and Hen Harrier populations

### *Habitats in which wind turbines are installed in Ireland*

Research studies and national surveys have increased our knowledge of the importance of various habitats and their use by Hen Harrier during the breeding period (Wilson *et al.*, 2012; Irwin *et al.*, 2012; Barton *et al.*, 2006; Ruddock *et al.*, 2012; 2016). Although several studies report that Hen Harrier continue to utilise wind energy developments for foraging in Ireland (Madden and Porter, 2007; O'Donoghue *et al.*, 2011; Wilson *et al.*, 2015) and that a small number will nest within a few hundred metres (O'Donoghue *et al.*, 2011; this review), other research indicates potential avoidance of habitats due to wind energy developments (Pearce-Higgins *et al.*, 2009a). In order to examine wind turbine interactions with habitats, two analyses were undertaken as part of this review. Firstly, the turbine databases were compared to the SPA habitat database available from Moran and Wilson-Parr (2014), and then a wider analysis was undertaken, utilising CORINE (EPA, 2012) habitat data at the national scale.

Moran and Wilson-Parr (2014) data is relatively high resolution but is only available for the SPAs. An analysis of this data with the RTD (NPWS, unpublished) identifies that the majority of the 319 turbines within the SPAs are located within five main habitat types (Table 10). These five main habitats are:

- cutover bog;
- conifer plantations (>15 years old);
- conifer plantations (of unknown planting year);
- combined wet/dry heath; and
- rough grassland.

Moran and Wilson-Parr (2014) categorised the different habitat types as currently suitable for nesting or for foraging. Forty four point five - 62.7% of the SPA turbines occur in habitats which could be suitable for nesting Hen Harrier. Similarly, 60.2% -78.4% of turbines are located in habitats that are classified as suitable for foraging. Patterns of occurrence within different habitats varied within individual SPAs (Table 11); the most influential SPA driving the pattern was the Stacks complex, as it contains relatively higher numbers of turbines (Table 5).

**Table 10. Habitats in which turbines are recorded within Hen Harrier SPAs, based on Moran and Wilson-Parr (2014).**

| Habitat Description | Habitat Code | Frequency of occurrence (n) | Percentage composition (%) | Suitable for nesting | Suitable for foraging |
|---|---|---|---|---|---|
| CUTOVER BOG | PB4 | 79 | 24.8 | Yes | Yes |
| CONIFER PLANTATION 15 YEARS PLUS | FOR>15YR | 63 | 19.7 | No | No |
| CONIFER PLANTATION | FOR_UNK | 58 | 18.2 | Possible | Possible |

| Habitat Description | Habitat Code | Frequency of occurrence (n) | Percentage composition (%) | Suitable for nesting | Suitable for foraging |
|---|---|---|---|---|---|
| UNKNOWN PLANTING | | | | | |
| COMBINED WET DRY HEATH | HH | 45 | 14.1 | Yes | Yes |
| ROUGH GRASSLAND 50%PLUS COVER JUNCUS | RG | 42 | 13.2 | No | Yes |
| UNPRODUCTIVE CONIFER PLANTATION | UNPRO | 10 | 3.1 | Yes | Yes |
| IMPROVED AGRICULTURAL GRASSLAND | GA1 | 6 | 1.9 | No | No |
| CONIFER PLANTATION 9 - 12 YEARS | FOR9_12YR | 5 | 1.6 | Yes | Yes |
| MOSAIC GRASSLAND CLUSTERED 30 - 39% | MG_C3 | 4 | 1.3 | No | Yes |
| DRY/HUMID ACID GRASSLAND | GS3 | 2 | 0.6 | No | Yes |
| CONIFER PLANTATION 13 - 14 YEARS | FOR13_14YR | 1 | 0.3 | No | Yes |
| CONIFER PLANTATION 4 - 8 YEARS | FOR4_8YR | 1 | 0.3 | Yes | Yes |
| FRESHWATER MARSH | GM1 | 1 | 0.3 | No | Yes |
| SCRUB | WS1 | 1 | 0.3 | Yes | Yes |
| UPLAND BLANKET BOG | PB2 | 1 | 0.3 | Yes | Yes |
| TOTAL | | 319 | 100% | | |

**Table 11. Habitats in which turbines are recorded within individual Hen Harrier SPAs in Ireland, based on Moran and Wilson-Parr (2014).**

| Habitat description | Mullaghanish Musheramore Mountain SPA | | Slieve Aughty Mountain SPA | | Slievefelim Silvermines Mountains SPA | | Stack's - Mullaghareirks SPA | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| CUTOVER BOG | | | 15 | 19.0 | | | 62 | 27.7 |
| CONIFER PLANTATION 15 YEARS PLUS | | | 24 | 30.4 | 4 | 36.4 | 34 | 15.2 |
| CONIFER PLANTATION UNKNOWN PLANTING | | | 38 | 48.1 | 1 | 9.1 | 18 | 8.0 |
| COMBINED WET DRY HEATH | 1 | 20.0 | 2 | 2.5 | | | 41 | 18.3 |
| ROUGH GRASSLAND 50%PLUS COVER JUNCUS | | | | | 4 | 36.4 | 39 | 17.4 |
| UNPRODUCTIVE CONIFER PLANTATION | | | | | | | 10 | 4.5 |

| Habitat description | Mullaghanish Musheramore Mountain SPA | | Slieve Aughty Mountain SPA | | Slievefelim Silvermines Mountains SPA | | Stack's - Mullaghareirks SPA | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| IMPROVED AGRICULTURAL GRASSLAND | 2 | 40.0 | | | | | 7 | 3.1 |
| CONIFER PLANTATION 9 - 12 YEARS | | | | | | | 5 | 2.2 |
| MOSAIC GRASSLAND CLUSTERED 30 - 39% | | | | | 1 | 9.1 | 3 | 1.3 |
| DRY/HUMID ACID GRASSLAND | 2 | 40.0 | | | | | 1 | 0.4 |
| CONIFER PLANTATION 13 - 14 YEARS | | | | | | | 1 | 0.4 |
| CONIFER PLANTATION 4 - 8 YEARS | | | | | | | 1 | 0.4 |
| FRESHWATER MARSH | | | | | 1 | 9.1 | | |
| SCRUB | | | | | | | 1 | 0.4 |
| UPLAND BLANKET BOG | | | | | | | 1 | 0.4 |
| **TOTAL** | **5** | | **79** | | **11** | | **224** | |

This review also utilised the most recently available CORINE (EPA, 2012; Lydon & Smith, 2014) habitat data, at the time of the analysis, to examine the broad types of habitats where turbines are installed across Ireland, both within and without the Hen Harrier SPA Network. Similarly to within the SPAs alone, the majority of turbines have been installed in peat bog habitats (48.1%) (Table 12) and a minority of turbines in the wider area occur within urban or more densely human-occupied habitats. All of the key seven habitats in which turbines most frequently occur (Table 12) could be useful to breeding or wintering Hen Harriers, although the resolution of these data and the quality of such habitats cannot be examined from these data sources. O'Donoghue (2010) reports the usage of reedbeds and upland (heath) areas for roosting, but further analysis of habitat co-occurrence would enable a more detailed examination of wintering roost areas and wintering foraging areas.

**Table 12. CORINE Habitats (EPA, 2012) in which turbines are recorded in the wider countryside**

| CORINE habitat description | CORINE Code | Number of turbines | Percentage of turbines (%) |
|---|---|---|---|
| Peat Bogs | 412 | 722 | 48.1 |
| Pastures | 231 | 311 | 20.7 |
| Transitional woodland shrub | 324 | 242 | 16.1 |
| Conifer forests | 312 | 93 | 6.2 |
| Land principally occupied by agriculture | 243 | 64 | 4.3 |
| Non-irrigated arable land | 211 | 32 | 2.1 |
| Moors and heathland | 322 | 26 | 1.7 |
| Green urban areas | 141 | 5 | 0.3 |
| Beaches, dunes and sand plains | 331 | 2 | 0.1 |
| Industrial or commercial units | 121 | 2 | 0.1 |
| Discontinuous urban fabric | 112 | 1 | 0.1 |
| Complex cultivation pattern | 242 | 1 | 0.1 |
| Mixed forest | 313 | 1 | 0.1 |

The erection of turbines within suitable nesting habitat (either within SPAs or in the wider countryside) may cause displacement of Hen Harriers from suitable habitat. Similarly, the placement of turbines within suitable foraging habitats may cause avoidance (Pearce-Higgins *et al.*, 2009a) and create barriers to movement. The indirect loss of usable breeding habitat due to proximity to wind turbines can be a result of displacement or avoidance behaviour. That is, Pearce-Higgins *et al.* (2009b) found that an average avoidance of 52.5% occurred at 500m resolution, although this ranged from -1.2% to 74.2% which would indicate that no avoidance, theoretically, would occur at 1km and thus, avoidance around turbines for foraging birds would extend to approximately 1km.

The reduction of habitat suitability by the construction and/or operation of a wind energy development within Hen Harrier ranges could lead to a reduction in food supply and such changes may reflect the indicative changes in breeding parameters observed by Fernández-Bellon *et al.* (2015) and Wilson *et al.* (2015) at 1km distance. Whilst Wilson *et al.* (2015) only observed small changes in prey abundance (at circa 100m from turbines), the wider avoidance of foraging habitats could have consequential effects on breeding success or productivity and may lead to gradual population declines over time.

As provisioning Hen Harriers forage greater distances in forested landscapes in Ireland compared to distances indicated by studies from other countries (Arroyo, 2006; Irwin *et al.*, 2012; Arroyo *et al.*, 2014), habitat connectivity is therefore likely to be an important consideration in wind energy development management and spatial planning for Hen Harriers in Ireland. Habitat fragmentation could also occur, as manifested by the barrier effect of wind turbines and/or overhead power lines (OHLs) and associated wind energy development infrastructure, though OHLs are used much less frequently in wind energy developments in Ireland, than previously (Eirgrid, pers.comm and ESB Networks, pers. comm.). This may affect provisioning Hen Harriers that are nesting in landscapes with high proportions of wind turbines and that are actively being avoided. Consequently, Hen Harriers may have to increase foraging periods to meet their own nutritional demands or those of their nestlings. Pearce-Higgins *et al.* (2009b) found a significant distributional effect of turbines on Hen Harriers but no significant effects of distribution of tracks or transmission (power line) infrastructure were noted.

The prevalence of wind turbines within foraging habitats may affect their profitability and hen harrier may have to travel larger distances to access other habitats, possibly increasing foraging time, energetic expenditure and range (see Ruddock *et al.*, 2008). Wind turbines can result in reduced habitat quality and extent (*e.g.* WINDHARRIER findings in relation to small bird abundances (Wilson *et al.*, 2015)), thereby limiting foraging, nesting or even roosting resources. This could explain the indicative negative associations observed by Wilson *et al.* (2015; 2016) on both breeding parameters and population decline, albeit there are other potential confounding factors. Whilst Fernández-Bellon *et al.* (2015) indicates that some breeding parameters may be affected at 1km, other research indicates that foraging behaviour of breeding pairs can be influenced by habitat changes at distances up to 3km from the nest (Amar

*et al.*, 2004; Arroyo *et al.*, 2009) and this could conceivably be larger based on average avoidance distances of 5-10km from extant turbines in 2015 (this review).

Arroyo *et al.* (2009) reported that human-wildlife conflict between the conservation of Hen Harriers, and the location of wind turbines for renewable energy generation, had increased (see also Madders and Whitfield, 2006). An understanding of foraging range and habitat selection can be useful in reducing this conflict by guiding the placement of turbines into areas that have the lowest quality habitat for foraging harriers, or managing habitats within existing wind energy developments to reduce collision risk (SNH, 2016).

### *Wind Energy Development Sensitivity Analysis*

The examination of species sensitivity to wind energy developments in order to inform spatial planning is a recognised tool for minimising conflict (Bright *et al.*, 2008a and 2008b). In Ireland, Tierney *et al.* (2012) and McGuinness *et al.* (2015) produced a sensitivity map that included consideration of Hen Harriers. This map was compared to the turbine database (1,502 turbines; RTD, 2016):

- three turbines (0.2%) were identified within the high risk category;
- 246 turbines (16.4%) within the medium sensitivity category and
- 564 turbines (37.5%) within the low sensitivity category (Figure 17).

The remainder of turbines were in areas with no data available *i.e.* no known sensitivities for the species analysed. There were 574 turbines (38.2%) located within the areas that had been identified as either medium or low sensitivity specifically for Hen Harrier, within 11 counties (Cavan, Clare, Cork, Donegal, Galway, Kerry, Leitrim, Limerick, Roscommon, Tipperary and Waterford) (See Tierney *et al.* (2012) for further details on the methodology used).

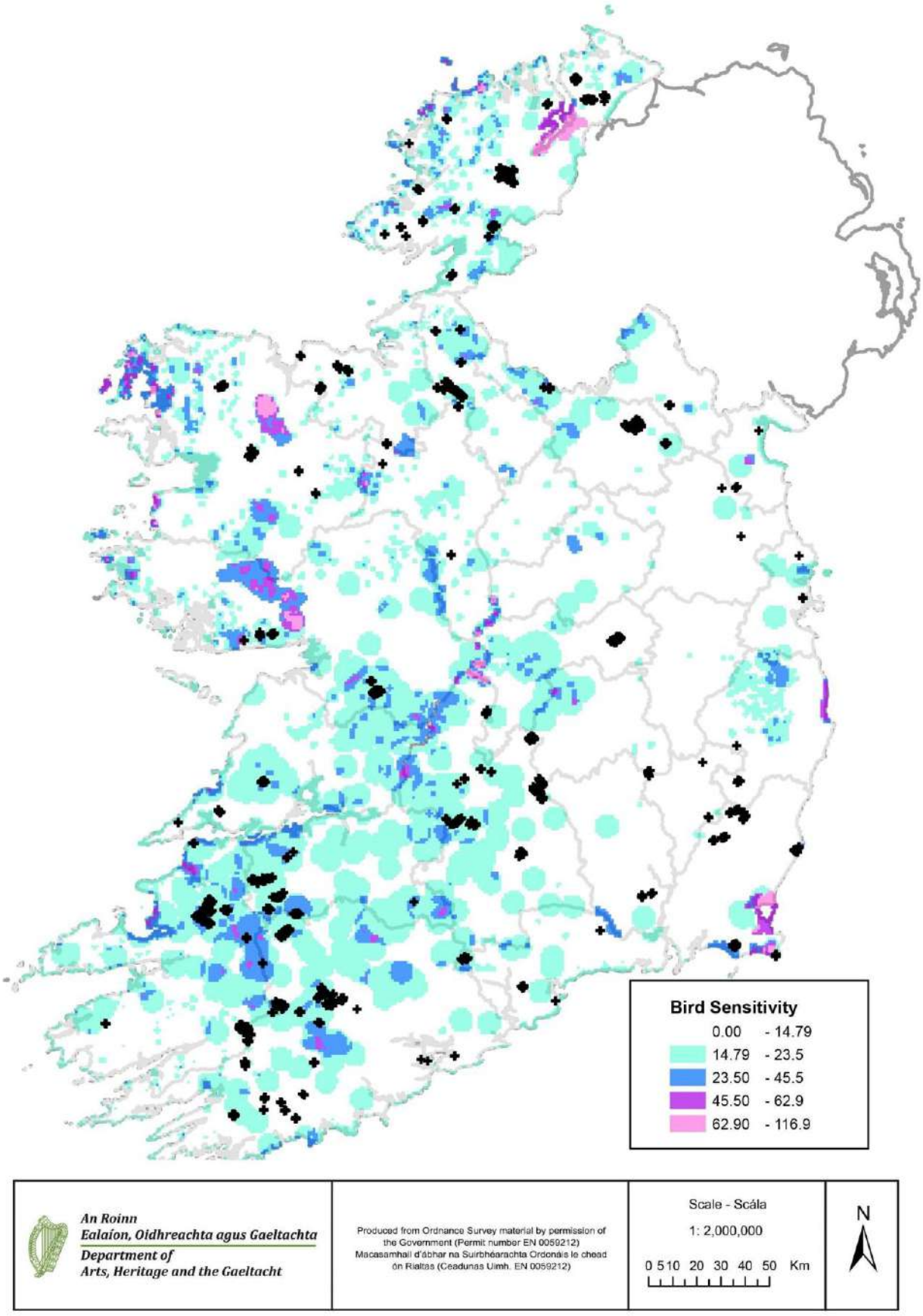



**Figure 17. Wind turbine distribution (+) and wind turbine sensitivity areas (derived from McGuinness *et al.*, 2015).**

# CHAPTER 4: SUMMARY OF INTERACTIONS & FUTURE CONSERVATION MANAGEMENT OPTIONS

## Introduction

This final chapter summarises the potential effects of wind energy development on Hen Harrier in Ireland and also sets out a series of options for the conservation of the Irish Hen Harrier population that are relevant to the wind energy sector. These options have been developed further through discussions with the Inter-Departmental Steering and have been integrated into the cross-sectoral Hen Harrier Threat Response Plan (NPWS-DHLGH, 2021).

The previous chapters have set out how the ambitious targets relevant to Ireland's renewable energy policy have resulted in an unprecedented level of wind energy development construction since 2000 and how demand for this development is likely to continue. The previous chapters have also detailed how such developments, at the project level or cumulatively, could affect individual Hen Harriers as well as site, regional and national population levels.

## Summary of interactions

With regard to the conservation management of the Irish Hen Harrier population, there are several effects that may arise as a result of potential interactions with the wind energy sector. These are as follows:

(i) loss of, or displacement from, foraging and nesting habitat during the breeding season;
(ii) direct disturbance of nesting and roosting birds;
(iii) loss of, or displacement from, winter foraging resources and roosting habitat; and
(iv) risk of bird mortalities through collisions with turbines.

While these will be expanded on below, it is first useful to summarise the pattern of wind energy development and the habitats within which they are installed, the recorded distribution of the Hen Harrier across Ireland, and possible associated population-level responses.

### Overlapping distributions and population level impacts

In 2015, breeding Hen Harrier territories (*i.e.* confirmed and possible breeding records) were recorded across 83 10km grid squares in Ireland. Over 32% of these squares overlapped with at least one wind energy development. This percentage overlap has increased nearly fivefold since the original national survey was conducted in 2000; meanwhile, the breeding harrier population is estimated to have declined over this period.

Using the RTD (NPWS, unpublished), it is calculated that almost 82% of turbines were located in the 100–400m altitudinal range; 92% of Hen Harrier territories recorded in 2015 were located in the same range. Over 66% of turbines and almost 60% of Hen Harriers occurred between the 200 and 400m contours. As described earlier, as of 2016, 44.5% - 62.7% of the SPA turbines occurred in habitats that could be suitable for nesting Hen Harrier. Similarly, 60.2% - 78.4% of turbines are located in habitats that are classified as suitable for foraging.

The most recent Bird Atlas (2007-2011) recorded harriers during the winter period across 403 10km squares; 88 of these 10km squares are known to contain winter roost sites (Balmer *et al.*, 2013; NPWS, 2015a). It has also been calculated that, as of 2016, over 1,000 turbines had been installed across over 16% of the known wintering range of the Hen Harrier (NPWS, unpublished).

For the WINDHARRIER study, Fernández-Bellon *et al.* (2015) assessed the breeding performance of Hen Harriers across Ireland in relation to wind energy development. Several measures of breeding performance were investigated and no statistically significant relationships were found between these breeding parameters and distance of the nest from the nearest wind turbine, although for those nests observed, nest success was lower within the closest distance band (0-1km) to turbines. Fernández-Bellon *et al.* (2015) conclude that these findings support earlier research that highlighted the importance of areas within a 1 km radius of raptor nests to breeding success.

Also for the WINDHARRIER study, Wilson *et al.* (2015) examined Hen Harrier population trends in relation to wind energy development in Ireland from 2000 to 2010, and noted that considerable overlap occurs between Hen Harrier breeding distribution and the location of wind energy developments. They reported "*A weak negative relationship was identified between wind farm presence and change in the number of breeding Hen Harrier pairs in survey squares between 2000 and 2010. However, the available evidence suggests that this was not a causative relationship but that local factors not included in the current study may have been responsible for the observed changes in Hen Harrier numbers within the survey squares. Furthermore, Hen Harrier population trends were negatively affected by a complex interaction between wind farm developments and the proportion of land between 200m and 400m above sea level*".

### Loss of, or displacement from, foraging and nesting habitat during the breeding season

During the breeding season and beyond, the diet of Hen Harrier consists of small birds and small mammals. Wilson *et al.* (2015) identified that the densities of forest birds were significantly lower within 100m of wind turbines; and that densities of open-country bird species were also found to be lower at wind energy development sites, but that these differences were independent of distance to wind turbines. Therefore, lower densities may be due to larger-scale effects of wind energy developments.

Examining the foraging preferences of adult birds during the breeding season and differences between wind energy development and control sites, Wilson *et al.* (2015) highlighted the importance for Hen Harriers of open habitats that hold high diversity and densities of prey species (rough grassland, natural grasslands, scrub and peatland).

Pearce-Higgins *et al.* (2009b) provide evidence of significant Hen Harrier avoidance of apparently suitable habitat within 250m of turbines, with a predicted 53% reduction of Hen Harrier flight activity within 500m of turbines, assuming that modelled habitat usage is proportional to breeding density. However, Haworth and Fielding (2012) examined Harrier flight activity data from five wind energy developments and a more limited level of avoidance

is suggested, concluding that Harriers are displaced at relatively smaller scales of between 0-100/200m (Haworth and Fielding, 2012).

The wider implications of these findings of displacement or avoidance effects need to be considered in relation to their potential effects on the Hen Harrier population at the national level. It is estimated that, as of 2016, 21% of all turbines in Ireland occurred within the breeding Hen Harrier SPA Network. The number of turbines within 1km of the boundaries of these SPAs had also increased, as set out earlier. Turbines have also been permitted in undesignated areas that have previously or continue to support breeding Hen Harrier. The review also indicates that, as of 2016, turbines outside the SPA network were predominantly located across peat bogs (48%), as well as there being a predominance of turbine installation in open habitats over which harriers are known to forage. Within the SPAs, as of 2016, over 50% of the turbines were installed over heath-bog and/or rough grassland.

### Direct disturbance of nesting and roosting birds

The presence of operating wind turbines can exert a displacement pressure on foraging and nesting harriers. The presence of ancillary activities, including construction and maintenance activities, near nest and roost sites can elicit direct responses from birds. This disturbance may manifest itself in the temporary abandonment of the area by nesting or roosting birds. Depending on the timing, intensity and recurring/chronic nature of the source of the disturbance, birds may abandon the nesting and/or roosting site entirely. For Hen Harrier, Ruddock and Whitfield (2007) suggests the implementation of a minimum set-back distance of 500 - 750m in order to minimise the potential impacts of human activity on nesting attempts.

### Loss of, or displacement from, winter foraging resources and roosting habitat

An examination of available data at the 10km level shows that almost one quarter of the known winter range of Hen Harrier in Ireland overlaps with wind energy developments. Although research on the impacts of wind energy developments on harriers outside of the breeding season is very limited, it is likely that some level of turbine avoidance by foraging birds occurs and therefore, some level of foraging habitat loss has occurred as a result of the development.

### Risk of bird mortalities through collisions with turbines

A review of the relevant scientific literature on the collision risk of harriers with turbines indicates that the species is probably at low risk of collision generally, given the low altitude of the majority of its flight activity. The WINDHARRIER report noted that harriers at wind energy developments spent 12% of their flight time within wind turbine rotor-sweep height, while the amount of time spent by juveniles flying at this height was negligible; thus, it was concluded that the overall collision risk to harriers during the breeding period season was low. However, as noted earlier, since 2015, and even in the absence of a robust system for carcass searches on wind energy developments, there have been three probable/confirmed incidences of Hen Harrier mortality caused by turbine strike and one possible case reported to NPWS-DHLGH. This suggests that collision risk for this long-lived species, with a low reproductive output, may increase along with any increase in wind energy developments.

## Wind Energy and Hen Harrier Conservation

Through the HHTRP process, various conservation actions can be recommended with a view to reducing pressures and threats on the Hen Harrier in Ireland. Specifically with regard to wind energy development, it is important to ensure that the integrity of Hen Harrier SPAs are not adversely affected by the individual and cumulative effects of wind energy developments and other plans, projects and pressures, *e.g.* by the reduction of the extent and/or quality of the habitats necessary to support the breeding Hen Harrier population.

In the planning of future wind energy developments, appropriate attention also needs to be given to allowing for a sufficiency of suitable breeding Hen Harrier habitat outside of the SPA network. The non-breeding/overwintering aspects of the species' life cycle also need to be considered in order to ensure that winter roosts and adequate foraging areas are maintained.

## Improving the available evidence base for the assessment of future wind energy developments

Projections show that an increase in both new development and repowering of onshore wind energy developments is both likely and necessary in order to meet renewable energy targets (SEAI, 2018). Therefore, it can be anticipated that there is likely to be ongoing, and possibly increasing, interest in the development of wind energy in areas that also happen to be important for Hen Harrier, both outside and within SPAs. A greater understanding of the use and suitability of habitats in these areas for Hen Harriers is necessary to improve understanding of the ongoing and future risks to the population.

The WINDHARRIER report (Wilson *et al.*, 2015) provides an extensive suite of research on wind energy developments in Ireland that has been used to both inform this report and widen understanding of Hen Harrier and wind energy development interactions. It also sets out useful recommendations, some of which are similar to the management options set out in this chapter. In particular, it provides a useful review of ornithology survey guidelines and recommendations for the implementation of standardised guidance for surveys.

In order for proposed wind energy developments, or the repowering of existing wind energy development, to be assessed for potential impact on the Hen Harrier population, it is important that sufficient levels of robust data and knowledge are collected by, and available and accessible to, developers and agents acting on their behalf, so that fit-for-purpose assessment documents can be produced (*e.g.* Environmental Impact Assessment Reports, Natura Impact Statements and Environmental Reports). It is also important that these data are readily available and standardised so that decision-making authorities can conclude the various assessment processes, to the standard required.

Recommendations are as follows:

- In order for ecological data from different wind energy developments to be comparable and aggregated for efficient strategic level analysis, the data collected needs to conform to particular standards. The production and adoption of best practice guidance in relation to the design and undertaking of bird surveys at the appropriate scales, in order

to inform fit-for purpose assessments and post-construction monitoring actions, would be of significant benefit. This would lead to an increase in the availability of data from comparable pre- and post-construction studies, including any carcass searches that are occurring.

- Easy access to project-level assessment documentation, including pre- and post-construction monitoring data, would further help in the assessment of in-combination and cumulative effects on Hen Harrier populations. The development of a facility to receive, store and report out on suspected bird collisions would also be a useful resource, with regard to providing data from both monitored (with formal carcass searches) and unmonitored (*i.e.* ad-hoc carcass recoveries) wind energy development.
- National Hen Harrier breeding surveys at five-yearly intervals need to continue for, at least, the medium term. The data derived from these surveys provides contemporary population estimates at both the SPA and national levels. It also enables the updating of other resources *e.g.* the production of updated maps of areas that have a higher likelihood of holding nesting pairs (*i.e.* HLNAs). These can be used as a tool to minimise potential disturbance events during the breeding season.
- The information presented in this report, and its implications for Hen Harrier breeding success, displacement *etc.* should be taken into account by parties involved in the ecological assessment (*i.e.* SEAs, AAs, and EIAs) of proposed wind energy developments, their repowering and associated or supporting policies, plans and programmes. This should include consideration of their potential effects on Hen Harrier outside the SPA network, particularly in non-designated regionally important zones, as required by Article 5 of the Birds Directive.
- Building on the work done by the SEAI, a spatial turbine database (RTD) has been further developed to support the development of this report (NPWS, unpublished). To promote effective cumulative level assessments, including collision risk modelling at various scales, the RTD needs to be further validated and maintained into the future, including through the addition of locations of recently-installed turbines. The RTD would be further strengthened if information relating to proposed, contracted or planned future wind energy developments was integrated.
- Further work is needed to gain a better understanding of the ecology of Hen Harrier outside the breeding season. More comprehensive and centralised knowledge on the characterisation and distribution of roost sites and wintering habitat use is also warranted. The fact that the possible Hen Harrier collision events occurred during the autumn/winter period is of particular relevance here.
- Hen Harrier habitat-offsetting works have been permitted as part of several wind energy developments. Focused research on the efficacy of such works would not only increase the planning authorities' confidence as to whether such works are effective in supporting the Hen Harrier, but furthermore, such research may also provide opportunity to provide guidance for the development of the most effective measures to minimise effects of wind energy developments on Hen Harrier.
- The production of a high-resolution habitat map for Ireland would help to inform Hen Harrier habitat suitability modelling work at the national level, as well as the production of more robust assessments and spatial planning.

- The implications of this review's findings, for the availability and quality of Hen Harrier habitat in the SPAs, should be reflected appropriately in the site-specific conservation objectives for those sites, and their associated conservation measures, as required under the Birds Directive.

### Spatial Planning Policy Development and the Wind Energy Sector

In parallel with the need to increase the evidence-base to inform future wind energy development proposals, further clarity should be brought to bear on spatial planning and land-use policy.

The HHTRP forestry sector report (NPWS, 2015a) shows that, as of 2015, over 50% of the six breeding Hen Harrier SPAs was under forestry management. The report also estimates that, for the subsequent 10 to 15 years, the extent of the forest that will be usable by Hen Harrier is likely to decline. The HTTRP agricultural sector report (NPWS, 2015b) highlights that various drivers are increasing the likelihood that the extent of farmed high quality Hen Harrier habitats will not increase in the near future unless there is direct intervention. For instance, within the SPA network, the establishment of conservation initiatives (such as the Hen Harrier European Innovation Partnership (EIP)), as well as the implementation of rotational forest management processes, should result in a redistribution of Hen Harrier breeding locations (both nesting and foraging) in the medium term.

As set out previously, some Hen Harrier SPAs contain relatively large numbers of wind turbines and there will be a considerable demand for, and acceleration of, wind energy developments over the coming years in order to meet renewable energy targets. Because of their interactions, the installation of wind energy developments in areas important for Hen Harriers may constrain opportunities for the co-location of the targeted conservation measures that are needed to restore sufficient suitable habitat for a stable and adequately-sized breeding population in the SPA Network, *i.e.* because the presence of the wind energy development may undermine the efficacy of the conservation measures.

As mentioned earlier, the creation of habitat to offset the effects referred to above has been determined not to be mitigation (in the meaning of a Habitats Directive Article 6(3) assessment), but is rather a measure to be assessed pursuant to Article 6(4) (*i.e*. compensation) (Supreme Court, 2016; ECJ, 2018). The Advocate General considered the question arising as providing a valuable opportunity to clarify its Article 6 case law "*given the need to reconcile the Member States' increasing use of renewable energy sources, such as wind power, and the protections afforded to habitats and species, such as the hen harrier*" and acknowledged the importance of both ambitions (Advocate General Tanchev, 2018). The need to apply the precautionary principle in appropriate assessments has also been enshrined in ECJ case law (*e.g*. where effects may arise but have not been proven) (*e.g.* Waddenzee Judgment (ECJ, 2004). Public authorities shall give consent to a plan or project, or adopt a plan or project, under Article 6 (3) of the Habitats Directive, only after having determined that it shall not adversely affect the integrity of a European site; furthermore, appropriate assessments should "*include complete,*

*precise and definitive findings and conclusions that are capable of removing all scientific doubt as to the effects of the proposed development on … [ sites] concerned*" (High Court, 2014).

Based on this report's review of available studies and best available knowledge, it can be concluded that the development of a wind energy development in, or immediately adjacent to, Hen Harrier habitat will result in some loss and/or reduction in quality of existing or current breeding habitat, through effects on, for example, breeding success and prey availability, which may result in negative changes to breeding productivity.

Thus, in line with the requirements of Article 6(3) and current case law concerning its application, project proposals (*e.g.* a proposal for new wind energy development, a proposal to repower an existing wind energy development, or a proposal to extend the operational life of a wind energy development through a new planning permission), that may affect the integrity of a Hen Harrier SPA will need to be able to demonstrate, with good quality, objective and reliable scientific evidence, that they will not adversely affect site integrity and its conservation objectives (*e.g.* result in significant mortality, displacement or affect the quality or availability of Hen Harrier breeding habitat, prey availability, and breeding success), including by taking into account the population status and trends for the species. This needs to be done in a manner that removes scientific doubt as to the effects that may arise, in combination with other plans and projects.

Relevant projects, plans or programmes, such as wind energy policy statements, strategies or frameworks that are developed, and their associated necessary environmental assessments (*i.e.* SEA, AA), should also reference and address the findings of this report.

Stakeholders could positively contribute to the robust assessment of the effects of wind energy development on Hen Harrier through a number of actions, including the following:

- Pre-application discussions with relevant stakeholders can identify potential nature conservation conflicts at an early stage and prevent/reduce both cost and time implications for all parties.

- Use and build on tools already developed to improve and to inform spatial planning and appropriate wind energy development siting, such as those referenced earlier in the report. This includes the long term maintenance and updating of the web resource that collates local authority wind energy strategies, the LARES methodology, map viewer and online tool.

- The production of sector-specific guidance on the assessment of the implications of proposed wind energy developments and repowering for Hen Harrier would be beneficial to inform the planning application process and decision-making. This would assist wind energy developers and operators, their ecologists, contractors and consultants, as well as competent authorities.

- In addition, in order to improve the effectiveness of avoidance and/or offsetting measures, a tool-box approach could be developed, following the undertaking of any

necessary research (see earlier Recommendations). Such avoidance and/or offsetting measures *could* include:

- The avoidance of turbine installation on areas of open heath/bog habitat as such habitats are likely to be of more long-term benefit to harriers than conifer plantations would be. This would preferably be informed by Irish Hen Harrier habitat modelling work and/or a national habitat map to enable specific targeting.
- The avoidance of wind energy development on or immediately adjacent to important winter roost sites.
- Consideration of how best to minimise collision risk, *e.g.* to manage the habitat in the immediate footprint of turbines in a way that reduces its residual attractiveness for use by Hen Harrier, as well as turbine design *etc*.
- Development of a methodology for best practice in post-construction monitoring (including the setting of a minimum level required) and application of results to inform and adapt ongoing post-construction mitigation measures.
- Avoidance of disturbance stimuli to breeding and/or roosting birds.

These measures could also be usefully supported by:

- Optimisation of the effectiveness of Construction Environmental Management Planning (CEMP) and the use of on-site Ecological Clerk of Works (ECoW) to oversee the implementation of mitigation measures, where appropriate.
- Development and implementation of Wind Energy Development Standard Operating Procedures designed to minimise and avoid Hen Harrier disturbance events that may arise from day-to-day wind energy development activities and scheduled maintenance operations, along with associated outreach activities to relevant professionals.

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**Note: Key references are highlighted in grey**


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# HEN HARRIER PROJECT
# Final Report



An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

The European Agricultural Fund for Rural Development: Europe investing in rural areas



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# Acronyms

**ACRES CP** - Agri-Climate Rural Environment Scheme Co-Operation stream
**AEOS** Agri-Environmental Options Scheme
**ARC** Activities Requiring Consent
**BPS** Basic Payment Scheme
**CAP** Common Agricultural Policy
**COVID-19** Corona Virus Disease 2019
**CRM** Customer Relationship Managemen
**CSP** CAP Strategic Plan

D-G
**DAFM** Department of Agriculture, Food and the Marine
**EIP** European Innovation Partnership
**EU** European Union
**FFNTG** Farming for Nature Technical Group
**GLAM** Generic Land Management System
**GLAS** Green Low-Carbon Agri-Environment Scheme

H - I
**HHP** Hen Harrier Project
**HNV** High Nature Value
I**CMSA** Irish Creamery and Milk Suppliers Association
**ICSA** Irish Cattle and Sheep Farmers Association
**IFA** Irish Farmers Association
**INHFA** Irish Natura and Hill Farmers Association
**IT** Information Technology

L - S
**LIFE French**: L'Instrument Financier pour l'Environnement
**LPIS** Land Parcel Information System
**MEA** Minimum Eligible Area
**NPI** Non-Productive Investment
**NPWS** National Parks and Wildlife Service
**NPO** Nest Protection Officer
**PASS** Partially Automated Screening System
**RBAPS** Results-based Agri-environment Payment Scheme
**SPA** Special Protection Area

# Introduction

The Hen Harrier Project Ltd successfully secured the Hen Harrier Project EIP following a public procurement process. The Operational Group included the Golden Eagle Trust and Brendan O' Gorman Accountants. The team were supported by Michael Martyn Agricultural Consultants and Tir Glas Agricultural Consultants and Dr James Moran. It was the largest EIP in Europe in the 2017-2022 CAP Strategic Plan (CSP).

Many of the natural and semi-natural habitats that the Hen Harrier depends on were created by agriculture. For centuries land management revolved around small scale tillage and the management of wet grassland, heath and bog as a grazing resource. The Hen Harrier and its prey thrived in this ecologically functional landscape. However, in recent decades, this relationship changed dramatically as demographic, economic and regulatory factors impacted on land use. All too often, the result was a deterioration in habitat quality at a landscape level. This has had a particularly adverse impact on a specialist predator like the Hen Harrier as they need large territories of suitable habitat that provide for breeding, foraging and wintering needs.

Afforestation and wind energy developments have had a dramatic impact on Irish upland fragmenting the available habitat and facilitating generalist predators such as foxes and Pine Marten. This had a particularly serious impact on Hen Harriers. Ground nesting birds such as Hen Harrier (and indeed many of their prey species) were directly impacted by nest predation but they have also been impacted by less productive territories with significant areas of forestry unsuitable for foraging forcing adult birds to travel further from the nest to provide for hungry hatchlings increasing the vulnerability of unfledged chicks to predators.

Within the breeding Hen Harrier Special Protection Areas (SPAs) these changes have been both positive and negative for the Hen Harrier. For example, while Hen Harriers, used young conifer plantations for breeding, these areas may have been acting as an ecological trap where elevated levels of nest predation may be contributing to a population decline. In tandem with these landscape changes, farming systems have also changed with increased winter housing of livestock, an increased concentration of production on improved grasslands and lower utilisation of heaths and marginal areas. Land eligibility requirement may have also contributed to the removal of scrub and the burning of rough vegetation.

These pressures have further reduced the quantity and quality of habitat available to Hen Harriers and their prey species. Similarly, these same changes in land use may also be undermining the social fabric of farming communities leading to de-population and land abandonment. The Hen Harrier Project sought to demonstrate that a locally focused scheme with the Hen Harrier as an indicator of a living landscape could help address these challenges. By supporting farming and farming families the project sought to enhance natural and semi-natural landscapes and help ensure that the outputs of vital upland management activity were rewarded and valued as ecosystem services.

A survey of breeding Hen Harriers in 2010 recorded 128 to 172 breeding pairs a number which was broadly similar to the totals recorded in the previous survey in 2005 prior to SPA designation. However notable declines of this species were recorded in some of its previous SPA strongholds. The 2015 survey of breeding Hen Harrier recorded further national declines with 108 to 157 breeding pairs. Further declines were also noted in four of the six of the SPAs. By the beginning of the scheme, the total SPA breeding population of Hen Harriers had declined by 10% since the 2010 survey and 27% since the 2005 survey.

In the years leading up to the commencement of the project, the continued decline of Hen Harriers in the Special Protection Areas designated for the species was evident. As a response to this, Ireland began the preparation of a Threat Response Plan for the Hen Harrier. The Threat Response Plan sought to cease, avoid, reduce or prevent threats, pressures or hazards that may be having an adverse effect on the conservation status of the Hen Harrier and/or causing the deterioration of the habitats of protected species within a European protected site under the Birds Directive (SPA). As an initial step, a moratorium on new forestry plantings was introduced and the licensing decisions for forestry activities began considering Red Zones (High Likelihood of Nesting Attempts) initially based on nesting locations detected in the 2010 and 2015 Hen Harrier National Surveys. In some quarters these measures were seen as restricting landowner's opportunities to earn an income from their land and depreciating the value of these lands. This caused tension among landowners with land designated as Hen Harrier SPAs and demands for compensation. Measures in traditional agri-environment schemes such as AEOS (Agri-Environmental Options Scheme) and GLAS (Green Low-Carbon Agri-Environment Scheme) did not assuage these concerns.

It was against this background of continued decline of the species in the areas designated for its conservation, increasing tensions regarding this designation and the perceived inadequacy of agri-environment schemes up to that point that lead to the decision to use the European Innovation Partnership (EIP) approach to develop an innovative locally led agri-environment scheme. This was innovative as, up to this point, EIPs were smaller, shorter in duration, more technical and not biodiversity focused. The €25,000,000 funding far exceeded the funding for other EIPs in the European Union at that point.

Following a public procurement process in early 2017, the contract to deliver this EIP was awarded to the Hen Harrier Project Ltd. In association with our partners in the Golden Eagle Trust and Brendan O'Gorman Accountants, we commenced the Hen Harrier Project EIP in May 2017.

Our ethos throughout was that by adding real value to the Hen Harrier's presence and by incentivising delivery of habitat quality on farms, the species and its habitats could be sustained. That effective conservation was possible within a cultural landscape where people, the Hen Harrier and wider biodiversity could thrive.





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## Project Description

The Hen Harrier Project designed and delivered the Hen Harrier Programme. Throughout this report, the Project is referenced when talking about the team or the EIP in general whereas the scheme that the farmers could join is referred to as the Programme. The Programme differed significantly from previous results-based schemes both in terms of scale and the dispersed nature of the project area. However, there were still opportunities to learn from previous Results-based Schemes.

The Hen Harrier Programme was designed for farmers in the SPAs, with farmers in the SPAs, to ensure maximum uptake and engagement. The aim was to achieve a shift in attitude towards the species while delivering a results-based agri-environment scheme (RBAPS). The principles that the Project team believe were the foundations for success, and on which the design was guided, are outlined below. These were based on experience from past schemes and projects as well as innovative approaches that the Project team felt were essential.

The scale of the project necessitated that the ambition had to be far higher than anything that was attempted in previous Agri-environment schemes or LIFE (French: L'Instrument Financier pour l'Environnement) projects. Achieving favourable participant to staff ratios were essential to demonstrate the scalability of the results-based concept at a regional or national level. The use of technology to allow a small team to administer the programme was essential to achieve this. The Project Team developed a included customised CRM (Customer Relationship Management) databases and the deployment of a bespoke app to enable advisors to enter scorecard details easily, quickly and in a standard format, directly into our databases and to certify the delivery of Supporting Actions.

## Hen Harrier Programme Principles

The programme's principles were modelled on those successfully developed by the Burren Farming for Conservation Programme but adapted for the specific needs of the Hen Harrier Project (HHP). They guided all aspects of the Programme's operation. The principles are:

1. **The farmer role is central**

The farmer is the key to farming for conservation. Firstly, farmers own the land, and the livestock needed to graze it. Secondly, farmers have the understanding and experience of how best to manage the land and livestock, knowledge that has been built up over generations. Thirdly, farmers are the ones with the most to lose and the most to gain from farming for conservation. Farmers need to play a vital role in the planning, delivery, monitoring and promotion of farming for conservation.

**2. Partnership**

Farming for conservation does not rely solely on the farmer, it requires different agencies to work together and to pool their skills and expertise. Our team brought a uniquely experienced group of farm advisors, researchers and raptor experts together to work with farmers and local communities.

**3. Farm planning is essential**

Every farm is different and must be treated differently. Effective farm planning - where the farmer combines their expertise with that of a trained farm advisor - can help to create a template from which the farmer could work effectively in future years. Without such a plan, works undertaken would have been haphazard and probably fail to deliver the best possible result for both the farmer and the Hen Harrier.

4**. Practical and innovative**

Farming for conservation is based on sound, traditional principles of managing the land with respect and care but it is not an approach which seeks to 'turn the clock back' to old ways of farming. Instead, this is a practical approach seeking to blend the best aspects of existing farming systems with new innovations and technologies to develop effective ways to feed and water livestock and to optimise habitats for the Hen Harrier.

**5. Flexible and locally adaptive**

Farming is increasingly a highly unpredictable business. Climate change is leading to unforeseen events, from floods to droughts. Markets are highly volatile and diseases, new and old, continue to impact on livestock. A farmer needs the flexibility to respond to unforeseen events. Farming for conservation sets out conservation goals and gives guidelines, advice and incentives to reach these goals, but ultimately, it allows the farmer the flexibility and discretion to deliver these goals as he/she sees fit.

**6. "An honest day's work for an honest day's pay"**

Farmers have the knowledge, skills and experience to farm for conservation. Farming on marginal lands in the uplands of the Hen Harrier SPAs is under pressure. Farmers need society's support to apply these 7talents for the benefit of the uplands, for broader biodiversity and for the Hen Harrier. Farming for conservation is based on results – it doesn't just seek to support farmers per se; it supports active farming which helps to maintain or enhance the natural heritage of these uplands.

**7. Creating real benefits**

Farming for conservation will benefit the biodiversity of the uplands in the Hen Harrier SPA network and the communities that live there. It will help to improve incomes and create new opportunities. It will help to protect the natural and cultural heritage of these areas for the people of these areas so that they can enjoy it and hand it on in a condition of which they can be proud. It will help Ireland meet its legal obligations under the Birds Directive, avoiding hefty fines for the Irish taxpayer. Society too will benefit from the cross cutting environmental services (biodiversity, carbon sequestration and climate adaptation) that these areas can provide.

**8. The importance of monitoring**

Monitoring is essential to prove that farming for conservation is delivering its goals, and to show that it provides value for money. In this project monitoring informs the project and makes adaptive management possible. Monitoring is essential to the core aims and objectives of the project.

The Hen Harrier Project focused on six breeding Hen Harrier SPAs in Ireland. The six SPAs are, alphabetically, Mullaghanish to Musheramore Special Protection Area (often shortened to Musheramore by the HHP team), Slieve Aughty Mountains Special Protection Area (often shortened to Aughties), Slieve Beagh Special Protection Area, Slieve Bloom Mountains Special Protection Area (often shortened to the Blooms), Slieve felim to Silvermines Mountains Special Protection Area (often shortened to Slieve felims) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle Special Protection Area (often shortened to Stack's). The SPAs occur across counties Cork, Kerry, Limerick, Tipperary, Galway, Clare, Laois, Offaly and Monaghan. See Figure 1 for their distribution.



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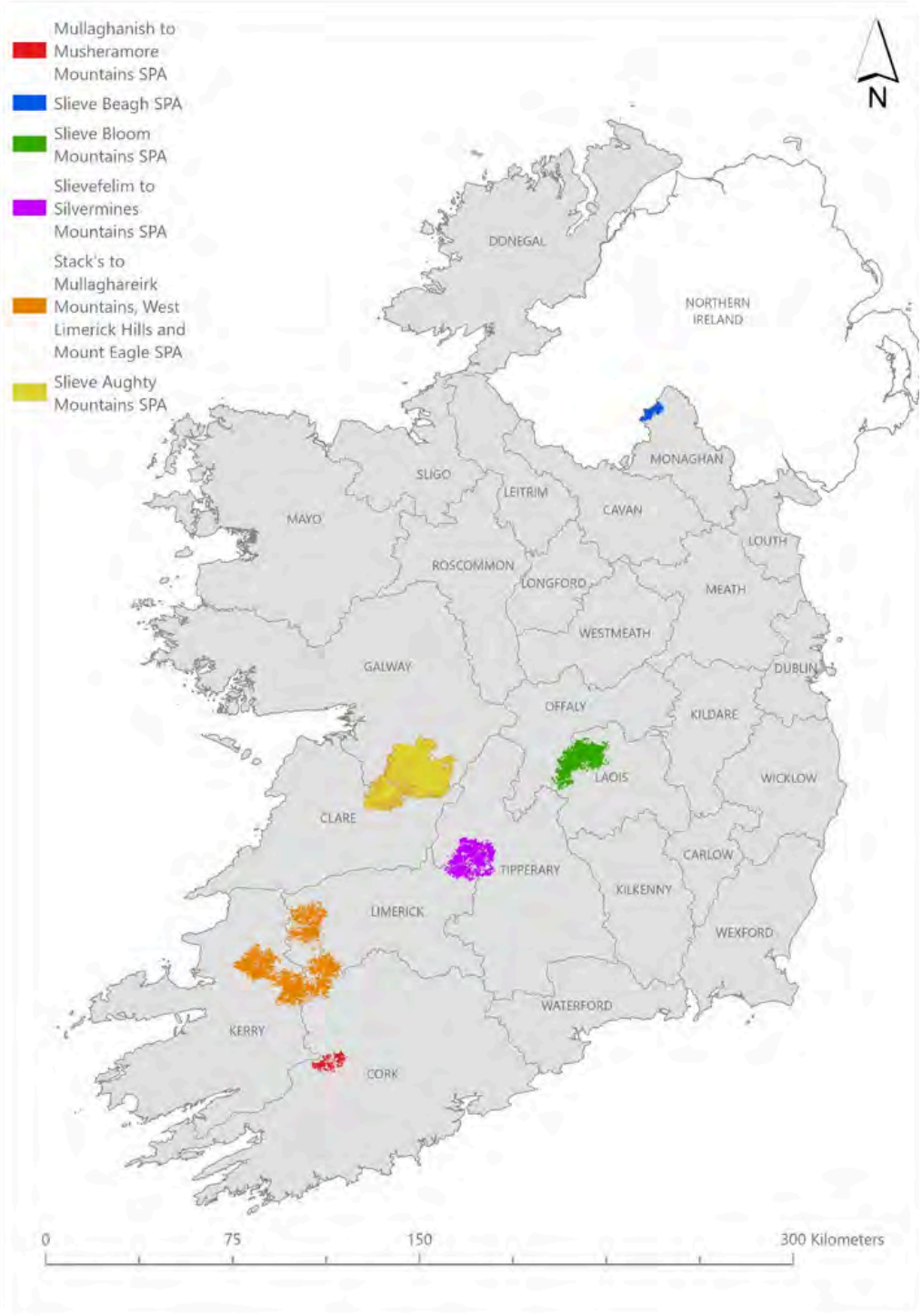



Figure 1. Breeding Hen Harrier SPA distribution across Ireland. The SPAs comprise over 167,000ha of land.

The SPAs comprise over 167,000ha of land. Just a third of this area is farmland with a very high proportion of the remaining two thirds comprising forestry (See Table 1). The dominant farm enterprises in the area were suckler beef, dry stock and some pockets of sheep farming. There were a small number of dairy farms in the Stacks SPA. Around 3,800 farmers farmed land in these areas at the time of the launch of the Hen Harrier Programme. The Programme was designed for, and with, these farmers.

| SPA | Area (ha) | Herd numbers | Farmed land (ha) |
|---|---|---|---|
| Stacks | 56,610 | 1546 | 20,730 |
| Slieve Aughty | 59,407 | 1181 | 20,648 |
| Slievefelim | 20,917 | 418 | 7,088 |
| Slieve Bloom | 21,771 | 384 | 4,275 |
| Musheramore | 4,961 | 159 | 3,053 |
| Slieve Beagh | 3,449 | 74 | 823 |
| **Total** | **167,115** | **3,762** | **56,617** |

Table 1. Area of the 6 breeding Hen Harrier SPAs in Ireland along with the numbers of farmers with at least one parcel of land intersecting the SPA layer and the total area of SPA that was farmland.

The Hen Harrier Project relied on a team of dedicated, multi-disciplinary staff open to listening and collaborating with farmers and other stakeholder over the course of the Programme. The people who worked on the Project team are outlined below (Table 2). Most members of the Project team had more than one role, allowing the project to achieve a lot with limited resources. Throughout the project lifetime, there was generally one full time Project Officer per 500 farmers. Additional staff were taken on as required during times of high workload, either as temporary staff or sub-contractors.

Table 2. List of people employed by the Hen Harrier Project in the course of the EIP.

| Staff Member | Title | Duration |
|---|---|---|
| Fergal Monaghan | Project Manager | May 2017 - April 2023 |
| Dr Caroline Sullivan | Deputy Project Manager, Ecology Specialist & Project Officer for Slieve Aughty Mountains SPA | May 2017 - April 2023 |
| Eoin McCarthy | Agricultural Specialist and Project Officer for Stacks and Musheramore SPA | May 2017 - April 2023 |
| Ryan Wilson-Parr | Ornithological Specialist and Project Officer for Slievefelims, Slieve Blooms and Slieve Beagh | May 2017 - April 2023 |
| Evelyn Joyce | Project Officer for Stacks and Musheramore SPA | Dec 2017 - April 2019 |
| Eibhlín Seoighthe | Administrative Assistant | May 2018 - Sept 2018 |
| Aoife Hanrahan | Administrative Assistant | Oct 2018 - Sept 2019 |
| David Miley | Mapping Assistant | Mar 2019 - Sept 2019 |
| Ciarán Sullivan | Mapping Assistant | Mar 2019 - Sept 2019 |
| Kristina Feeney | Mapping Assistant, Administrative Assistant and Project Officer for Slieve Aughty Mountains SPA | April 2019 - Dec 2022 |
| John Kelly | Project Officer for Slieve Aughty Mountains SPA | Aug 2021 - Dec 2022 |
| Padraig Cronin | Project Officer for Stacks and Musheramore SPA | June 2019 - Dec 2022 |

The Hen Harrier Project Ltd. established an office in Oranmore, Co. Galway. This location meant that staff in the main office were within 60-90 minutes' drive of the four largest of the six SPAs with good motorway access for the remaining most southerly and northerly SPAs. A small office was opened in Abbeyfeale, Co. Limerick also. The Project Officer for Slieve Beagh, the Blooms and the Slievefelims worked remotely from the east coast which allowed swift access to these SPAs also.

The Golden Eagle Trust were responsible for the Hen Harrier monitoring work during the breeding seasons from 2017 to 2022. Shane O'Neill, Jamie Bailey, Frank Connolly, Tim O'Donoghue, Dougie Ruddock and were key members of the monitoring team headed by Dr Marc Ruddock.

## Steering Committee

The Project team were guided through the course of the EIP by a steering committee with representatives from DAFM (Department of Agriculture, Food and the Marine), the Forest Service, NPWS (National Parks and Wildlife Service), private and Teagasc advisors and SPA farmers (Table 3). The private advisor and the farmer representative were appointed as members of the committee for a limited time. These roles were rotated to another private advisor and farmer to gain multiple perspectives from across the SPAs. The COVID-19 pandemic resulted in fewer rotations happening than the team had initially anticipated. Public health considerations meant that steering group meetings had to be in a virtual format for a period, but the in-person meetings recommenced before the end of the Project.

Table 3. Members of the Hen Harrier Project Steering Committee

| Member | OrganisaHon |
|---|---|
| Fergal Monaghan | Hen Harrier Project |
| Caroline Sullivan | Hen Harrier Project |
| Marc Ruddock | Golden Eagle Trust |
| Lorcan O'Toole | Golden Eagle Trust |
| Margaret Murray | Department of Agriculture, Food and the Marine |
| Bridgeena Nolan | Department of Agriculture, Food and the Marine |
| Denis O'Connell | Department of Agriculture, Food and the Marine |
| Kevin Collins | Forest Service |
| Andy Bleasdale | National Parks and Wildlife Service |
| Catherine Keena | Teagasc representative |
| A farmer representative | Rotating position from different SPAs |
| Private advisor representative | Rotating position from different SPAs |

Denis Hayes and Dan O'Donoghue (Stacks SPA) were the two farmer representatives and Denis Tuohy (Slieve Aughties SPA) and Martin Mulvihill (Stacks SPA) were the two private advisor representatives over the Project term.

The Project team reported to the Steering Committee on progress and developments over the Programme lifetime. The Committee assisted with issues that arose over the course of the Programme such as data sharing arrangements and decisions on setting Hen Harrier Bonus targets and payments for example.

## Scheme Design and Development

The next section outlines some of the key elements of the scheme development. It is difficult to capture the full breadth of the issues that were considered during scheme design and development. Some things that seemed like they would be good ideas were trialled and failed or were considered but were not feasible for a programme that had to operate at scale. It's important to remember that actions or approaches that were possible for 30 farms or even 100 farms become impossible, or their value or utility reduced, when more than 1,500 farms were being catered for.

### Co-creation of scheme with farmers; Development farms

The Project team recruited twelve development farms across the six breeding Hen Harrier SPAs in Ireland. Nominations were invited from the following farming organisations; Irish Farmers Association (IFA), the Irish Natura and Hill Farmers Association (INHFA), the Irish Farmers with Designated Land 11(IFDL), the Irish Cattle and Sheep Farmers Association (ICSA) and the Irish Creamery and Milk Suppliers Association (ICMSA). With the exception of the ICSA, all of these contributed to the process by nominating suitable farms from their membership. These were supplemented by nominations from advisors operating in those areas and by the National Parks and Wildlife Service (NPWS) (Table 4). The objective was to get at least one development farm per SPA representing a range of farm enterprises, part-time and full-time farmers and farmers with full and partial SPA designations. These farmers received a payment to cover their time interacting with Project team members and for the use of their farms for developing the scheme, including field trips, scorecard development, and testing, trialling and providing feedback on the utility of proposed actions.

Table 4. List of development farm locations, associated SPA, enterprise type and nominator.

| County | SPA | Enterprise type | Nominated by |
|---|---|---|---|
| Cork | Mullaghanish | Sheep | IFA |
| Clare | Slieve Aughties | Suckler cattle and sheep | IFA |
| Galway | Slieve Aughties | Suckler | IFA |
| Galway | Slieve Aughties | Suckler | INHFA |
| Monaghan | Slieve Beagh | Cattle | Michael Martyn |
| Tipperary | Slievefelim | Cattle | NPWS |
| Tipperary | Slievefelim | Sheep | IFDL |
| Cork | Stacks | Replacement Dairy Heifers | IFDL |
| Kerry | Stacks | Suckler beef | Eoin McCarthy |
| Limerick | Stacks | Dairy | ICMSA |
| Kerry | Stacks | Dairy | Eoin McCarthy |
| Offaly | Slieve Blooms | Suckler | Michael Martyn |

The development farms were visited regularly by the HHP team during the development phase of the Programme (Figure 2). The main habitats on the farms were mapped. The condition of those habitats and their contribution to Hen Harrier ecology was also assessed. The scorecards were developed based on high-quality fields achieving a maximum score of 10/10 with fields with lower quality habitats and/or issues of concern receiving a proportionally lower score. The scorecards were tested on these farms and feedback was gathered from the development farmers throughout the process to ensure that terminology and deliverables were clear.





Figure 2. (L) Fergal Monaghan, Michael Martyn and Marc Ruddock listening to development farmer Denis Hayes talk about his farm management in the Stacks Mountains SPA. (R) Michael Martyn discussing land management with development farmer Gabriel Rehill in Sliabh Beagh.

The relationships developed during the design phase of the Programme were long-standing and very valuable. The development farmers were an excellent source of feedback as different elements were rolled out. For example, an initial deadline for the first round of supporting actions was resulting in farmers feeling under pressure to bring heavy machines into fields before the start of the bird nesting season. This had the potential for creating the perverse impact of important HHP fields being damaged and creating areas of bare soil. When this was brought to the attention of the Project team, they were able to the deadline was removed allowing actions to be certified as delivered at any stage.

**Co-creation of scheme with farmers; Consultation meetings**

**Farm organisation consultations**

The Project Manager had several meetings with the farming organisations who wanted to input into the scheme design. Meetings were held with the Irish Farmers Association (IFA), Irish Creamery and Milk Suppliers Association (ICMSA), the Irish Natura and Hill Farmers Association (INHFA). The Project Manager also engaged with the Irish Farmers with Designated Land (IFDL) group during this period. The Irish Cattle and Sheep Farmers Association (ICSA) did not participate in this process although they were invited to do so. The meetings outlined the principles of a results-based approach, the consultation process and how the results of that would be incorporated into the scheme. Any concerns raised by these groups were noted and addressed within the scheme where possible. Most concerns related to payments and concerns around farming restrictions in SPAs.

**Farmer consultations**

Consultations with farmers were a key part of the development process for the Hen Harrier Programme. They were essential to inform the Project team, to establish a commitment to open dialogue and to demonstrate to farmers that the work on the programme had begun. Most importantly, they were necessary to inform the Project team of issues of concern to farmers so that these could be appropriately addressed in the Programme design phase. Here, we summarise the issues raised in the consultation phase, how they contributed to the design of the programme and how the questions asked would now be answered in the Hen Harrier Programme.



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Farmer consultations ran for seven weeks, from early-July to the end of August 2017. During this period, the Hen Harrier Project held 31 farmer consultation meetings throughout the SPA network. Over 500 farmers attended these meetings. These were supplemented by meetings with the Farm Representative Organisations and a seminar for farm advisors.

**Attitude Assessments**

At the start of the meetings, before any information had been presented, farmers were asked to complete a short exercise. They were asked four questions:

Q1. Thinking about your area and your farm, write down five words that best describe it today.

Q2. Thinking about the Hen Harrier, write down five words that you would associate with it today.

Q3. Describe farming in your area in 20 years' time

Q4. Describe farming in your area in 20 years' time, in an ideal world.

The farmers responses were collated into four-word clouds. A word cloud is a visual representation (image) of word data. In other words, it is a collection, or cluster, of words depicted in different sizes. The bigger the word appears, the more often it's mentioned and therefore, the more important it is.

The results presented below made it clear to the Project team what the key issues were across the SPAs. There were many commonalities among them, and the Project team believed that it would be possible to address some of them through a results-based scheme.

The response to question 1 almost always included the word 'rushy' and 'wet' and so we removed them to allow other words to be visible also. The other commonly used words included 'mountain', 'disadvantaged', 'forestry', and 'hardwork'. 'Hilly', 'suckler', 'poor land', 'marginal', 'scenic', 'not viable', 'unprofitable' also appeared frequently (Figure 3).




Figure 3. Q1. Thinking about your area and your farm, write down five words that best describe it today

The response to question 2 highlighted the key feeling toward Hen Harrier in these areas. Restrictions was the one word that was used most frequently. Other words used regularly in relation to the Hen Harrier by the farming community were ‘protected’, ‘money’, ‘scarce’, ‘don’t know about it’ and ‘land devalued’ (Figure 4).




Figure 4. Q 2. Thinking about the Hen Harrier, write down five words that you would associate with it today.

The farmers outlook for the next twenty years was captured in question 3. They imagined their areas as being ‘forestry’ with ‘no farming’. They saw an elimination of the small farm with ‘big farms only’ and ‘no young farmers’ remaining in the areas (Figure 5).




Figure 5. Q3. Describe farming in your area in 20 years’ time

The outlook was quite different when the same question had the words ‘in an ideal world’ added to it. The hope that farmers had for their area was obvious with profitability, sustainability and still farming being key here. Other words of note were ‘good grazing’, ‘young farmers’, ‘biodiversity’ and ‘proper funding’ (Figure 6).

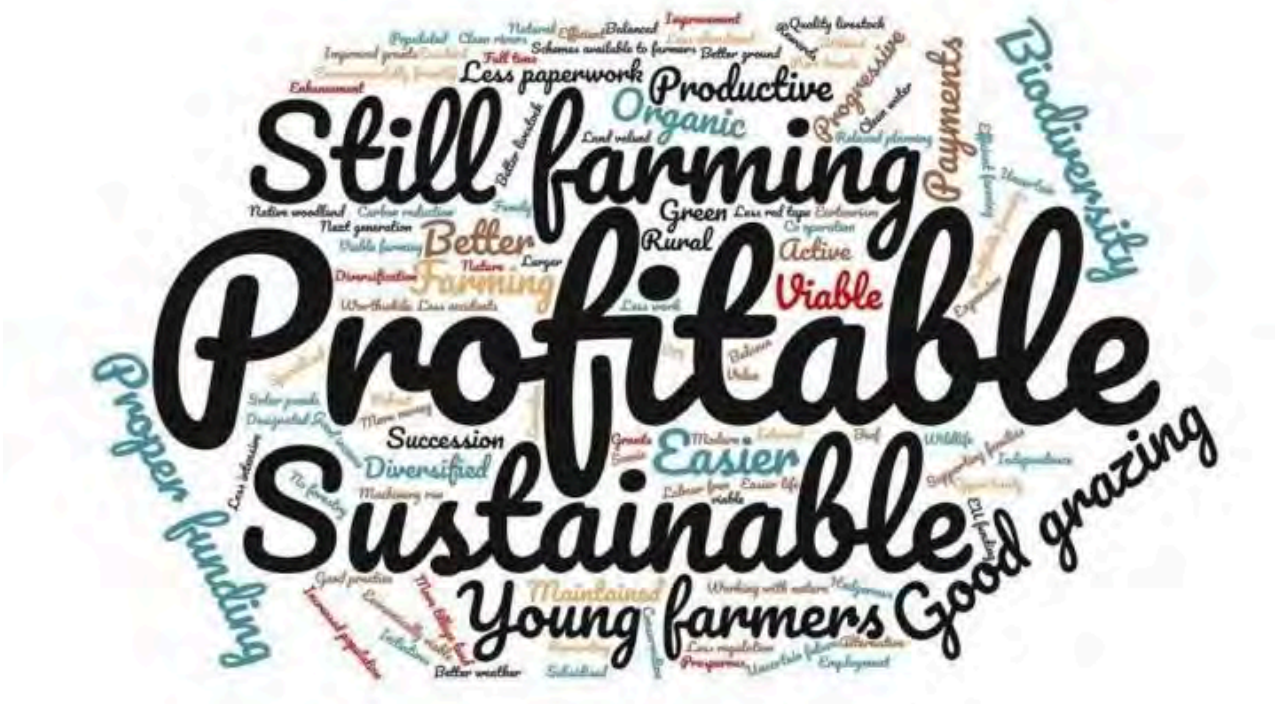



Figure 6. Q4. Describe farming in your area in 20 years' time, in an ideal world

The consultations themselves comprised of a short presentation on what a results-based approach would mean followed by a discussion on how the farmers felt about the approach and what needed to be incorporated into it. The team realised after the first couple of meetings that attendees were expecting scheme details as opposed to a consultation and so in subsequent meetings it was made clear from the introduction what the meeting was and what it wasn't. This was likely a reflection of farmers experience where schemes were developed centrally, and farmers informed afterwards. That was not our intention. It was important to us that the farmers voice was heard and incorporated into the scheme as much as possible.

**Responses to over-arching themes and discussions**

Following the consultations, the HHP team put together the most frequently asked questions along with the reasons why certain things were included in the programme, or were not or could not be included, in the programme. This was made available online and was a useful reference document for Project Officers when dealing with queries. The responses to the main over-arching themes and the discussions are outlined below.

**Programme payment rates**

The Project team had to ensure that the funds available were used to the best possible effect. This required striking a balance between the rate of payment and the number of participants. To do this the Project team had to consider the finite resources available and the need to deliver sustainable agricultural and conservation outcomes. The payment system was designed to deliver a significant payment to those who engaged with the programme and delivered high quality habitats. This approach incentivised success but left the farmer free to choose between a market for agricultural products and one for ecosystem services.

In the consultations with farmers and farming organisations, some were in favour of including every farmer and every hectare in the programme. The idea that participation should be restricted to very large farms was also expressed. Payments of €370 per ha, or payments equivalent to forestry premia, were also proposed. These approaches were not considered to be viable. If every farmer and every hectare was included, the payment rates would be too low (approx. €53/ ha) to achieve the desired results. Such an approach would have presented a high risk of failure and would not have satisfied any 16 of the stakeholders. The higher area-based payments suggested would limit the area covered by the programme to approx. 11,000 ha, and the number of participants to approx. 3-500. Selecting participants, even if the programme were restricted to those with more than 19 ha, would have been an impossible task. A small number of participants would have received very high payments, while the majority would have been paid nothing, such an outcome would have been divisive and was considered likely to cause further discontent.

Even if this approach were permitted by the governing regulation, the area covered would be too small to deliver the required conservation objectives. In addition, the prospects for building community engagement would have been poor as too many people would have been left behind. With both the "paying on every hectare" and the "€370/ ha" models, the net result would be to reduce the prospects of success and potentially undermine future agri-environment schemes. The model chosen was inevitably a compromise, providing worthwhile payments covering as much land and to as many participants as possible.

**The project should pay for the farm plans**

The Hen Harrier Project produced the initial Farm Plan at no cost to the farmer and advisory costs were incorporated into the habitat payments. This was done as part of a series of measures to reduce the impact of advisory costs on farmers. These costs were a concern for many farmers. A number of issues contributed to this: application risk, cash flow implications and the effect on the net benefit from participation.

1) Application Risk: Advisors and farmers were clearly worried that significant investment in a Farm Plan would be required in advance of an application. If the application was unsuccessful, this investment would be lost. The design of the Programme removed this risk by basing selection on existing data sources, i.e. BPS (Basic Payment Scheme) Land Parcel data and Hen Harrier monitoring carried out by the Project. The operation of the selection process only required a single page Expression of Interest form that could be prepared by the applicant at no cost other than postage.

2) Cash Flow Implications: We recognised that even if participants could recoup their transaction costs from future payments, they still experience a negative cash flow impact in the interim. To minimise this, the Project produced the Farm Plan at no cost to the participant. As advisory support would still be required to assess habitats and to apply for Supporting actions, the design of the Programme also narrowed the interval between the need for advisory support and farmer/ programme payments to 3-4 months.

3) Effect on the Net Benefit from the Programme: The funding for the project was limited. The delivery of the scheme required advisory input, and this had a cost. Payments to cover these costs could be made directly by the Hen Harrier Project to the advisor or be made to the farmer who would then be responsible for paying the advisor. Either way, the money was coming out of the same fund. While direct payments from the project to advisors would reduce cash flow issues for farmers, it could have potentially created other difficulties, including linking the advisor too closely to the Project team raising the question of who does the advisor work for and potentially greater overall advisory costs.

A hybrid approach where the project would pay the initial costs and farmers pay the annual costs was considered. This was rejected as it could lead to an expectation that direct payments to advisors would continue, leading to confusion and frustration on the part of both advisors and farmers alike.

It was decided to incorporate advisory costs into the habitat payments to farmers, rather than pay advisors directly, as it is likely that a farmer dealing with an advisor across a range of schemes would be able to get a more competitive price than the Project. Also, it was deemed that direct payments to 17th advisor could create a risk that the advisor would be seen as an agent of the Project rather than as a support to the farmer and finally, the rules for costing payments to participants included provision for transaction costs. The Project team believed that this approach removed barriers to entry and was a cost-efficient way of utilising public funds for the provision of advisory support to participating farmers.

**Confusion and misinformation on rush management**

Delivering optimal structural diversity on rushy grassland is best delivered through targeted grazing by livestock. Cutting and weed licking can supplement grazing in achieving the desired outcome but grazing remains indispensable in achieving the complex sward structures that were deemed to provide optimal foraging territory for Hen Harriers. GLAS has its own rules and participants in that scheme had their contractual obligations to DAFM. In GLAS 1 participants were required to cut parallel strips in grassland dominated by rushes (>70%) to improve vegetation structure. The Hen Harrier prescription in GLAS 2 & 3 was different, allowing for rush cutting but not requiring it. The Hen Harrier Project team were concerned that the focus on rush cutting in GLAS was excessive and that this posed a risk to achieving the projects objectives. There was real concern over the risk posed by mowing to ground nesting birds and small rodents, essential parts of the Hen Harriers prey base. We undertook to continue to work with advisors and DAFM to clarify rush management needs on farms participating in the GLAS scheme and to encourage late cutting to minimise impacts on prey species.

**Perceived Restrictions/Consent Issues on land management**

The Activities Requiring Consent (ARCs) in SPAs designated for breeding Hen Harrier are:

1) Agricultural reclamation of heath or bog. The Hen Harrier Programme recognises the biodiversity value of peatlands and through the bog/heath scorecard rewarded farmers for supporting and enhancing this quality.

2) Construction, removal or alteration of fences, stone walls, hedgerows, banks, or any other field boundary other than temporary fencing. Hedgerows are considered as a landscape feature and must be retained as a condition of the Basic Payment Scheme; this applies to all lands and is not linked to the designation. The Hen Harrier Programme recognised the value of field boundaries including hedgerows and included them in the calculation of the field score on the grassland scorecards

3) Off-road recreational use of mechanically propelled vehicles. The use of all-terrain recreational vehicles is not an agricultural issue and was not part of the programme provided to farmers. We did however engage with Coillte on measures to mitigate harm caused by the unauthorised use of Scrambler motorbikes in certain Coillte properties.

The moratorium on further afforestation in the Hen Harrier SPA areas was an issue for the Hen Harrier Threat Response Plan being developed by the NPWS.



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The requirement for Screening for Appropriate Assessment to be undertaken under Article 6(3) of the Habitats Directives and submitted with any planning application for development of land in SPA areas were a planning issue for the local authority and were beyond the remit of the Hen Harrier Project. The Hen Harrier Project undertook to assist participants with Screening for Appropriate Assessment arising from agricultural activities.

**Confusion and misinformation in relation to regulations**

Discussions with farmers revealed significant confusion on the extent of the regulations that apply in SPAs designated for Hen Harrier, with many convinced that they are not allowed to cut hedges, remove scrub, clean drains etc. Many farmers believed that the full set of ARCs applied on all NATURA designated sites. Whereas the agricultural operations covered by ARCs in these SPAs only related to 18the drainage of bog or heath and to the removal of field boundaries. The maintenance of drains on grassland was unaffected by the SPA designation and the cutting of hedges or the removal of scrub were limited by the legal restrictions applying everywhere, i.e. the prohibition on cutting from March 1st to August 31st. The moratorium on new forestry was introduced in 2013. It was to be reviewed as part of the Hen Harrier Threat Response Plan.

There was clearly a communication problem with the regulatory requirements arising from the designation being misinterpreted by many stakeholders. We believed that many of the issues created or exacerbated by this could be addressed through improved communication between the parties involved. The Hen Harrier Project worked with DAFM, NPWS and farming stakeholders to assist all parties to reach a common understanding of the regulations that apply in the Hen Harrier SPAs.

On designated land, issues also arose in respect of the planning process, these are a matter for the relevant local authority. The Hen Harrier Project undertook to assist participants with screening for appropriate assessment if this was required by a local authority for developments linked to participation in the programme.

The key issues raised by farmers during the meetings are categorised in Table 5 below.

| Issue | Frequency (%) | Mul | SAu | SBe | SBI | SFe | Sta |
|---|---|---|---|---|---|---|---|
| Compatibility with ANC, BPS & GLAS | 77.4 | - | 1 | 3 | 5 | 1 | 3 |
| Eligibility issues and DAFM Penalties | 67.7 | 1 | 4 | 1 | 2 | 2 | 1 |
| Project should pay for the farm plans | 51.6 | 1 | 11 | 4 | 1 | 3 | 5 |
| Payments must be proportionate to forest grants | 48.4 | 1 | 5 | 2 | 6 | 4 | 9 |
| Confusion and Misinformation on Rush Management | 45.2 | 1 | 12 | 5 | 7 | - | 2 |
| Restrictions/Consent on land management | 41.9 | - | 6 | 6 | 3 | 7 | 6 |
| Confusion and Misinformation of Regulations | 38.7 | - | 7 | 7 | 8 | 8 | 7 |
| Scoring System will result in small payments for small farms | 32.3 | 1 | 2 | - | - | - | 4 |
| Should be paid on with GLAS | 29.0 | - | - | 8 | 4 | - | 8 |
| Criticism of NPWS & Designation Process | 22.6 | - | - | 9 | 9 | 5 | 14 |
| Farmers Disadvantaged & Livelihood devalued | 19.4 | - | - | 3 | 10 | 6 | 15 |
| Project should be available to all Farmers in SPAs | 16.1 | - | 8 | - | 12 | 9 | 10 |
| Compensation for designation | 16.1 | - | 13 | - | - | - | 11 |

| Issue | Frequency (%) | Mul | SAu | SBe | SBl | SFe | Sta |
|---|---|---|---|---|---|---|---|
| There should be an appeals process for project scores | 16.1 | - | - | - | - | - | 12 |
| Commonage should be allowed | 12.9 | - | 3 | - | 11 | - | 16 |
| Pine Marten are an issue | 12.9 | - | 9 | - | - | - | 17 |
| Payment should be up-front | 9.7 | - | - | - | 13 | 10 | 13 |
| Don't want to be dictated to by DAFM or NPWS | 9.7 | - | - | - | - | - | - |
| Land that is not designated should be eligible | 6.5 | - | 10 | - | - | 11 | - |
| There should be funding for infrastructure/access | 6.5 | - | 14 | - | - | - | - |

Table 5. Main points raised by farmers during the consultation meetings. Issues that were raised with a frequency of 5% or less are not shown here.

Abbreviations: Mul: Mullaghanish to Musheramore Mountain SPA (n=1); SAu: Slieve Aughty Mountains SPA (n=9); SBe (n=2): Slieve Beagh SPA (n=2); SBl: Slieve Blooms Mountains SPA (n=5); SFe: Slieve Felim to Silvermines SPA (n=5); Sta: Stacks to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (n=8).

## Scorecards

### Scorecard design

Designing scorecards was a key element of the scheme development. They had to reflect the farmed land in the SPAs. The dominant habitat types on these farms were rushy wet grasslands, blanket bog and upland heath, and small patches of scrub and woodland (Figure 7).



Figure 7. The main habitats covered by the scorecards in the Hen Harrier Programme. Clockwise from top left, a typical high quality semi-natural wet grassland field, a species-rich wet grassland field, a bog/heath field with good cover of heather, a scrub/woodland field with birch woodland.



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The design of the scorecards took place on development farms with ecology and ornithology input focussing on the elements that needed to be delivered for the Hen Harrier in conjunction with other ecosystem services. Four scorecards were designed which allowed elements specific to particular habitat types to be assessed. They were Wet Grassland, Species-rich Grassland, Bog/heath and Scrub/woodland. All scorecards had two sections. The first section was an assessment of the Ecological Integrity and gained marks for the field. The second section assessed the Threats and Future Prospects of the field, sections generally got a zero if the threat was absent or negative marks if a threat was present. The greater the threat, the more marks were lost. The scorecards were designed to signal to the farmer what management and resulting habitat features were positive and what were negative from a scoring perspective (Figure 8).



Figure 8. Examples of damaging activities on HHP farms recorded over the Project term. Clockwise from top left, bare soil, turbary on a bog/heath field, dumping of farmyard manure and burning.

The Wet Grassland scorecard rewarded some pollinator services such as flowering plant diversity and abundance, but good vegetation structure received a higher weighting as this was considered a key requirement need for Hen Harrier foraging. Field boundary assessments were also included to improve foraging conditions for Hen Harrier. Small areas of scrub were also rewarded on this scorecard. These are important nesting areas for small birds an important forage resource for the Hen Harrier. It was decided to describe these scrub areas but not to set limits on their size as every field is different and values can detract from the key focus of what these areas are providing for the Hen Harrier. Despite being called the Wet Grassland scorecard, it was applied to any grassland habitat in the Programme. The positive indicator species list covered dry, calcareous and acid grasslands also. This approach reduced confusion for farmers and for advisors who, in most cases, had no formal ecology training, while still ensuring that multiple habitat types could be assessed. If details on grassland habitat types were required by the Project team, these could be gleaned from the positive species listed.

The Species-rich Grassland scorecard was exactly the same as the Wet Grassland scorecard, but the weighting of the categories differed, giving a greater weighting to species-richness and abundance over vegetation structure. Because species-rich grasslands are so rare nationally, a premium was paid for farmers whose fields were species-rich within the SPAs i.e. more than 13 positive indicator plants present.

Key threats that would reduce the score on either grassland scorecard, if present, were land abandonment (resulting in rank grassland and scrub encroachment) and damaging activities such as supplementary feeding or bracken cover.

The Bog/heath scorecard covered a range of habitats but predominantly blanket bog, wet heath and acid grassland. It focused on delivering vegetation structure that would be suitable for foraging and nesting Hen Harriers. This ideal habitat was a mosaic of vegetation, tall enough for the Hen Harrier to nest in along with shorter vegetation suitable for small ground nesting birds, such as Meadow Pipit and Skylark, as these are key food supply species for the Hen Harrier. The scorecard also aimed to reward the delivery of additional ecosystem services delivered by good quality peatland habitats such as intact hydrology (marks lost for drains and damaging activities to strongly discourage practices that impacted on these features).

The Bog/heath scorecard strongly discouraged practices that constituted threats and pressures to this habitat through high negative scores. A -30 score was associated with the most severe, negatively affecting activities for each of the scorecards. This was to discourage such activity by sending a clear signal to the farmer and the advisor that those activities are undesirable. For example, burning can have catastrophic short-term effects on bird populations and can alter vegetation structure in a manner that reduces its value to Hen harriers. Widespread turf cutting (or limited turf cutting by sausage machine extraction) can have very significant long-term impacts on peatland hydrology.

The Scrub/woodland scorecard was designed to attribute value to these small, infrequently occurring habitats within the SPAs. While technically these habitats are not farmed to any great extent, they were considered to be valuable areas for Hen Harriers and other birds. Many Hen Harrier nest sites were located in areas of gorse/ furze often mixed with brambles and Bracken which in many cases were technically ineligible for direct payments. Not rewarding these areas at all could also have had the perverse effect of incentivising their removal to increase the grassland and peatland areas that would be eligible for payment.

The scorecard also included areas of woodland. While woodland is not of direct value to Hen harriers it does provide support for a range of prey species. As a rare habitat in the Irish landscape that needs to be valued, the HHP team decided to include these areas in the Programme. Many scrub and woodland sites were ineligible for direct payments under the land eligibility rules at that time. Including them for payment was possible because the Hen Harrier Programme was not a land parcel-based scheme. Their inclusion for payment helped assign a value to these lands and reduced the risk of clearance. The Project team contributed to discussions with DAFM on addressing the anomaly within the land eligibility rules that posed this risk. The key threats and pressures to these habitats were the presence of invasive species and being a dumping ground for waste materials.

The scorecards and the guidance documents on how to use them are available here http://www.henharrierproject.ie/resources.html.

**Scorecard payments**

All fields in the Programme were delineated, given a unique identifier and assigned a habitat scorecard based on referencing orthoimagery, on the Department of Agriculture mapping system, Generic Land Management System (GLAM). This work was done by the Project team. All land declared in the Basic Payment Scheme (BPS), regardless of the Minimum Eligible Area (MEA), were considered for payment (even where the MEA was 0) in the Hen Harrier Programme, provided one of the scorecards could be applied to it. Some areas such as farmyards, domestic houses, quarries, lakes and commercial forestry were assigned 'Area Not Scorable'. The delineated maps were issued to farmers and made available to advisors prior to the first scoring season.

From 2019 onwards, scores were submitted on a purpose-built app designed to be used in areas of poor connectivity. This was the first use of an app for habitat reporting in an agri-environment scheme in Ireland. A scorecard could be changed in the field if the assigned scorecard was determined to be incorrect. All scorecards could yield scores of between 0 and 10. Scores of 0, 1, 2 or 3 would not receive a payment. The Potential Habitat Points available on each field were also calculated at the time of delineation. These were based on the available Hen Harrier foraging and nesting resource and a relative habitat value. The relative habitat value varied depending on the habitat type and whether the participant was in GLAS or not (Table 6).

Table 6. Habitat values used to calculate the maximum number of points

| Habitat | Not in GLAS | In GLAS |
|---|---|---|
| Species-rich Grassland | 150 | 90 |
| Wet Grassland | 100 | 60 |
| Bog / Heath | 75 | 60 |
| Scrub / Woodland | 50 | 50 |

The reduced value used for participants in the GLAS Scheme was to account for the risk of double payments across both schemes. Compliance with the requirements of GLAS and payments within that scheme were deemed to account for the balance between the rates for land under contract in GLAS and lands farmed outside of that scheme.

The Potential Habitat Points are the maximum points that a field can attain. If a field has a maximum potential score of 100 and receives a score of 5 out of 10, the actual points accrued would be 100 x (5/10) = 50 points. Payments were calculated based on accrued points.

The Programme implemented a degressive payment system. The payments were highest for the first 1,000 points, dropping to a lower level for the next 1,000 points with every point after 2,000 attracting the lowest rate (Table 7).

| Points range | Payment per point (€) |
|---|---|
| 1-1000 | 2.25 |
| 1001-2000 | 1.50 |
| 2001+ | 1.00 |

Table 7. Payment rates per point accrued for Hen Harrier Programme

This approach ensured that smaller farms could still draw down a meaningful payment while also ensuring that farmers with large farms remain incentivised to improve their scores. There was no cap on the amount that a farmer could receive as the use of digressive payments ensured that the risk of an inefficient use of funds was addressed. This system retained the flexibility to adjust the payment rate per point as the budget allowed over the lifetime of the Programme.

**Expressions of Interest and Contract offers to the Hen Harrier Programme**

The Project Team sought to remove barriers to entry to the Hen Harrier Programme. We sought to address the high upfront cost experienced by farmers in Agri Environment Schemes up to that point. Farmers simply had to submit an Expression of Interest form. This was a simple one-page form requesting details of name, herd number, address, phone number and consent for the Project team to access certain LPIS (Land Parcel Information System) data from DAFM. Forms were available online and hard copies were distributed through Farm Advisors and were sent to farmers on request. There was no cost to the farmer other than postage and no advisor was required at this point.

The Hen Harrier Project team operated a rolling intake process, this differed from the tranche-based system operated in previous Agri-Environment Schemes. Offers of contracts to successful applicants were made monthly from December 2017 (just seven months after the award of the contract to the Operational Group). This approach was necessary as there was a real limit to how many farms plans could be produced by the team each month. The date of a contract offer had no real impact on the farmer as payment was for each breeding season as opposed to each calendar year. Intake each month was prioritised as follows.

Category 1: Development Farmers. The farmers who assisted with the development of the Hen Harrier Programme had to make an Expression of Interest, but they were prioritised in the selection process. All development farmers applied and were offered a contract by the end of February 2018.

Category 2: Critical Sites. All farms with land (from 2017 BPS application) within a defined distance of a 2017 Hen Harrier nest site.

Category 3: All other applicants.

Applicants in Categories 2 & 3 were ranked in accordance with a formula that considered the area of designated land they farmed and the proportion of their land that was designated. This was deemed fairer than the simpler metric of designated area. It allowed the small farmer with a large proportion of his land designated to be competitive with his neighbour with a larger holding. Eighty contract offers were made in December 2017 and January 2018; the numbers increased to a minimum of 100 per month from February 2018. The intake ceased temporarily in the summer when it would no longer be possible for farmers to have their lands assessed. The offers made each month were divided between the SPAs based on the proportion of the total herd numbers (in the six SPAs) present in each SPA.

In total 695 contracts were offered in advance of the 2018 breeding season. Over 90% of these were accepted. These farmers represented the largest group ever taken into a results-based agri-environment scheme to that point. Following discussions with the Department of Agriculture, Food and the Marine, a decision was made to continue offering new contracts to interested farmers and to accommodate all that applied. The majority of the additional intake joined the scheme in advance of the 2019 field assessment season, although small numbers continued to be accepted in later years. Ultimately, over 1,600 farmers joined the Hen Harrier Programme (Table 8). Together these farmers managed 36,157.27ha of privately owned SPA land and a further 10,213.9ha of shares in commonages within the SPA network a total of 46,371.21 ha.

The area under contract accounted for almost 70% of the agricultural area in the six SPAs that the project operated in. This made the Hen Harrier Programme the largest results-based agri-environment scheme in Ireland. All these farmers were free to leave the programme at any time without penalty. Barring deaths of participants and a very small number who lost their SPA land due to the expiry of leases (<5), only two farmers left the programme, both of these never submitted an assessment and their participation lapsed in accordance with the specifications.

| SPA | No of farmers |
|---|---|
| Stacks to Mullaghareirk's Mountains | 673 |
| Slieve Aughty Mountains | 594 |
| Slievefelim to Silvermines | 151 |
| Slieve Bloom Mountains | 80 |
| Mullaghanish to Musheramore | 88 |
| Slieve Beagh | 30 |
| Total | 1616 |

Tabel 8. Maximum number of farmers in each SPA at the end of the Hen Harrier Programme

**Supporting Actions and Annual Works Plans**

A crucial component of the Hen Harrier Programme was the supporting actions fund that allowed farmers to apply for, and draw down, funding for actions that would assist with improving scores and thus payments for farmers. Supporting Actions included both direct habitat and wildlife support actions and infrastructure actions such as fencing and the provision of drinking water for livestock. The inclusion of infrastructure actions was both to enhance the capacity of the farmer to deliver improved habitats through improved management, and to ensure the continuation of farming on marginal lands where under-investment had been a feature for many years. Specifications for each supporting action, with details of suitable locations, minimum standards of delivery and payment rates were published by the Project Team and are available here http://www.henharrierproject.ie/HHPActions.pdf. Costings were based on income forgone, costs incurred and transaction costs.

Each farmer was allocated a personal fund of €40/ha of land in the Programme for use on supporting actions. These actions were applied for through GLAM by the advisor. The suitability and location of each supporting action proposed in the Hen Harrier Programme was assessed by the Project team in the context of habitat type and quality, and the potential for disturbance of Hen Harrier nests or roosts during either the undertaking and/or the operational phase of the supporting actions. The assessment also considered if seasonal work restrictions on the delivery of certain actions were required. A Partially Automated Screening System (PASS) made it possible to screen the large numbers of actions proposed (Text box 1).

Text box 1. Details on how the PASS system worked.

Screening of actions was carried out using a Partially Automated Screening System (PASS) which applied a series of tests to proposed actions. For example, one test was “Are there more than 13 positive indicator species present?”. The answers to all tests were either Yes or No. Where the answer was “No”, the test was not relevant, where the answer was “Yes”, a default response was determined by reference to a Rules Matrix. If the action had no “Yes” then it could be approved. If the action had one or more “Yes” then it was examined in more detail before a decision was made. For example, a Wild Bird Cover Strip proposed in a field with more than thirteen positive indicators would be rejected as it would replace an existing important habitat, but a water trough could be approved if it didn’t pose a threat to the semi-natural grassland habitat.

Without the PASS, the effective delivery of the supporting actions part of the programme would not have been possible. This approach was subsequently expanded and incorporated into the screening of Non-Productive Investments (NPIs) and Landscape Actions in the ACRES Co-operation Scheme in the following CAP cycle.

The operation of the supporting actions aspect of the Programme was technically challenging at the scale planned in the Hen Harrier Project. Initially, the approval of actions was intended to be time limited and that undelivered actions would expire. This was to avoid the risks associated with having to retain funds to cover the cost of previously authorised actions until the conclusion of the Programme. However, the impact of COVID-19 (specifically the impact of the lockdowns) delayed the 25delivery of many actions and forced the extension of the authorisation for approved supporting actions.

A total of 992 farmers (61%) applied for at least one supporting action through the Hen Harrier Programme. The actions that were applied for are listed in Table 9. In all, 7,949 actions were applied for. Of those, 682 farmers (42%) delivered 4,057 Supporting Actions over the course of the Hen Harrier Programme. This accounts for 51% of the actions applied for.

| Supporting Action | Number delivered | Delivered length/area |
|---|---|---|
| **Gates** | 1,149 | N/A |
| **Fencing (Permanent Electric Fencing)** | 714 | 149,061 m |
| **Fencing, (Post and Wire)** | 523 | 88,793 m |
| **Water Trough** | 414 | N/A |
| **Water Piping** | 317 | 38,543 m |
| **Wild Bird Cover Strip** | 304 | 44,378m |
| **Fencing (Post and Wire) - Hill Sheep** | 133 | 26,730 m |
| **Access Track - Upgrade** | 126 | 21,635 m |
| **Culvert** | 94 | N/A |
| **Scrub Rides** | 67 | 6,355 m |
| **Flail Cutting** | 52 | 233ha |
| **Planting new hedgerows** | 37 | 3,694 m |
| **Solar Powered Fence** | 34 | N/A |
| **Pheasant Feeders** | 18 | N/A |
| **Pasture Pump** | 17 | N/A |
| **Solar Powered Pump** | 13 | N/A |
| **Bord Bia Quality Assurance Scheme** | 7 | N/A |
| **Targeted Grazing Infrastructure** | 6 | N/A |
| **Other (misc and less than 5)** | 25 | N/A |
| **Totals** | 4,057 | N/A |

Table 9. List of delivered actions and their frequency. Miscellaneous actions and actions with fewer than 5 instances are omitted from this list.

Aside from the standard available actions, participants had the option of proposing any action that they believed might assist with achieving the goals of the programme. There were several actions proposed by participants that the Project team felt would go toward these goals and so were approved by the team and delivered by the participants. These included well, water tanks, drain blocking, wader scrapes, multi-purpose ponds, Willow firebreaks, ram pumps, water storage tanks and rainwater harvesting systems. The flexibility of a bespoke action proposal option promoted innovation within local farming communities. They could assess their own areas, propose solutions, discuss and firm up these solutions with a team of people who wanted to see the solution implemented, submit a defined fundable solution that the Project team could screen and deliver that action with payment following shortly thereafter.

**Hen Harrier Monitoring**

The Golden Eagle Trust carried out extensive monitoring work annually from 2017 until 2022. This work informed the Hen Harrier Bonus payment (described below). Nest and roost site data were used in the supporting actions screening to ensure that actions that might disturb breeding pairs, chick rearing or overwintering birds wouldn't be approved or would be approved with seasonal conditions attached. Monitoring work commenced annually in April and continued across all 6 SPAs until all chicks had fledged from successful nests (usually in July). The data contributed to decisions on nest protection efforts across the SPAs and assisted with decisions on local campaigns such as our wild bird cover demonstration sites. There had never been such an intensive monitoring campaign for Hen Harrier before this. The annual data gave important insights into the impact of weather conditions, fire events and land management on the Hen Harrier breeding pairs and their ability to fledge chicks (Table 10). The monitoring was able to identify pairs that failed early in the season who established a second nest. This data was shared with the National Parks and Wildlife Service and was used to update the boundaries of red zones used in the licensing of forestry activities.

| SPA | 2017 Nests | 2017 Fledged Nests | 2018 Nests | 2018 Fledged Nests | 2019 Nests | 2019 Fledged Nests | 2020 Nests | 2020 Fledged Nests | 2021 Nests | 2021 Fledged Nests | 2022 Nests | 2022 Fledged Nests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stacks to Mullaghareirk's Mountains** | 27 | 13 | 22 | 6 | 28 | 17 | 30 | 13 | 34 | 9 | 30 | 13 |
| **Slieve Aughty Mountains** | 9 | 2 | 6 | 1 | 6 | 4 | 6 | 3 | 7 | 3 | 6 | 3 |
| **Slievefelim to Silvermines** | 7 | 3 | 8 | 2 | 7 | 1 | 6 | 3 | 4 | 2 | 6 | 3 |
| **Slieve Bloom Mountains** | 10 | 6 | 10 | 2 | 10 | 6 | 10 | 1 | 10 | 0 | 10 | 1 |
| **Mullaghanish to Musheramore** | 2 | 1 | 2 | 1 | 2 | 2 | 5 | 4 | 4 | 2 | 5 | 4 |
| **Slieve Beagh** | 3 | 1 | 5 | 4 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 |
| **Total** | 58 | 26 | 53 | 16 | 56 | 32 | 61 | 16 | 62 | 18 | 61 | 16 |

Table 10. Number of confirmed nests and number of fledged nests for every year that monitoring took place from 2017 to 2022.



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**Hen Harrier Bonus**

The Hen Harrier Bonus payment was a key innovation in an Irish Agri-Environment Scheme. The decision was made to pay a bonus based on models developed in Sweden (Lynx and Wolverine) and Finland (Golden Eagle). These bonuses rewarded relevant stakeholders for population numbers of target species. All payment claims received in a given year were considered for the Hen Harrier Bonus Payment. Eligibility required a single field having a minimum score of 6/10 on at least one field, demonstrating a higher than the minimum level of delivery required for a habitat payment. There were two bonus payments that participants could qualify for.

Firstly, the SPA level payment based on SPA level objectives agreed with the steering committee in advance of the following field season. The SPA level payment recognised that due to low numbers of birds and landscape characteristics, that not all areas could expect to have a nesting pair of Hen Harriers, yet these farms may still be making a valuable contribution through the provision of habitat suitable for hunting throughout the year. Those farmers in SPAs which continued to support a stable or increasing Hen Harrier population deserved recognition.

If SPA level goals were achieved, then all participating farmers in that SPA with a field scoring 6 or higher in that SPA qualified for the Hen Harrier bonus. For example, if an SPA reached its objective, then all participants in that SPA with at least one field that scored a 6/10 received a payment. See example below (Table 11) from 2018. Of the 610 eligible participants, 147 received a share in the €100,000 fund. Each share was worth €680.27 (i.e. €100,000/147).

| SPA | 2018 Objective | 2018 Confirmed | Eligible Herd Numbers | Qualified Herd Numbers |
|---|---|---|---|---|
| Stacks to Mullaghareirk's Mountains | 23 | 22 | 258 | 0 |
| Slieve Aughty Mountains | 8 | 6 | 198 | 0 |
| Slievefelim to Silvermines | 4 | 8 | 66 | 64 |
| Slieve Bloom Mountains | 10 | 10 | 41 | 39 |
| Mullaghanish to Musheramore | 1 | 2 | 23 | 22 |
| Slieve Beagh | 3 | 5 | 24 | 22 |
| | 49 | 53 | 610 | 147 |

Table 11. Example of an annual SPA level targets and eligible and qualifying participant numbers.





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Secondly, a local nest or winter roost payment was also available. Participants qualified for the local nest or winter roost payment based on having at least one field with a field score of 6 or higher within 1km of a breeding site/winter roost site, or a successful nest site. They qualified for two shares if that land was within 1km of a successful nest, i.e. a nest where the breeding pair successfully fledged at least one chick. Qualifying participants were identified by intersecting their LPIS parcels with nest and roost data with a 1km buffer added. Any participant with a field within the intersects qualified for the nest/winter roost bonus payment. For example, of the 610 eligible participants in 2018, 124 received a share in the nest/roost €100,000 fund. 36 of those people received a double share. This gave 160 shares. Each share was worth €625. For participants who qualified for two bonus payments, the payment was capped at €1,000.

Farmers could receive both payments up to a maximum of €1000 in 2018 (this increased to €1200 by the end of the Programme. The operation of the bonus payment was analogous to a dividend with dedicated funding being divided each year between qualifying participants. This ensured financial certainty on the overall cost to the project each year. While it did result in some annual variation in the size of the bonus received by participants, this was never a cause of contention. The bonus payment varied annually depending on whether the SPA reached its objective and how many nests were successful. The fund available was reviewed regularly to ensure that the bonus payment remained meaningful. For example, if more people qualified but the fund remained the same, there would have been a reduction in the bonus payment that those people would receive. This was the case in 2020 for example, when farmers in the Stacks SPA qualified for the SPA level bonus (Table 12). The Project team, in conjunction with the steering committee, reviewed the bonus figures on an ongoing basis to ensure that payments were meaningful and in 2020 the available fund was increased to maintain payment levels.

| SPA | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|
| **Blooms** | 41 | 70 | 71 | 72 |
| **Musheramore** | 24 | 86 | 85 | 87 |
| **Slieve Aughty** | 17 | 30 | 109 | 9 |
| **Slieve Beagh** | 16 | 26 | 26 | 4 |
| **Slievefelims** | 66 | 145 | 145 | 2 |
| **Stacks** | 64 | 640 | 630 | 637 |
| **Total** | 228 | 997 | 1066 | 811 |

Table 12. Number of herds qualifying for a Hen Harrier Bonus Payment from 2019 to 2022. Numbers from 2018 available in Table 11.

**Farmer training**

Mandatory farmer training was delivered to farmers in the Hen Harrier Programme. This training was an opportunity to ensure that every farmer who signed up to the Programme knew what it was about. Training topics included the operation of the Result-based Agri-environment Scheme, Hen Harrier Programme Scorecards, Hen Harrier Ecology and Supporting Actions. Training was delivered in the evenings and ran for three hours. This ensured that farmers with off-farm jobs were catered for. Several training sessions were organised in each SPA throughout the winter months to provide as much flexibility as possible.

COVID-19 had a serious impact on the ability to deliver in person training in 2020 and 2021. When the first cases of COVID-19 occurred in Italy, the Project team, with the support of the steering committee, accelerated the delivery of farmer training. By the time of the first COVID-19 lockdown, training had been delivered to over 90% of participants. Following the lockdowns, the HHP team focused on the production and delivery of educational videos.

Links to these films were sent by text message to relevant participating farmers. For example, farmers with cattle and bog or heath habitats would have received a link to the “Managing cattle on the hill” film. Links to showcases showing films on related topics were sent to Hen Harrier farm advisors. Views on the Vimeo site were principally people who followed the link sent to them by the Project team. A significant proportion of participating farmers received a level of training that would not have been possible otherwise.

The direct contact between the project team and every farmer participating in the scheme was very important to the success of the programme. Hearing directly from the programme administrators that they had flexibility, that they didn’t have to do anything additional, or different, and that they could leave at any time, gave the farmer the space, and the peace of mind, to engage with the programme and to try out supporting actions without big risks or outlays.

**Advisor training**

Advisors played a critical role in the large-scale rollout of this results-based agri-environment scheme. While the Project team surveyed the commonage, it would have been impossible to score the private land annually without significant additional resources. The Hen Harrier Project were totally dependent on the use of the advisor resource to operate this large results-based programme. Ensuring that these advisors were equipped to fulfil the important tasks assigned to them was an essential task for the Project team. Training was offered to any advisor who wanted to be a HHP approved advisor. The training consisted of two days in the Winter and two days in late Spring immediately prior to the field season. This comprehensive training included topics listed in table 13.

Table 13: A list of key training topics provided to advisors

| |
|---|
| Introduction-need for the EIP |
| RBAPS for HNV farmland; a new approach |
| The Hen Harrier Project Team; Composition/ Role |
| Agriculture in the SPAs |
| Hen Harrier Ecology- life cycle, behaviour, habitat and prey preferences |
| Hen Harrier population trends and monitoring |
| Hen Harrier Threats- predation, habitat loss and fragmentation |
| Land abandonment and wildfire risk |
| Animal health issues in the uplands |
| The Hen Harrier Programme-design and development |
| The role of the HHP advisor, key habitats and how they will be scored |
| Payments structure |
| Farm Plan & Annual Works Plan |
| Quality control, inspections and penalties |
| Activities requiring consent, archaeological sites etc |
| Interactions with DAFM schemes |
| Training for participants and advisors |
| HHP Supporting Actions Specifications |
| Habitat assessments |
| Threats and Future Prospects |
| HHP mapping system and score submission system |
| Planning a field survey |
| Bog/Heath scorecard and Scrub scorecard |
| Wet grassland scorecard and Scrub scorecard. |

The Spring training had a significant field element. Final approval of advisors was dependent on passing an examination as proof that a minimum standard had been achieved. Scoring fields wasn't possible unless the examination was passed. Advisors who failed this examination were offered a second opportunity to take it. The small number who failed a second time were given one to one instruction, focusing on their weaknesses, before they had a final, third attempt. As payments were dependent on an assessment of the ecosystem services delivered by the farmer it was vital that all concerned; the general public, the farmer, advisors, DAFM and the EU (European Union) Commission had full confidence in the veracity of these assessments. Training for advisors was essential to give this assurance that the scores and the payments based on them reflected the reality on the ground.

The time taken by advisors to do this training was a signal of their (and their employers) commitment to being HHP advisors. To supplement the basic training provided to all advisors, the Project team provided additional one-on-one support or group training where requested. All fields in the Programme were surveyed annually and the time commitment for the advisors in completing this for all their clients was significant. The Project team ran voluntary feedback sessions in the Autumn with advisors to get feedback on the previous season and to identify things that could be done to assist advisors with efficiencies before the next field season. This included feedback on the text in the guidance documents, requests for clarity, suggestions on how things could run better etc. An advisor resource was developed using a shared digital space containing scheme level resources which was available to all advisors. They also had access to the annual field scores and score reports (details of what each field scorecard contained) for their own clients only. The HHP team also implemented a system of farm verification visits annually that helped to inform advisor training needs.

**Verifications**

Farms in the HHP were not subject to inspections by DAFM (inspections were of the Project, not the farmer). Instead, each year between 80 and 90 farms, covering between 2,000 and 4,000ha, were selected for a verification visit by the Project team. The HHP selected 89 farms at random in year one. These farms had all fields with a payment claim in that year (i.e. fields scored) scored again by a Project Officer following the advisor visit. This helped to compile a risk profile that was used in the following 31years. Where the scores submitted by the advisor were different to those assessed by the Project Officer, the farmer was paid based on the Project Officer scores. The verifications were also used to identify training needs for the advisors in two general categories. Firstly, they assisted with highlighting general training needs, for example, when the same issue came up repeatedly, across multiple advisors, the HHP team knew that the scorecard guidance document should be reviewed, and additional training may need to be delivered before the next field season. Secondly, they identified individual advisors who had specific training needs, for example, those who had high numbers of misidentified positive indicators or incorrect vegetation structure assessments. Where this was the case, more targeted one-on-one training was provided to individuals to address specific issues.

**Information and Communication Technology Development**

The Project team in conjunction with our IT (Information Technology) partners (Intuity Technologies) developed a file sharing system using Sharepoint. This allowed secure access to appropriate files by Project Staff and DAFM. A sub-site of this system acted as a support site for HHP advisors. It permitted them to access material relevant to their individual clients including maps, farm plans etc in a secure and confidential manner. Advisors were also able to access reference material that would assist them in their work through the support site. Working with Intuity, the Hen Harrier Project team developed the Dynamics database. This database was used for the collation of annual habitat data, for the calculation of payments, and the screening of proposed actions. It was also used to give appropriate suggestions for field-level management change to improve habitat scores. This gave the farmer and their advisor specific management advice.

A revolutionary innovation for the large-scale administration of results-based agri-environment schemes was the development of an app that was used by HHP approved advisors in the field to score fields and verify the delivery of supporting actions. The roll out of the app to advisors commenced in 2019. The HHP team had some very specific requirements of the app, namely that it could work effectively offline due to the nature of the areas that the app needed to work in. The Hen Harrier SPA farms are in some of the most remote High Nature Value (HNV) landscapes in Ireland.

The IT unit within DAFM worked with the HHP team to further develop the GLAMS system to facilitate the production, approval and printing of Annual Works Plans. Procedures to transfer data from GLAMS to the HHP database were developed in association with DAFM and Intuity.

Our digital partners were shortlisted for the Irish Technology ITAG awards for Best Digital Project, and Best New Talent for one of their staff, who worked on its development in 2019.

The Dynamics CRM also dealt with the screening and authorisation of proposed Supporting Actions. The Annual Works Plan was generated by the CRM and the app that we developed also served as a mechanism for claiming payments for delivered actions. The calculation of payments to participating farmers was calculated on the CRM, the reports generated were shared with DAFM through a shared SharePoint library. In the case of Supporting Actions the CRM produced two reports, the first included the gross value of all Supporting actions approved for payment in the preceding month, the second showed the value of the payment due to each farmer who delivered one or more of these actions. The totals of both of these should be the same. These reports were published on a set date (the 25th of the month and published to the SharePoint site. This facilitated a rapid drawdown of the funds required to make these payments.

The suitability and location of each supporting action approved in the Hen Harrier Programme was assessed in the context of the habitat type and quality, and the potential for disturbance of Hen Harrier nests or roosts during either the installation and/or the operational phase of the supporting actions. The assessment also considered if seasonal restrictions were required. The Project team developed a Partially Automated Screening System (PASS) that gave the Project Officer rapid access to all key data sources enabling a faster decision-making process with a reduced risk of error. Using this system, huge numbers of supporting actions were assessed and approved in reasonable timeframes by a small team of people.

**Text Box 2. Nest Protection App**

An app was also designed to assist Nest Protection Officers with carrying out their work during the 2021 and 2022 seasons. The app was designed to capture location, time and frequency of activity in real time. It reduced the administrative burden on the NPOs and increased the reliability and efficiency of receipt of data. The HHP team also collaborated with NPWS staff to make the app available for nest protection activity beyond the Project.

**Local Actions Fund**

The Local Actions Fund was perhaps one of the most innovative elements of the Hen Harrier Programme. It assisted engagement with local communities and ensured that solutions to issues could be trialled and supported where appropriate (Table 14). Nest Protection activities over the course of the Programme represented the largest drawdown type from the Local Action Fund drawdown.

The fund facilitated several trials over the course of the Programme. The hugely successful feed bucket trial began in 2018 and ran until the end of the programme with demand for feed buckets increasing year on year. Wild Bird Cover demo sites and seed preparation were another important investment. This resulted in Wild Bird Strips becoming the most popular non-infrastructure supporting action delivered over the programme term, a big achievement in areas without any tradition of tillage. Other important investments included Local Area Partnership and Demonstration Farm development activities. The initiation of several of these will benefit the roll-out of ACRES CP (Agri-Climate Rural Environment Scheme Co-Operation stream) in the same areas.

| **Local Action Fund** | **Total (€)** |
|---|---|
| Nest Protection | 412,631 |
| Local Action Grant | 153,784 |
| Feed Buckets Trial | 91,360 |
| Wild Bird Cover | 31,532 |
| Demo farm development | 19,834 |
| Mob Grazing Trial for Gorse Management | 9,136 |
| Fire Recovery | 3,994 |

Table 14. Key Local Action Fund headings and expenditure

**Nest Protection**

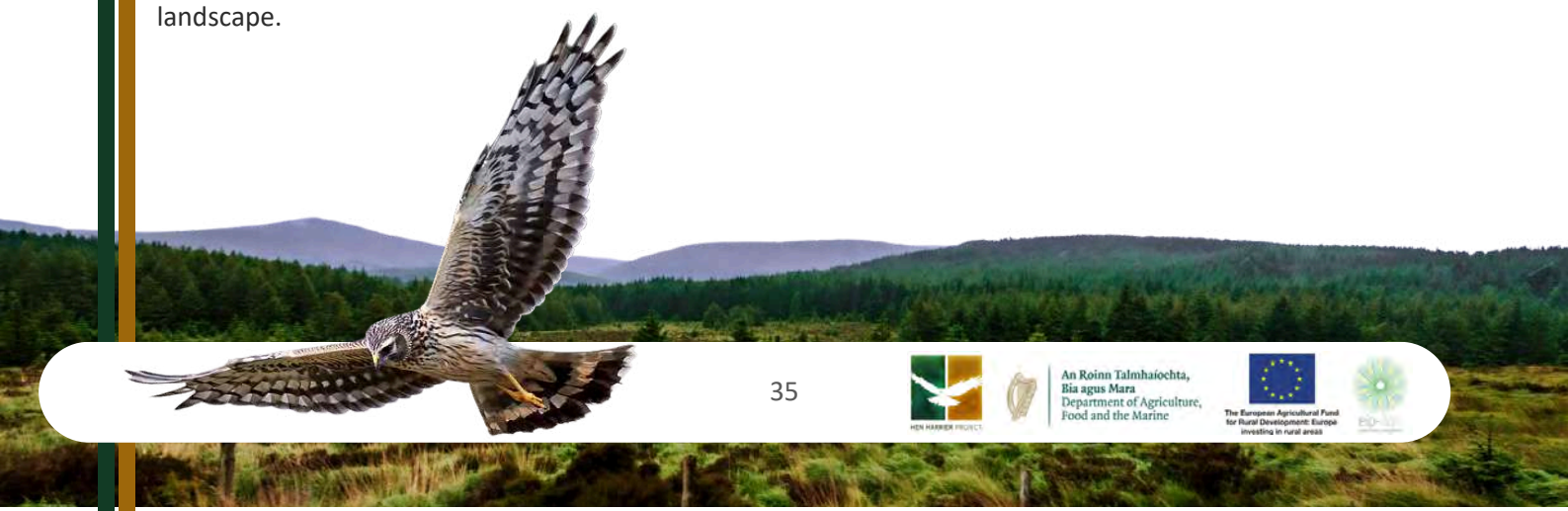
It is recognised that Hen Harrier populations may be influenced by factors such as food availability, illegal killing, poisoning, habitat quality, disease, grazing/livestock movement, human disturbance and predation. The Hen Harrier Project team recognised the multiple pressures facing the Hen Harrier and aimed to address as many of those as possible. The results-based element was designed to help address habitat quality. Education and local outreach campaigns aimed to reduce disturbance caused by activities such as topping rushes during the breeding season or turf cutting. However, nest predation was widely considered to be one of the most significant threats to breeding Hen Harriers.

In the 2015 national survey, 20% of the breeding failures (10 of 49 pairs) was due to predation. Predation by mammals was the third most frequently recorded pressure on the Hen Harrier population in Ireland. Predation by crows and foxes were recorded to be most frequent pressure in the Stacks and Slieve Aughties SPAs. During HHP monitoring conducted in 2017 there were eight nests where predation was deemed the cause of nest failure. It was noted that the risk of predation was particularly high during the late nesting stage. This loss affected approximately 13% of the total SPA nesting population in 2017.

The team felt that, if adequately protected, breeding success at these nests could result in a rapid, direct increase in fledging rates and recruitment to the population. Predation can be a limiting factor in Hen Harrier nest success and studies indicate that (provided no illegal killing of Hen Harriers occurs) predator management could positively influence Hen Harrier populations. Although the evidence for the effects of predation varies widely, losses of Hen Harrier nests in Ireland were relatively high and predator control could serve as a rapid means to increase the productivity of the SPA populations. This could have increased the number of juveniles available for recruitment into the future breeding populations and thereby help reverse population declines. This would be especially beneficial where large scale habitat management was also taking place through the Hen Harrier Programme in Ireland.

It was hoped that the effects of nest protection within the SPAs would have two key benefits. Firstly, direct reduction of predation of Hen Harrier nests and chicks thus increasing breeding success and reduction in mobbing by Corvids improving Hen Harriers energy levels and the delivery of food to the nest; and secondly, indirectly increasing bird biodiversity and helping to increase abundance and breeding success of other ground nesting birds of conservation concern such as Red Grouse and Curlew and prey species for the Hen Harrier such as Lapwing, Snipe, Meadow Pipit and Skylark.

A request to provide a nest protection service was advertised in 2018, 2019, 2020, 2021 and 2022, though the regions covered varied from year to year. This strategy was funded from the local actions fund of the Hen Harrier Programme. Due to the difficulty in providing a comprehensive nest protection service over the entire area of the six SPAs designated for breeding Hen Harrier, resources were concentrated near selected nests based on their vulnerability to predation. This assessment was made by the HHP team considering the previous history of nests at each location and the setting of the nest in the local landscape.





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This strategy sought to reduce the predation risk to Hen Harriers (and other ground nesting birds), but the results were not as good as had been hoped for. There were three reasons for this. Firstly, nest protection efforts could only reduce the pressures on Hen Harrier, not remove them. A key issue was that Pine Marten were a predator in some areas. They were noted close to nests shortly before fledgling loss in the Slieve Aughties for example, but they are a protected species and so could not be targeted. So, while the team focused on foxes and corvids, this did not remove the threat of predation. There was a real concern that control of foxes just led to an increase in predation by Pine Marten, however it was not possible to prove or disprove this hypothesis.

Secondly, the availability of local people with the skills and time to do the job was not consistent throughout the SPAs. While the hunting skills were often present, the conservation focus of this work required full-time management during the field season and the seasonal and dispersed nature of the work mitigated against the recruitment and retention of suitable people. Thirdly, there were significant challenges with the licensing process for this activity. The operation of Nest Protection Officers in pairs was found to be very effective, ensuring that traps could be checked daily and spotter/shooter teams providing more effective fox control. From the perspective of the Project team, the establishment of a formal training and certification for those involved in nest protection, with (if possible) the offer of year-round employment would be beneficial for future schemes.

While nest protection is a hugely important element in the management of landscapes for ground-nesting birds in a fragmented landscape, it is at best just buying time for threatened species. A permanent solution for ground nesting birds must be based on re-establishing the large areas of open habitat that these birds depend on, and the availability of suitable nesting sites remote from the cover that sustains the activity of generalist predators. Agri-Environment Schemes with short funding cycles are not suited to this task or to the development and management of a long-term nest protection resource.





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**Local Action Fund Grants**

The Local Actions Fund Grant was the second biggest drawdown of the Local Action Fund with over €150,000 spent in local communities where project and community goals aligned. The HHP Local Actions Grant fund accepted applications from farmers either individually or in groups, community groups, small local businesses, schools and sports or social clubs serving the community in breeding Hen Harrier SPAs. This fund aimed to provide support for actions that could not be delivered through an individual farm plan. There were three open calls during the lifetime of the Hen Harrier Programme with 42 successful applications (Table 15). Applications could be made under specific themes that aligned with the goals of the Programme, for example, Enhancing Biodiversity, Agricultural Sustainability, Education & Training and Support for local food or craft producers. Anyone within (or close to) the SPA could draw down funds for innovative ideas. Schools, individuals and small businesses all benefited from the fund while the Hen Harrier Project benefited from the local engagement and outreach opportunities that the operation of the fund created.

| Year | Number of Successful Local Action Fund Grant Applications |
|---|---|
| 2019 | 14 |
| 2020 | 10 |
| 2021 | 18 |
| Total | 42 |

Table 15. Number of successful local Action Fund Applications per year.

The successful projects included the Vincent Wildlife Trust, who installed roosts for Lesser Horseshoe Bats in the Slieve Aughties. Cobbs Road Wildlife Trail in Co. Limerick put in plants to provide feeding opportunities for pollinators and birds, installed bird and bat boxes and insect logs, improved their trail surface and improved signage. They also installed a bird hide & viewing equipment. Meenkilly National School, Abbeyfeale, Co. Limerick planted wild bird cover and put in an outdoor classroom with a nature trail, sensory garden & seating. Loughfouder National School, Tralee, Co. Kerry put in a mural, wildflower bed, outdoor classroom/seating area and redeveloped the school's bug hotel while Lough Graney Nature Sanctuary, Co. Clare ran free biodiversity workshops on Hen Harrier for local schools. A river walk was established by the Tidy Towns Committee in Athea, Co. Limerick complete with a statue of a Hen Harrier that was christened "Hedwig" by local school children. The Tidy Towns Committee in Ballyvourney in Co. Cork established a sensory garden, complete with another Hen Harrier statue (selection of images of these in Figure 9).

Figure 9. Top, l-r; Cobbs Road Trail Ashford Co Limerick showing wild bird cover and the bird hide. Middle l-r; Loughfouder National School mural and Meenkilly National School polytunnel and outdoor classroom. Bottom l-r; 'Hedwig', archway, path and tree planting in Athea Co. Limerick.













The amounts of money that were distributed through the Local Actions Fund were small for the individual applicants with the call recommending a maximum value of €5,000 for each grant. The value of these small grants in educating and engaging local communities on the Hen Harrier, the threats the bird faces and its value as something special about their area was immense. Administering these types of grants took staff time and was resource heavy. In many cases, the first application was unsuccessful but where the Project Team could see potential, they worked with groups to improve applications in the future. The ability of the Project to directly pay contractors who delivered works for local communities was also very beneficial as it avoided cash flow issues that could have resulted in no actions taking place in these areas.

These micro grants were part of a strategy to shift attitudes towards the Hen Harrier in areas where the designation of the SPAs had proved unpopular. In conjunction with the Hen Harrier bonus payment, it allowed farmers and communities to access some of the value in the presence of the birds in their area. It helped achieve an attitudinal shift from a situation where the majority were indifferent to the bird's plight, to one where people began to see the Hen Harrier as a shared resource for the community.

**Trials**

**Wild Bird Cover Strips**

While bird cover plots were largely accepted as beneficial for wildlife and were being implemented in traditional agri-environment schemes, they were generally applied to large areas. Wild Bird Cover plots were included in GLAS but their uptake in Hen Harrier areas was close to zero. The reasons for this were obvious. Firstly, establishing a crop requires tillage equipment. The Hen Harrier SPAs are upland areas with no recent tradition of tillage and farmers were simply not equipped to deliver this task. Secondly, many of these farms had very limited areas of good quality land, the little they had was needed for hay/silage or to support livestock with early grazing. These farmers simply could not afford to commit one of their best fields for a crop for wildlife for 5 years. Finally, the benefits of a wildlife crop were never adequately explained to farmers, for most this action was just not a viable option.

To realise the benefits of a Wild bird cover crop, the approach had to change we had to demonstrate that it could fit in with farming operations, the payments had to recognise the costs involved and farmers had to be convinced of both the practicality and the value of the action. The Project team decided to change from a plot, as provided for in GLAS, to a 10 m wide strip. This allowed the farmer to commit a small portion of the field to a crop for wildlife while retaining most of the field for agricultural purposes. The payments had to be increased, recognising the outlay involved in hiring in a contractor for works related to crop establishment and covering the mobilisation costs that this would involve irrespective of area.

Farmers had to be convinced that this was a viable option for them, that a crop could be established and that this crop did support wildlife, not just Hen Harriers, but a host of other species as well. To achieve this, the Project team recruited farmers with suitable land who were willing to host open days on their farms, to establish a crop. This was done outside of the Supporting Actions system so that these farmers retained their allowance for other works on their farm. These open days were a great success, farmers could see a successful crop on land that looked very like their own and on a farm with a similar farming enterprise. Many of them could identify places on their own farm where this approach could work and subsequently signed up for this as a supporting action. The fact that, unlike GLAS, this choice was an annual one and that they were free to change the location, increase, decrease or cease providing a crop, on an annual basis and were not tied into a 5-year commitment was very important, it reassured the farmer that the delivery of this action could adapt to the needs of the farm.

Wild Bird cover crops were the fastest way to increase the food supply for Hen Harriers. Increasing the productivity of habitats close to nests to boost the supply of food to chicks and improving the defence of the nest against predators by reducing the time adult birds spent away from the nest, were key objectives of the Wild Bird Cover strip initiative. Supporting small birds through the Winter leading to an increase in population to breed the following Spring was also important as it was providing hunting opportunities for newly fledged chicks.

The delivery of this crop required that the project team address as many of the barriers to entry as they could. The team developed specifications and guidance for the action, produced training films and organised the delivery of appropriate seed mixes. The strip would be most beneficial when established next to a mature field boundary, ideally a hedgerow (or a treeline or an earthbank), as Hen Harrier like to hunt along linear features and the cover from the nearby boundary maximises the benefit of the bird seed for small birds and mammals. The team devised a seed mix that would grow effectively in fields with poorer drainage and more acidic soils which were typical in the SPAs. The seed mix was packaged by the Project team and distributed directly to farmers approved for this action. This action was delivered on SPA designated lands and on undesignated land within 1km of the boundary of a breeding Hen Harrier SPA. It was not available on Special Area of Conservation (SAC) designated sites or on species rich grassland, Bog/Heath or Scrub/Woodland fields. On wet grassland fields this action was not available if the number of positive indicators was greater than 5 and the cover of positive indicators was above a certain level to ensure that an important permanent semi-natural grassland habitat was not replaced by a temporary crop. The crops were sown as a 9m wide strip, running parallel to an existing boundary with a further uncultivated area at least 1m wide between the crop and the boundary. The crop had to contain a cereal crop (preferably Triticale) and Linseed. Other seeds such as Buckwheat, Mustard, Fodder Radish, Forage/ Oil Seed Rape and Vetch could also be included in the seed mix (Figure 10).

The sowing rate was 7.5 Kg of Triticale/ 100m strip and 1.5 Kgs of Linseed. Other seeds were included in much smaller quantities. Triticale was the recommended cereal crop as it had considerable advantages over Oats. It is better suited to acidic soils and poor ground conditions. It also had stronger straw which delayed lodging and the chaff on the seed triticale made it less attractive to birds and rodents, ensuring that seed consumption was delayed until other food sources were depleted, thus ensuring that a significant feed resource was retained into the mid-winter period. All of this required testing and recommended seed mixes changed over the course of the Project in response to lessons learned. Buckwheat was dropped and fodder radish or stubble turnips promoted.



Figure 10. Clockwise from the top left, wild bird cover seed mix provided to HHP farmers, field preparation in advance of seed being sown, seed being sown, triticale and buckwheat in flower, triticale, seed heads of radish, linseed, triticale and buckwheat.

The team worked with farmers in the Programme to trial Wild Bird Cover across the SPAs. Once the seed mix was confirmed, the Project team also had to establish local demonstration sites that farmers could visit to see that these strips would work on their farms. While small-scale crops would have been planted on many of these farms in living memory, the practice is not current, and many farmers would not have planted a crop in decades.

The establishment of these demonstration sites and the running of the open days took significant time and resources. The result of this investment was the delivery of over 44km of Wild Bird Cover strips delivered by 120 farmers as supporting actions before the end of the Programme. The investment in piloting and demonstrating Wild Bird Cover strips was necessary to engage and mobilise farmers in these areas early in the Programme cycle. This investment was rewarded by the establish of significant extra food sources for the Hen Harrier throughout the Programme. The lessons learned here allowed Wild Bird Cover strips to be included as a Non-Productive Investment (action) in ACRES CP which began in 2023.

**Upland Grazing Trial**

The grazing of upland pastures (particularly peatlands) by cattle at suitable stocking densities can have a beneficial effect on biodiversity. It could also reduce wildfire risk by preventing the excessive dominance of Purple Moor Grass (Molinia caerula). Reducing the dominance of Purple Moor Grass could benefit other plant species and thus plant biodiversity. Carefully managed extensive grazing can also improve the utilisation of these upland pastures, securing their continued eligibility for direct payments and freeing up lowland areas in summer for silage production. Summer grazing of uplands was traditional practice, we sought to demonstrate that it could still be used to deliver valuable ecosystem services that supplement the value of agricultural output from the land.

The forage available on the uplands changes dramatically during the growing season. In early summer, Purple Moor Grass growth is supported by nutrients stored over the winter in the plant's roots. In early summer, the nutritional value of this grass can be quite high, but this falls off dramatically after July. Cattle introduced to the hill from August onwards may avoid areas of dense Purple Moor grass due to its reduced palatability that late in the summer. This can result in under-grazed Purple Moor Grass dominating large areas. In Autumn the plant begins transferring resources to its roots and the leaves start to die off. Its dead leaves give many peatlands a familiar beige grassy look in winter and spring.

The dead leaves dry out rapidly during periods when moisture levels are low, particularly when the wind is coming from the Southeast and create a substantial spring wildfire risk. Burning (controlled or otherwise) does not address the problem as the living part of the plant at this time of year is below ground and is unharmed by spring fires, allowing it to flourish again after the fire has passed. In fact, fires kill off competing plants leading to increased dominance by Purple Moor Grass. These spring fires pose a serious risk to wildlife, including the Hen Harrier. They also threaten the eligibility of land for direct payments and are a risk to people and property. They destroy agricultural infrastructure, including fencing, and tackling them uses important fire brigade and defence force resources.

One way to address these issues is through grazing cattle on the uplands during the summer months. Introducing a few cattle or ponies is unlikely to be enough, particularly on large sites where animals may just congregate in favoured areas, leaving large areas under grazed. Management is needed to achieve a more targeted grazing pattern. The HHP sought to support suitable stock in upland sites in June and July when the nutritional value of Purple Moor grass was at its highest. Defoliation through grazing at that time of year could reduce the amount of litter available as fuel the following Spring. It could also prevent the transfer of nutrients to the plants roots in Autumn reducing the vigour of the plant the following year.

We wanted to encourage cattle to utilise areas of the site that they would tend to ignore. Finally, we wanted to ensure that cattle extracted the maximum nutritional value from the grazing available and retained, or better still, put on condition, whilst delivering a valuable ecosystem service.

To achieve these objectives, we needed to optimise land management in a manner that delivered a profit from the animals used to deliver ecosystem services. Ideally, the farmer could derive an income from both strands of this process, an income from the sale of cattle and a payment for the delivery of ecosystem services from the Hen Harrier Programme. The HHP team worked with Devenish Nutrition, Dawn Meats and participating farmers to achieve these objectives and unlock the potential of cattle grazing in the uplands.

In conjunction with Devenish Nutrition, we developed a Low Moisture Feed Block (Figure 11). This was a new product unlike anything else on the market. It had a high protein content which helped with weight gain, but it also provided an additional nitrogen source in the form of feed grade Urea. This supported bacteria in the animal's gut and helped ensure that plant matter was fully digested and its nutritional value to the animal maximised. Bacteria in the rumen are very important for the cow. They produce amino acids and proteins that the animal then absorbs, and they help break down cellulose in the diet. However, the animal's diet can determine how effectively these microbe's work. A diet of upland vegetation is often low in nitrogen, and this can reduce microbial activity and consequently the value that the animal gets from its diet.




Figure 11. Devenish Nutrition feed buckets developed for the Hen Harrier Programme.

By supplying vitamins, minerals and nitrogen, the feed blocks help improve the efficiency of the animal's digestive system. This provides the energy the animal needs to carry out the desired conservation grazing while putting on weight and condition.

The blocks developed by Devenish for the Project are not safe for sheep or horses due to the levels of trace elements such as copper, iodine and selenium. On lands where horses were present an alternative commercial block was used instead. The blocks can attract animals into the parts of the site where there is a need to focus grazing. The opposite is also true, the buckets can be used to reduce grazing pressure in particularly sensitive habitats by drawing animals away during part of the grazing season.

As part of a demonstration, the blocks were initially supplied free of charge to a small number of farmers in the Slieve Aughties SPA and the Stacks to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA Mullagherierks SPA in 2018 and 2019. These farmers' animals grazed upland Purple Moor Grass dominated sites for 60-81 days during June, July and August over two years. Older cattle, often cull cows were used as it was thought that animals with a mature digestive system would do better on the upland vegetation. Older animals with a mature skeleton may also be better suited to environments with low levels of calcium and phosphorous in the vegetation available as forage.



Cattle in participating herds were weighed (free of charge) before going to the hill and again after coming down. In 2018, of 44 animals across 10 herds, 42 animals gained between 0.22 and 1.87kg per day. The average weight gain was 0.81kg/day. In 2019, of 49 animals across 4 herds, 45 animals gained between 0.05 and 1.73kg per day. The average weight gain was 0.91/day. The best performance was on Purple Moor Grass dominated sites at low stocking rates (the best performing herd was grazed at a stocking density of 1 LU/ 6 ha for 60 days). This herd consumed 0.8gs of feed block per animal per day in 2018. The planned intake was 0.35 Kgs. This led to the development of a harder lick in 2019 to reduce intake in future seasons.

In 2018, animals were finished on grass before going to the factory. The cattle were fit for slaughter after coming down from the hill and didn't put on any notable additional weight on the lowlands in 2018 before going to the factory (Figure 12). In response to this, animals went straight from the hill to the factory in the 2019 trial.



Figure 12. Aberdeen Angus Cull Cow at the beginning of the trial (left-hand side) and at the end of the trial (right-hand side) in the Slieve Aughty Mountains in 2018.

Devenish Nutrition supplied the feed buckets required for the demonstration and adjusted the feed bucket composition based on feedback from participating farmers. For example, following feedback from farmers who used the product in 2018 the size of each bucket was reduced from 25Kg to 18Kg, and an improved handle was incorporated to address ergonomic concerns. The results helped fine tune the feed block which was subsequently supplied to Hen Harrier Programme farmers until the Programme ended in 2022.

The HHP paid for the transport of animals from where they were purchased, to the farm, paid for a veterinary check and the cost of any dosing or vaccinations required and provided the livestock weighing service as mentioned above. The Project team managed the logistics of distributing the feed buckets and salt licks while the farmer was paid €216 for their time in engaging with the project team. This payment was in addition to any payment due under the Hen Harrier Programme.

Dawn Meats supported the trials by guaranteeing a processing outlet for finished livestock; and providing a production premium. They bought the animals from the farmer at the end of the demonstration. They paid 10c/kg over and above the national average price for animals of that grade as quoted in the Farmers Journal for the week that the animals were sold. They paid an additional 4c/kg if these animals met Dawn Meats quality standards. Dawn Meats used the meat from these animals for market testing to establish how a market can be developed for meat produced through sustainable farming in the uplands (Figure 13)



Figure 13. Hen Harrier Project farmer Dan O'Donoghue with representatives of Bord Bia and Dawn Meats.

Beef from some of the animals in these trials was served at a number of events in 2018 and 2019. It was an option on the menu at the Teagasc Agri-Environment Conference in Gort, Co Galway on October 25th, 2018, where it was a hugely popular choice, and the feedback was excellent. It was also on the menu at the awards dinner for the Listowel Food Fair on Saturday November 9th, 2019. Two farmer events were held to show the Project teams appreciation to the farmers involved in the trial and to give them an opportunity to sample the mountain beef that they had produced. These were held in Kennedy's, Rearcross, Co Tipperary on 12th November 2019 and the Horseshoe Bar, Listowel, Co. Kerry on 30th October 2021.

In 2020 the feed blocks were offered at a supplemented rate to farmers in the Hen Harrier Programme. Pallets of blocks were delivered around the SPAs where there was demand. This approach was very resource intensive and as a result, in 2021 and 2022, the blocks were delivered to local independently owned co-ops where Hen Harrier Programme farmers could collect them. The cost of the blocks was supplemented by the HHP, and the remainder deducted from the farmer through the Hen Harrier Programme Habitat Payment (this ensured that there were no barriers to trying this innovation for the farmer).

This trial was instrumental in bringing abandoned and under-utilised lands back to active management across the SPAs. The benefits extended beyond fire control. The support from the HHP team gave farmers the ability to incorporate SPA uplands into their upland farming enterprise with more certainty from a habitat management, animal health and forage perspective. The score for many of the fields involved in these trials also increased.

**Grazing gorse trials**

In the Musheramore SPA, 90 farmers participated in the Hen Harrier Project EIP between 2018 and 2022. Large parts of the area are peatlands, mountain and upland grassland but some more iintensively managed lowlands are also present. The main farming enterprise in this area are sheep, beef, dairy and a mix of each on some farms. Farmers regularly commented during information meetings and training days that their uplands are becoming undergrazed and hence, a fire risk. The main issues being Purple Moor Grass dominance and the presence of European Gorse and Western Gorse on the land. Farmers asked if the HHP team could focus on this issue and assess what could be done to help them manage their land better and in an environmentally friendly way.

The team undertook to explore the targeted grazing solutions to both the Gorse and mixed Autumn Gorse/ Purple Moor Grass situations. The trials consisted of three separate approaches,

1. Using Goats to control mixed Gorse (Ulex europaeus), Brambles (Rubus spp), Willow (Salix spp) scrub

2. Using Horses/ Goats to manage mature Gorse (U. europaeus).

3. Using Horse to manage mixed Autumn Gorse (U. galli) and Purple Moor Grass (Molinia caerula)

Three sites were identified for these trials, Trials 1 & 2 were on a farm in Ullanes East near Ballymakeera, Co. Cork, trial 3 was on a farm in Ullanes West. On the land used for the Goats trial an area of approx. 0.3 ha was fenced off with three strands of temporary electric fencing and a water supply laid on. The water supply was a gravity fed system sourced from a nearby stream feeding two water troughs within the trial area. The site contained a small number of mature trees and a large area of Gorse with Brambles and Willow, there was a small area of grassland around the periphery. The site was stocked with 20 Saanen Goat (a dairy breed) wethers but most of them were relatively young c. 2 yrs old. The animals were introduced in March 2021 and remained on the site for 3 weeks.

Goats on mixed Gorse, Bramble and Willow Scrub

The Goats browed the Brambles and Willow preferentially, only moving to the Gorse after the other species were largely exhausted. Browsing on the Gorse was predominantly on the tips with limited bark stripping, however some of the mature trees present did suffer some bark damage, when this was observed the trees were protected with welded 2cm mesh wrapped around their trunks to a height of 2m. The goats remained on the site for three weeks. Interestingly although the goats could clear the fence, their strong social habits meant that animals that did clear the fence did not venture far and, in all cases, returned ty themselves to rejoin their flock.

Overall, the results were disappointing while much of the scrub was cleared, recovery after the removal of the goats was very rapid. The team accepts that the animals used were too young and too light and that larger/ older animals form a meat breed may have performed better. Recovery of fast-growing Brambles and Willow is inevitable in the absence of continued management in the summer months. It is possible that a mixed flock of Sheep and Goats could provide this. The Sheep could compete with Goats for summer grass and encourage them to browse on recovering Brambles and Willow although this approach was not tested in the trial. Using Goats to control scrub can be effective but is likely to be of very limited utility in an Irish context, primarily due to the difficulty in sourcing large numbers of suitable animals.

**Horses on Gorse**

The site had a dense, high cover of European Gorse, up to 3m high in places with brambles also widespread. The farmer had cleared the site of gorse mechanically five years previously, but with a large seed bank and no competing vegetation recovery was rapid resulting in a dense even aged stand up to 3m tall due to the difficulty of access and the abundant alternative grazing available on nearby grassland.

The farmer agreed to help manage a grazing of European Gorse trial through a combination of horses and goats for a payment of €200 plus a daily rate of €24.80 for the 9-week duration of the trial. The trial commenced in February 2021 and ran until April 2021. The farmer agreed to the following:

1. Allow mulching of narrow strips of gorse to allow HHP team erect required fencing for animals
2. Check animals daily and ensure they are in good health
3. Retain animals in the prescribed plots for the duration of the trial
4. Ensure adequate water and feed buckets were always available to animals
5. If weather was to deteriorate, the farmer would have to provide hay to the animals as an additional feed source.
6. Fences were to be checked daily including solar powered fence units
7. Animals to be re dosed if required
8. Allow video recording of the trial on three occasions by HHP
9. Assist the project officers where required

The area involved was approx. 0.4 ha (c.1 acre). It was fenced off with a temporary electric fence powered by a solar charger and stocked with six horses in early February 2021 (Figure 14). The horses were mature females. No pregnant animals or mares with foals at foot were used. The trials were restricted to non-breeding females to avoid possible risks from poorer nutrition to animals with high nutrient requirements. Stallions were not used due to the perceived difficulty of containing them in a small area. If suitable Gelding had been available, they would have been considered. They were in good, healthy, condition at the start of the trial. The animals grazed the site for 6 weeks and left at the end of March. After the horses left, a small herd of goats were introduced, and they stayed in the field for a further 4 weeks. Daily monitoring of the trial was very important to ensure there was no animal welfare issues.

Before the start of the trial, there was very little vegetation under the gorse, the canopy kept the ground in deep shade and there was a thick layer of litter (mostly dead gorse leaves and twigs). During their time on the site, the horses grazed the grassy areas in between the gorse first and as this resource was depleted, they turned to the gorse. At this time of year, the sap is starting to rise in the gorse stems increasing their palatability. From the beginning horses browsed the Gorse focusing largely on stripping the bark from the ground up. They also grazed the spikey leaves of the gorse, but the bark was more attractive for them. The passage of large animals through the site physically broke a lot of gorse stems and created paths through the previously impenetrable scrub. These were of value later on when the goats were introduced which opened the site up for the goats and allowed them to access the entire area. By the end of the grazing period evidence of bark stripping and stem breakage were widespread.




Figure 14. Site preparation for the gorse grazing trial. L-R Trial site before grazing, site preparation and fencing.

Members of the Project team visited the site at the end of July 2021 to see how the vegetation had developed over the summer. During the follow-up visit, it was observed that many gorse plants had died, and others had a sickly yellowing appearance. This level of die off apparent after just 4 months was a surprise. The bare soil was completely colonised by grasses and annual weeds. The growth was very lush as a result of the canopy opening up and light reaching the ground. Trampling by the horses incorporated much of the gorse litter into the soil and probably resulted in faster decay times and the release of nitrogen to the soil. This undoubtedly helped many of the grasses. Gorse recovery from seed was very limited, but new shoots from root stocks were relatively common. New growth from once dormant buds along the stems was also commonplace. This may have been encouraged by damage higher up on the stem and by the increased light levels nearer the ground.

Brambles were abundant, although still small. While these were always present at some level, there was a risk that they could become problematic without further management. Brambles likely benefitted from the increased light levels, the disturbance of the litter layer and the high levels of available nitrogen arising from the breakdown of gorse litter. It was clear that ongoing management would be required. Grazing continued with sheep for the rest of that summer. The gorse regrowth was still very soft and vulnerable to grazing, knocking it back by targeted goat and sheep grazing could prevent recovery of some plants. Simply abandoning the site would allow much of the gorse to recover. It was considered likely that recovery of Gorse would initially be mixed in with a lot more brambles and as recovery proceeded with a diminishing supply of grasses, until eventually a dense Gorse canopy re-established.

The Horses were reintroduced in the following January/ February. The dead stems of gorse were very brittle by this stage. It was expected that trampling by the horses would break them down opening the site up further. Grazing and trampling by horses in January/ February could also help control brambles before they got out of hand, as well as causing further damage to the remaining gorse plants. This helped complete the transition of the site to the more open mosaic of grassland and scrub that was planned.

In hindsight, the contribution of the goats was probably minimal. There were too few of them and they were physically too small. The timing and duration of their grazing ensured that most of their browsing was on the soft young growth of Gorse, a pattern that was unlikely to have had a long-term impact on the vegetation. The horses on the other hand appeared to have a dramatic effect. Grazing at a high stocking rate (11-13 LU/ Ha) for a short period in late Winter/early Spring, had a considerable impact on the gorse. Stem breakage and bark stripping causing almost immediate, and long term, impacts.

In summary, late Winter/early Spring grazing of horses holds a lot of promise for managing gorse. However, it must be focused, i.e. the animals must be confined at a relatively high stocking rate at a very specific time of year, and it has to be followed up with summer grazing. All of this requires careful management, and this has a cost. At key sites, where the management of gorse is beneficial, the increased management costs could be supported as a landscape level intervention in a future agri-environment scheme. Overall, the trial went very well and showed that great progress can be made on sites like these with some planning and investment. Targeted grazing of gorse using horses is now a landscape action in the ACRES CP scheme.

**Horse on Autumn Gorse and Purple Moor Grass**

Project staff worked with farmers in Ullanes West area of the Mullaghanish to Musheramore SPA to trial the use of the targeted grazing of horses to manage dense Autumn Gorse/ Purple Moor Grass with the aim of increasing biodiversity and reducing wildfire risk. This approach was inspired by similar work in Northern Spain where Autumn gorse poses a serious fire risk and rural depopulation and a reduction in farming activity is contributing to its spread.

In 2021 approx. 3ha was temporarily fenced off and grazed with up to 5 horses for July and August. In early September, the fences were lifted, and the horses allowed to graze the entire site. In 2022, another 3ha adjacent, to the 2021 site was fenced off and grazed in a similar way. Ideally a rotational grazing system where horses graze each block hard for one summer in four would be introduced.

To date the results have been very encouraging, with reduced levels of Purple Moor Grass litter in the area that had targeted grazing in 2021 and a greater diversity of other grasses, hard rush and flowering plants, less large tussocks of Purple Moor Grass compared to the areas outside the 2021 trial.

There are considerable benefits in using horses for this purpose,
1. Their method of grazing, biting the Purple Moor Grass off very close to the ground greatly weakens the plant and reduces the amount of litter produced and the dominance of the species
2. Horses have large appetites and consume a lot of vegetation
3. There is no risk of the animals contracting TB from deer
4. They are active and cover a lot of ground and create a lot of structural diversity by breaking down paths through tall vegetation. Autumn Gorse is not susceptible to bark stripping in the same way as European Gorse but it is vulnerable trampling. Large animals like horses can break it down in places allowing recovery of Heather and herbaceous species.

While they are hardy they do need to be looked after, feed blocks to supply minerals are essential, horses should not be kept on site for too long and they have to be checked on a regular basis.

Conservation grazing can be used to improve habitats and reduce fire risk. As we move into the new ACRES scheme the Hen Harrier Project will be disseminating the lessons learned in trials like this. Employing cattle and horses for the summer control of Molinia and horses for the winter/ early spring management of Gorse.

The use of Horses for targeted grazing on mixed Autumn Gorse/ Purple Moor Grass dominated sites is being introduced as a Landscape Action in the Acres Co-operation Scheme.





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**Conifer treeline removal trial**

A farmer in the Slieve Aughty Mountains SPA approached the HHP team about restoring a riparian area along the Corra river on their farm. Following field visits and discussions, a riparian rehabilitation plan was proposed. This involved removing the conifer treelines along the riparian edge of the field and encouraging natural regeneration by excluding grazing animals along with additional native tree planting on surrounding boundaries. A total of 72 mature conifer trees were removed in Turkenagh, County Clare. This work was carried out in October and November in 2022 by specialist contractors. Approximately 40 of these trees were situated on a 200m long earth bank, the rest of the trees were along the Corra river itself. Many of the trees were very large with a circumference of 120cm at chest height. The subsequent planting of native trees along the earth bank was done to stabilise it and provide good foraging habitat for Hen Harrier. In comparison, the conifer treeline provided a vantage point for predatory/nuisance species to Hen Harriers such as corvids and little in the way of hunting opportunities.

The large conifers blocked light reducing the diversity of plant species with consequent impacts on wider biodiversity. The trees also posed a risk to the ecology of this stretch of the Corra river by keeping the river in almost permanent shade. Care was taken when removing the conifer trees to ensure that they landed in the field and not in the river (Figure 15). The brash was removed and left in piles to decay naturally, the logs were cut into 3-meter lengths. These logs were then removed from the site by the farmer. Each side of the earth bank was fenced with sheep wire fencing, as was the boundary along the river. Two crossing points were maintained by installing gates to ensure access for grazing on the plots on the other side of the river.



Figure 15. Field boundary in Turkenagh Valley, Co. Clare before and after conifer treeline removal

Two staff members carried out a baseline survey of the plant community present on the site where conifer trees were removed and where tree planting took place. 100 native trees were planted on the site in February 2023. Sixty on the earth bank and 20 along the riverbank (some cuttings of the willow already present on the site were also taken and planted here). Another 20 trees were planted in an area where erosion had caused the existing fence to collapse into the river – this corner of the field was fenced off to encourage the existing vegetation to develop and help stabilise the bank. The trees species planted were Birch, Oak and Mountain Ash. Biodegradable, spiral tree guards were used to protect the trees from deer and hares.

This type of restoration plan would not have been possible without the willingness of the farmer, their trust in the Project team and the flexibility of the Local Action Fund. Similar to the Wild Bird Cover strips, lessons learned here allowed conifer treeline removal to be included as a Landscape Action in ACRES Co-operation scheme.

**Invasive species treatments**

The presence of invasive species was recorded on a field level in the HHP scorecards. These data were analysed and, the areas where invasive species were concentrated, identified. Japanese Knotweed was the most recorded invasive species. Farmers in areas with Japanese Knotweed on their farm were invited to attend workshops run by a specialist contractor on the correct method to treat Japanese Knotweed. Two injector kits were bought by the Project team and were loaned to farmers who had completed the training, on request. Additionally, a specialist contractor was funded by the HHP to treat infestations on farms where the farmer couldn't deal with it themselves. Follow up treatments were funded in subsequent years to ensure that this invasive species was appropriately dealt with. The experience gained in these trials was hugely beneficial for two key reasons. Firstly, they were useful proof of concept exercises. It proved that data collected through the scorecards could be used for more than just calculating a payment, it could also be used to identify training needs and target interventions to address environmental challenges. Secondly, this approach allowed the team to develop the specifications and costings that would be required for the roll-out of such actions on a large-scale. These lessons provided a good basis for Landscape Actions for removal of invasive species in the ACRES CP scheme.





A stand of Japanese Knotweed was removed from a commonage in Co. Clare through this process. Commonage shareholders attended the workshop where we established that the infestation was too well established for them to be able to effectively treat it themselves. A specialist contractor was funded by the HHP to treat it beginning in 2021, with a follow up treatment in 2022.

Text box 3. Japanese Knotweed treated on farms during the Hen Harrier Programme

## Key Performance Indicators

### Field scores

The total land area in the Hen Harrier Programme in 2022 was over 46,000 ha. The dominant habitats were wet grassland and bog/heath. Less than 10% of the farmed land in the six SPAs for breeding Hen Harrier comprised species-rich grassland or scrub/woodland (Table 16).

| Habitat | Commonage area (ha) | Private land area (ha) | Total area (ha) |
|---|---|---|---|
| **Wet Grassland** | 361.98 | 21,151.47 | 21,513.45 |
| **Bog/Heath** | 9665.03 | 11,363.80 | 21,028.83 |
| **Species-Rich Grassland** | 21.70 | 2,062.15 | 2,083.85 |
| **Scrub/Woodland** | 165.23 | 1,579.85 | 1,745.08 |
| **Total** | 10213.94 | 36,157.27 | 46,371.21 |

Table 16. The total area of private land and commonage in the Hen Harrier Programme in 2022 by habitat type

The Hen Harrier Programme success can be measured through the scored land. Year one of this type of scheme provides an essential baseline for the condition of the target habitats. The average score per habitat can give us an overall picture of what is happening in an area in any given year (Table 17).

### Private field scores

Overall, there was a significant increase in the field scores from 2019 to 2022 (Table 17). The wet grassland fields rose from an average of 5.21 in 2018 to 5.86 in 2022. In whole number terms, this is an increase from a score of 5 to a score of 6. This is important as the farmer was paid on the whole number score. The species-rich grassland scores were higher on average. This is not surprising as these fields are, by definition, unimproved, semi-natural grasslands. Again, in whole number terms there was an increase in score from 6 to 8. Bog/heath fields showed a similar pattern moving from a score of 6 to a score of 7 in whole number terms. The scrub/woodland fields had no significant increase. The average score tells a lot but can also hide some of the finer details.





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Table 17. The number of fields, average score per habitat type and standard deviation of the mean for private fields across each year of the Hen Harrier Programme

| | 2018 | | | 2019 | | | 2020 | | | 2021 | | | 2022 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Habitat** | **No of fields** | **Avg Score** | **Std Dev** | **No of fields** | **Avg Score** | **Std Dev** | **No of fields** | **Avg Score** | **Std Dev** | **No of fields** | **Avg Score** | **Std Dev** | **No of fields** | **Avg Score** | **Std Dev** |
| **Wet Grassland** | 6,377 | 5.21 | 2.71 | 13,390 | 5.42 | 2.53 | 13,661 | 5.64 | 2.57 | 13,735 | 5.63 | 2.46 | 13,102 | 5.86 | 2.47 |
| **Species-Rich Grassland** | 219 | 6.41 | 2.14 | 1,087 | 7.76 | 1.38 | 1,402 | 8.06 | 1.35 | 1,327 | 8.02 | 1.29 | 1,364 | 8.11 | 1.31 |
| **Bog / Heath** | 862 | 6.48 | 2.40 | 1,560 | 7.20 | 2.06 | 1,579 | 7.24 | 2.12 | 1,625 | 7.44 | 2.04 | 1,630 | 7.39 | 2.09 |
| **Scrub / Woodland** | 558 | 7.10 | 2.55 | 1,240 | 7.00 | 2.53 | 1,353 | 7.16 | 2.48 | 1,373 | 7.09 | 2.46 | 1,343 | 7.18 | 2.43 |
| **Total** | 8,016 | 5.51 | 2.72 | 17,277 | 5.84 | 2.56 | 17,995 | 6.08 | 2.58 | 18,060 | 6.08 | 2.50 | 17,439 | 6.28 | 2.48 |

Another way of looking at the scores that provides some insight into the effectiveness of the results-based approach, is to look at the number of fields in each of the paying categories from zero to ten and examining the changes over time in these. Scores from 2018 are excluded here as farms that entered the scheme in 2018 were offered places using a ranking and selection system. Of the approximately 600 farms that entered the programme in 2018, these were generally larger and had a high proportion of SPA land. From 2019 onward, there were approx 1,600 farms in the Programme each year. From a data analysis perspective, comparisons from 2019 onward are more meaningful as the number of farms are similar and there is no rank and selection bias (Note: all eligible farms were accepted into the programme in 2019).

The numbers of fields scoring less than 4 in 2019 and 2020 was quite high at almost 1,900 fields but this fell to 1,506 fields in 2022. This is a drop of over 20%. Similarly, the number of fields scoring an 8 in 2019 was just over 2,900 with an increase to almost 3,700 in 2022. This is an increase of over 25%. There is a general trend of the numbers of fields scoring less than 6 falling over time and the number of fields scoring greater than 8 increasing over time with the number of fields scoring a 7 having a bell curve appearance as the scheme progressed (Figure 16).





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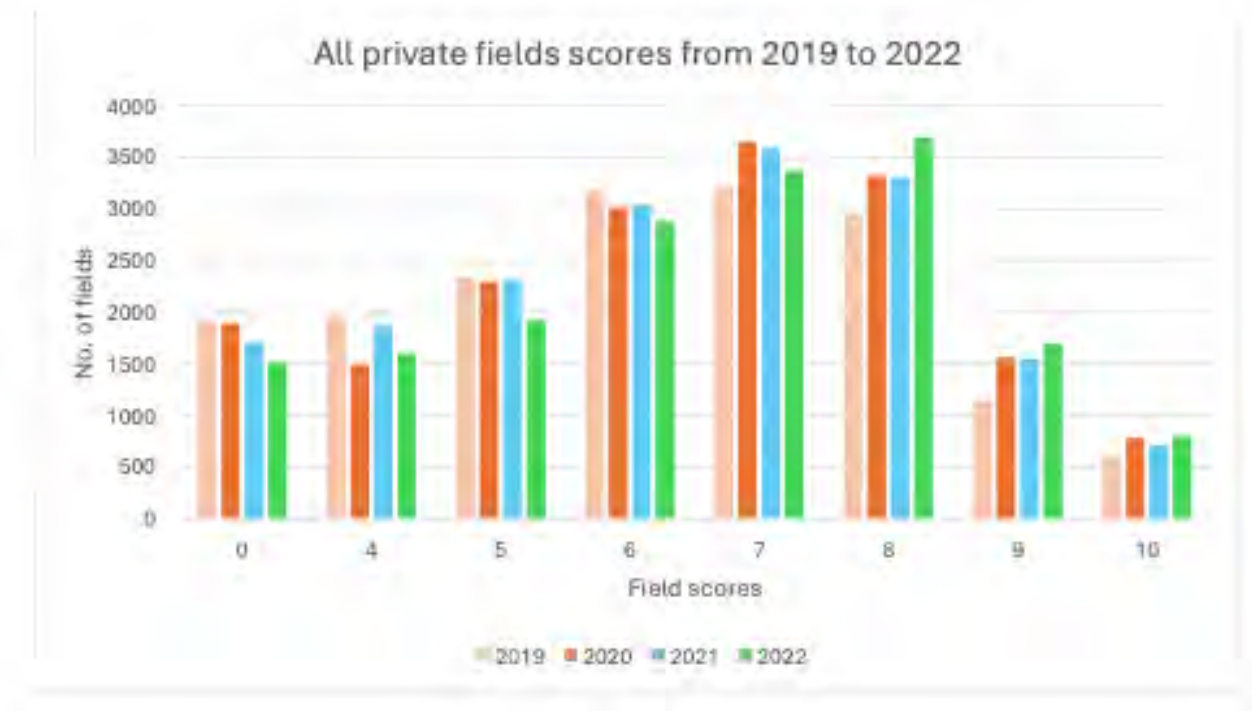



Figure 16. Numbers of privately owned fields receiving non-payable scores (<4), and scores of 4,5,6,7,8,9 and 10 per year from 2019 through to 2022

To more easily visualise the changes from 2019 to 2022, figure 17 shows the data for years 2019 (year 1/2) and 2022 (year 4/5) only (weather it was year 1/2 or 4/5 of the Programme depends on the original year of entry of the farmer i.e. 2018 or 2019).

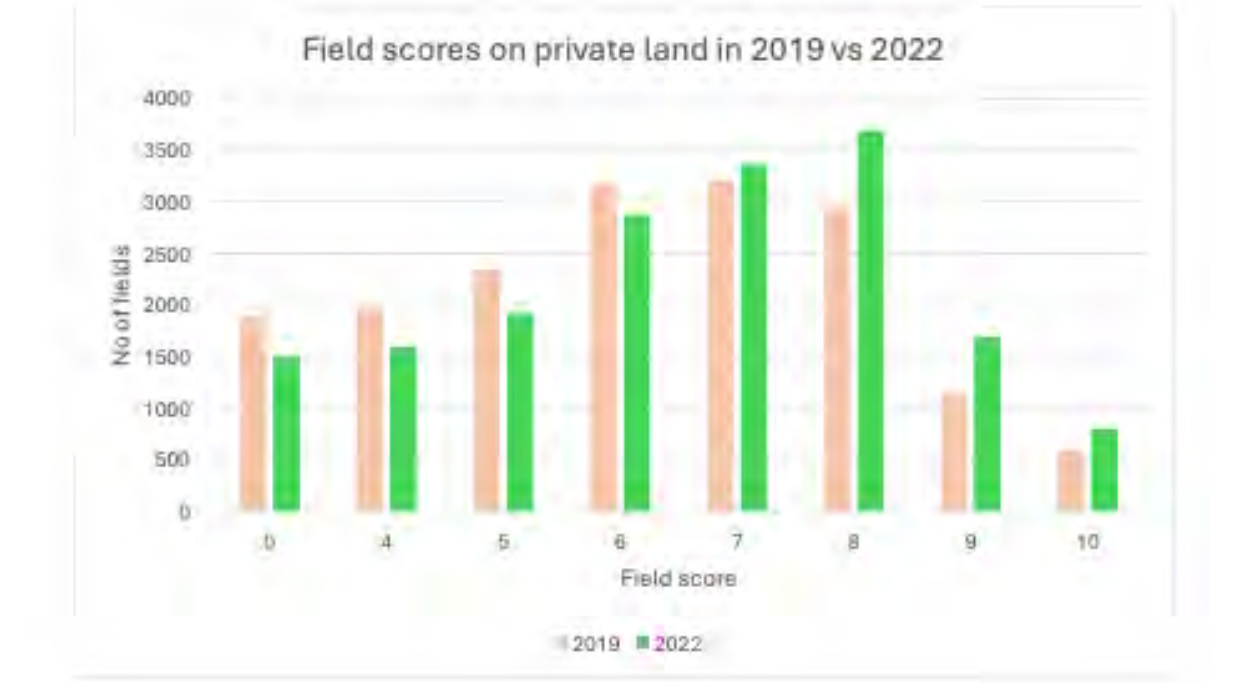



Figure 17. Same data as provided in figure 16 but excluding data from 2020 and 2021 to show more clearer changes from year 1/2 in the programme versus year 4/5 in the programme (depending on the year of entry). Numbers of privately owned fields receiving non-payable scores (<4), and scores of 4,5,6,7,8,9 and 10 in 2019 and 2022

From an ecological perspective, different habitats have different response times to management changes. Generally speaking, grassland habitats (unless they are improved agricultural grasslands), are likely to respond positively to management changes in a shorter timeframe than bog/heath habitats. For example, grasslands have a more defined growing season during the summer months, and delaying mowing, or topping rushes early or late in the season, can result in the delivery of very good vegetation structure from a suboptimal vegetation structure baseline, in a single growing season. The response of Bog/heath vegetation structure management changes is slower, particularly if the past management has resulted in short vegetation.

That said, there are many things considered on the scorecards that can be dealt with quickly, particularly in relation to threats and pressures, for example removing dumping or ceasing supplementary feeding will have a response within a single season. A huge component of the HHP was ensuring that farmers knew what the programme was paying for and that it was providing advice on how to achieve it. Through the delivery of key messages over the lifetime of the programme on how different issues could be tackled, farmers improved scores consistently across the dominant habitats. See figures 18, 19, and 20 below.

Figure 18 shows the changes in scores for privately owned wet grassland fields from 2019 to 2022. The trends follow those of the full dataset shown in Figure 17.

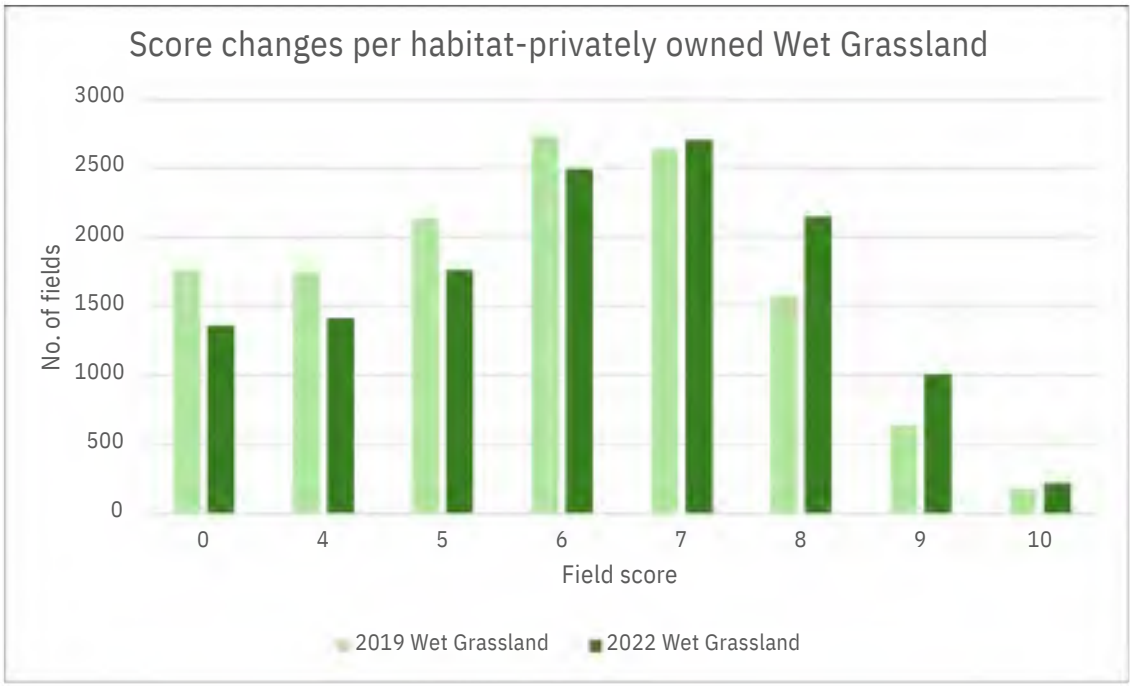



Figure 18. Numbers of privately owned wet grassland fields receiving non-payable scores (<4), and scores of 4,5,6,7,8,9 and 10 in 2019 and 2022.

The number of species-rich grassland fields was a lot fewer than wet grassland fields. They accounted for less than 5% (4.6%) of the area under contract in the HHP . These fields are a high-quality subset of the wet grassland fields, so unsurprisingly, the species-rich grassland fields scoring less than 7 was low (Figure 19). The key mechanism for improving scores in these fields was to remove the threats that were present. An increase in the number of fields identified as species-rich grassland fields increased over the course of the scheme. This may be related to advisor confidence in plant identification over that time as they gained experience and received annual training.

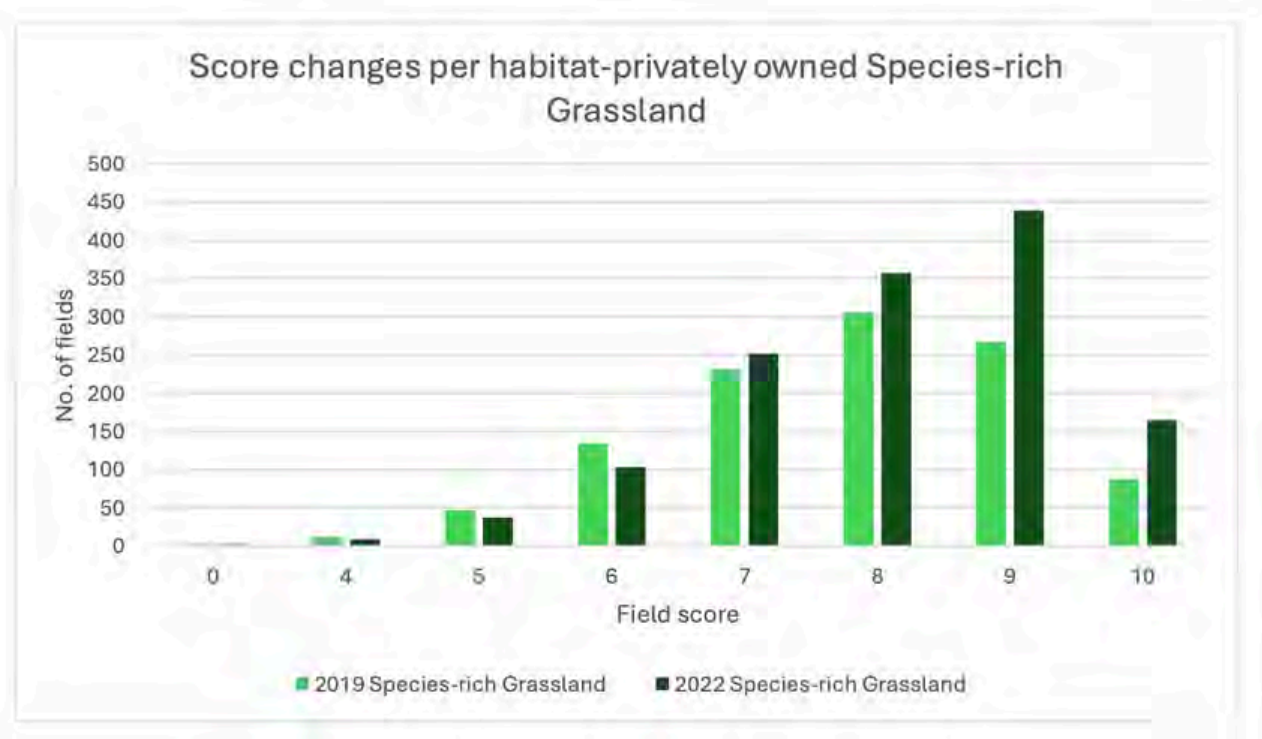



Figure 19. Numbers of privately owned species-rich grassland fields receiving non-payable scores (<4), and scores of 4,5,6,7,8,9 and 10 in 2019 and 2022.

Similar to the species-rich grasslands, the bog/heath fields were predominantly semi-natural and so the numbers receiving scores of less than 6 were small, even in the first year of scoring. The number of fields scoring a 6 dropped from 243 to 185 over the course of the programme (a 31% drop). There was a 20% drop in the number of fields scoring in the 0-6 range overall. The number of fields scoring a 7, 8, 9 or 10 increased from 1,074 fields to 1,240 fields or 15% (Figure 20).



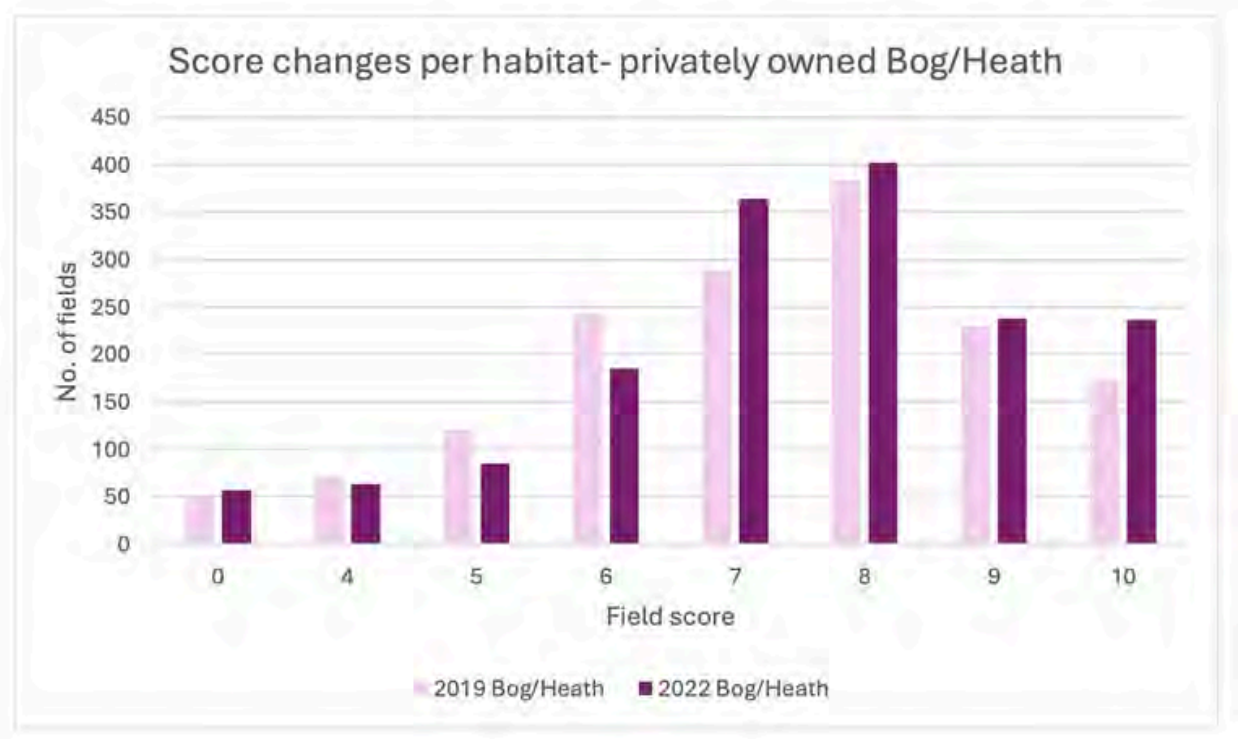



Figure 20. Numbers of privately owned bog/heath fields receiving non-payable scores (<4), and scores of 4,5,6,7,8,9 and 10 in 2019 and 2022.

Scrub/woodland scorecards accounted for around 3.5% of the contracted area in the Hen Harrier Programme. These areas were a small component of farms in the SPA but the HHP team felt that where they were present that they needed to be rewarded for two reasons. Firstly, they are an important habitat for Hen Harrier and additionally, not paying for scrub/woodland fields could result in the perverse outcome where farmers could be incentivised to remove them to increase the grassland or bog/woodland areas eligible for the Programme.

The scores show that, in general, the quality of these fields is high (Figure 21). The scorecards still provided signals for the farmers to reduce the threats to these habitats such as dumping and provided value for them resulting in a slight increase in higher scores across these fields.





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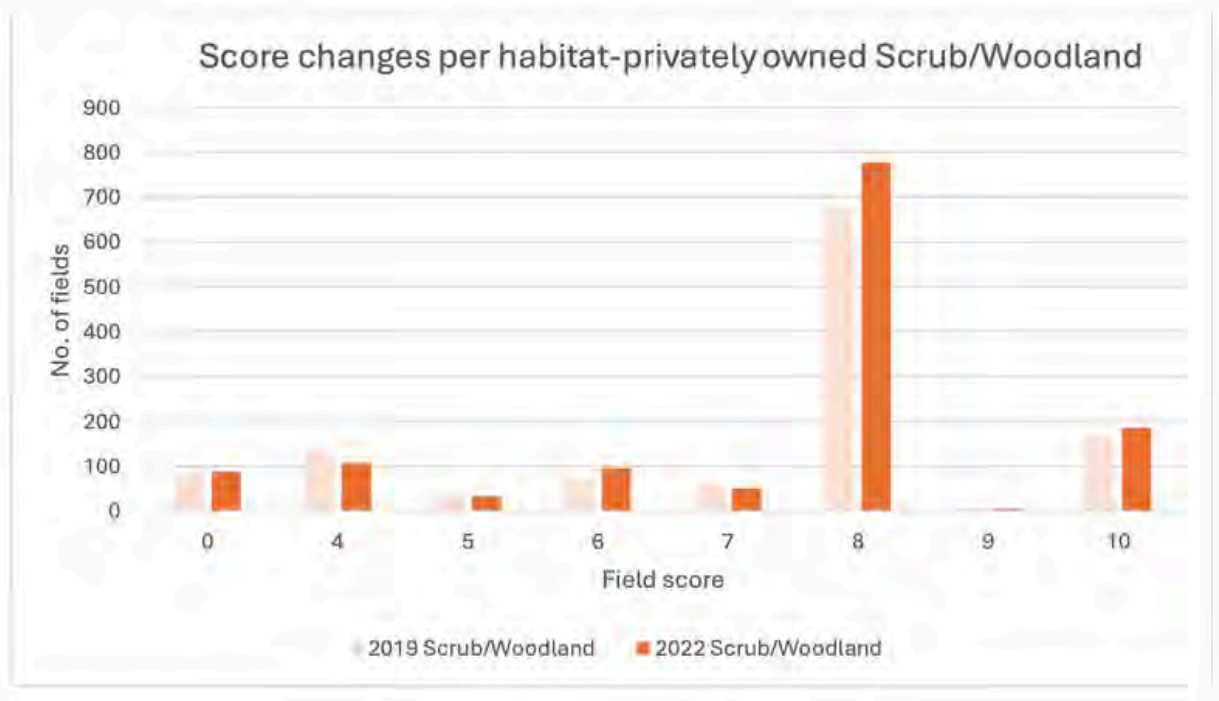



Figure 21. Numbers of privately owned scrub/woodland fields receiving non-payable scores (<4), and scores of 4,5,6,7,8,9 and 10 in 2019 and 2022.

Again, while the data can be viewed across habitats or divided by scores, it is interesting to see if the responses was similar across the six SPAs. Geographically, the SPAs span nine counties from Ulster to West Munster. A testament to the approach is that the response was similar across all areas. If a results-based approach was scalable, it would need to be applicable across a high number of farms and be administered effectively by a small team. Figures 22, and 23, show that while the landscape in each of the SPAs differ slightly, for example, in Musheramore to Mullaghanish SPA, a higher proportion of the lowlands are more intensively managed, the trends across the different SPAs with different farm numbers and in different geographic regions are similar. The scorecard data allows teams working in the area to investigate unusual occurrences, such as a reduction in fields scoring a 10, to see what the underlying causes might be.





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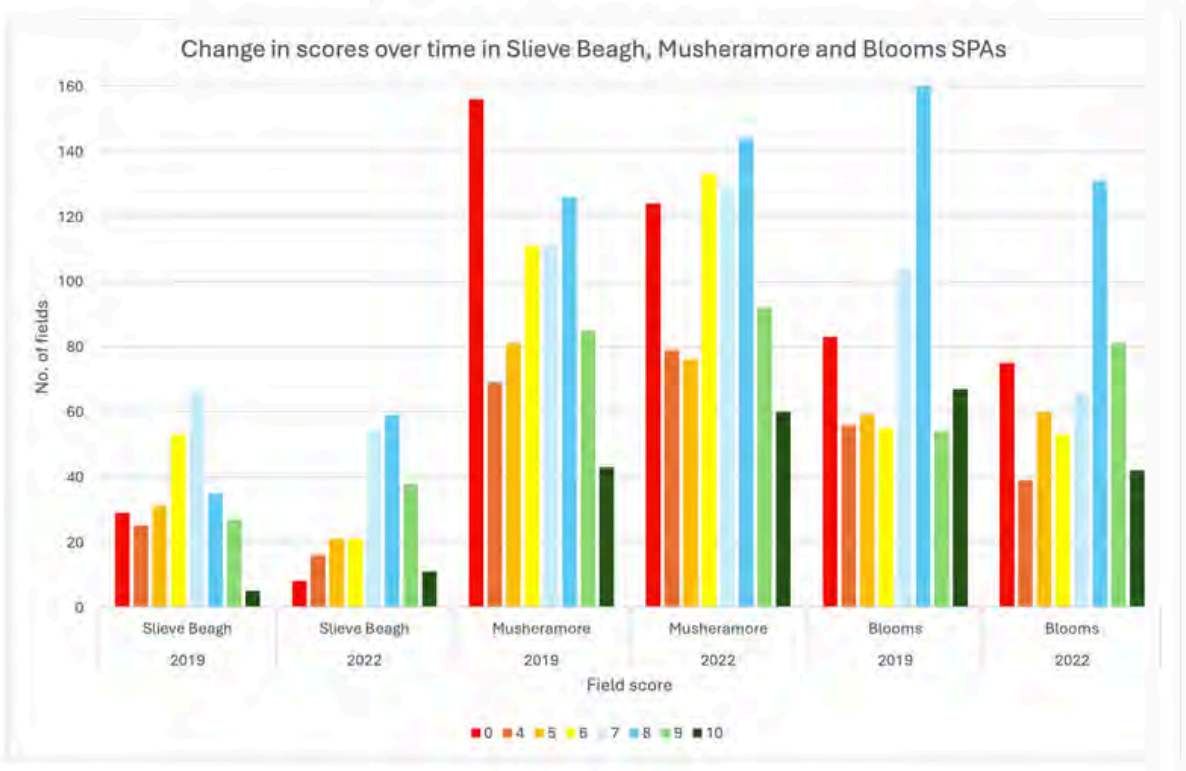



Figure 22. Score ranges in 2019 and 2022 for the three smaller SPAs in the Hen Harrier Programme

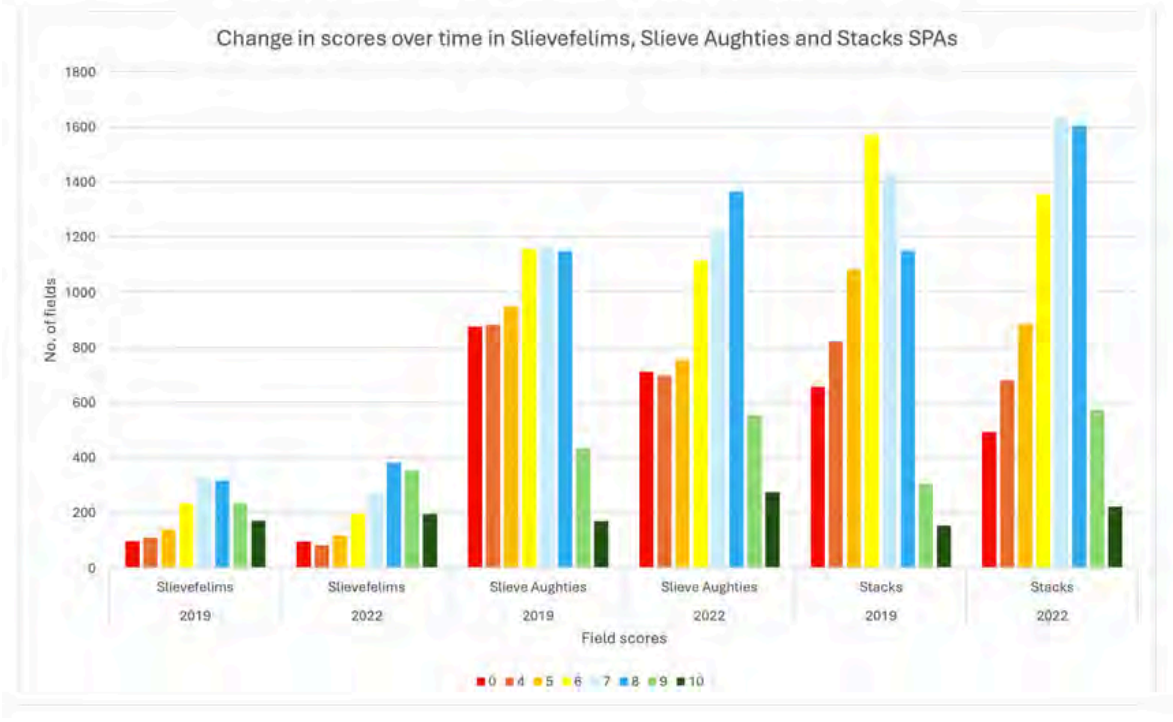



Figure 23. Score ranges in 2019 and 2022 for the three larger SPAs in the Hen Harrier Programme

## Commonage Field Scores

Commonage scoring was carried out by the HHP team. This was an important innovation. It removed the complications associated with shareholders with multiple advisors having to agree on a single advisor to submit scores for their commonage. It also removed some of the pressure on advisors during the field season. All habitats were present on commonage but the proportions were very different to those on privately owned land. Almost 95% of the commonage in the HHP was assigned a Bog/heath scorecard. Around 5% was assigned a grassland scorecard of one kind or other and less than 1% was assigned a scrub/woodland scorecard. The commonages were all surveyed in the first year that they came into the Programme and were surveyed twice more before the end of the contract i.e. Year 1, 2 and 4 or year 1, 3 and 5. This is because changes in management on commonage habitats generally take time to take effect. Any shareholder who had carried out actions on a commonage that could change the score, such as removing a damaging activity or an invasive species, could request a rescore to ensure that the value of carrying out that action was seen as soon as possible. Despite the slower response rates of commonage habitats to management changes, the scores from 2018 compared with 2021 show a progression towards higher scores (Table 18).

Table 18. The number of fields, average score per habitat type and standard deviation of the mean for commonage fields across each year of the Hen Harrier Programme

| Habitat | 2018 No. of fields | 2018 Avg Score | 2018 Std dev | 2019 No. of fields | 2019 Avg Score | 2019 Std dev | 2020 No. of fields | 2020 Avg Score | 2020 Std dev | 2021 No. of fields | 2021 Avg Score | 2021 Std dev | 2022 No. of fields | 2022 Avg Score | 2022 Std dev |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bog/ Heath** | 101 | 6.1 | 1.9 | 139 | 6.3 | 2.1 | 144 | 6.3 | 2.1 | 150 | 6.6 | 1.9 | 151 | 6.6 | 1.9 |
| **Scrub/ Woodland** | 26 | 7.5 | 2.7 | 37 | 6.8 | 2.6 | 35 | 7.8 | 1.9 | 35 | 7.8 | 1.7 | 35 | 7.8 | 1.7 |
| **Species-Rich Grassland** | 4 | 9.3 | 1.0 | 4 | 7.3 | 1.3 | 4 | 7.8 | 1.5 | 5 | 8.0 | 1.2 | 5 | 8.0 | 1.2 |
| **Wet Grassland** | 44 | 4.3 | 3.9 | 51 | 1.8 | 2.5 | 50 | 3.1 | 3.3 | 53 | 4.2 | 3.0 | 53 | 4.2 | 3.0 |
| **Total** | 175 | 5.9 | 2.9 | 231 | 5.4 | 2.9 | 233 | 5.8 | 2.8 | 243 | 6.3 | 2.5 | 244 | 6.3 | 2.5 |





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The figure below shows scores from bog/heath scorecards only as they represent the majority of the commonage scores (Figure 24). The scores from 2018 v 2021 (the last big year of scoring) are shown to provide a good comparison. Unlike the private land, the majority of the commonage came in to the Programme in 2018 when 40% of the Programme's farmers joined. These 40% brought almost 80% of the Programme's area of commonage with them (78%) since just one shareholder joining the Programme required the whole commonage to be surveyed.

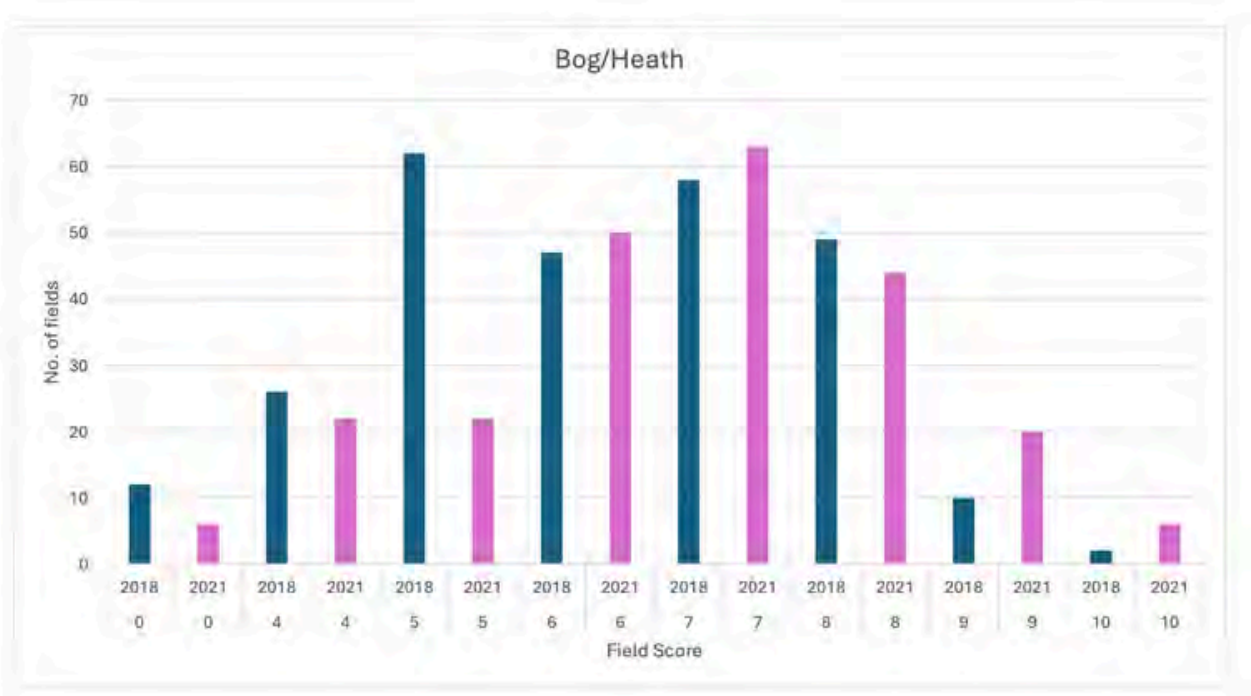



Figure 24. Score ranges in 2018 and 2021 for the bog/heath fields in SPAs in the Hen Harrier Programme

A total of 55% of bog/heath commonage fields scored 0-6 in 2018 (147), with 45% scoring a 7 or higher (119). These represented 60% and 40% of the commonage land area respectively. In 2021, the numbers of bog/heath commonage fields scoring 0-6 had dropped to 43% (100), with 57% (133) scoring a 7 or higher. These represented 38% and 62% of the commonage land area respectively. The area of commonage fields with a bog/heath scorecard scoring a 7 or greater doubled between 2018 and 2021. This was an excellent result and if the Programme had continued the trend indicates that more fields would move out of the 0-6 scoring range and move into the 7+ scoring range, especially if a budget for peatland restoration works were made available as supporting actions.



**Rate of attrition**

The scheme officially launched on December 8th, 2017, just 6 months after the contract was awarded to the Hen Harrier Programme Ltd. Expressions of Interest were invited in November of 2017, by March 31st, 2018, the team had received 1,635 applications for the Programme. By the end of the contract, we had received 2,198 applications. 1,616 of those applications resulted in a farmer taking up a contract. Some applications were invalid, while others resulted in an offer of a place in the programme that wasn't availed of. Four applicants were offered places in the HHP but were not active participants at the end of 2022. Two of those were applicants who withdrew from the Programme as the land that was designated SPA was rented and their rental agreements ended. The other two signed a contract but never submitted a payment claim. These contracts were terminated after two seasons with no payment claim. This represents an attrition rate of 0.25% over the course of the Programme. By any standards this is an incredible retention rate for any scheme which we believe is a testament to the Hen Harrier Programmes efficacy for the farmers it was designed for.

**Programme reception and legacy**

There were no 'before' and 'after' surveys for the Hen Harrier Programme but anecdotally, the reception was excellent. Farmers who joined the Programme didn't leave it (as the rate of attrition confirms above). At the beginning of the Programme, difficult phone calls, animated meetings and even Hen Harrier persecution were not unusual. By the end, the Project team felt that they had a good working relationship with the farmers in the Programme and the two-way communication throughout the term of the Programme meant that there was an adaptability that farmers appreciated. In simple terms, if something didn't work, it was changed or stopped. Farmers in Hen Harrier SPAs campaigned for the retention of the Hen Harrier Programme in 2022 when the new CSP details were announced.

During a national Land Use Review looking into community engagement, the Hen Harrier Programme was put forward as a good example of how to positively engage farmers. As outlined above, many of the pilots and trials carried out during the Hen Harrier Programme, including the results-based approach at a large scale, were incorporated into a high ambition national agri-environment scheme, ACRES CP , that commenced in 2023.





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## Financial Report

A summary of all project expenditure is detailed in table 19. On 31 December 2022, the project was mostly complete. For several months after this, any outstanding claims for supporting actions or local actions funds were dealt with. Once all these were claimed, expenditure was at 94.4% of the funds made available to the EIP . This represents a small underspend, but all the project objectives were met.

Table 19. Overview of costs across the spend categories over the term of the Hen Harrier Project EIP

| Spend category | € |
|---|---|
| Habitat Payment | 15,673,794 |
| Hen Harrier Bonus Payment | 2,275,537 |
| Supporting Actions Payment | 1,153,575 |
| Local Actions Fund | 738,171 |
| Administration | 3,749,474 |
| Total Project Cost | 23,590,551 |

## Payments

The total amounts paid out in farmer payments per year are listed below (Table 20). These values relate to payments made in a given year as opposed to the reporting periods for the annual reports. Every hectare of land that was eligible for payment could receive a payment as there was no cap. Because of this, there is an increase in payments associated with the increase in scores over the lifetime of the programme.

Table 20. Total funds received from DAFM and paid to farmers for Habitat, Hen Harrier Bonus and Supporting Actions Payments over the course of the Hen Harrier Programme (Figures are to the nearest euro)

| Payment type | 2018 (€) | 2019 (€) | 2020 (€) | 2021 (€) | 2022 (€) | Total (€) |
|---|---|---|---|---|---|---|
| Habitat | 1,583,461 | 3,021,908 | 3,570,928 | 3,620,745 | 3,876,752 | 15,673,794 |
| Hen Harrier Bonus | 156,717 | 452,733 | 11,149 | 620,947 | 1,033,991 | 2,275,537 |
| Supporting Action | 0 | 226,253 | 21,551 | 388,475 | 517,296 | 1,153,575 |
| Total | 1,740,178 | 3,700,894 | 3,603,628 | 4,630,167 | 5,428,039 | 19,102,906 |

**Note: The annual variation in the value of some payment types was influenced by Covid related restrictions and payments being made before years end in some years and following the new year in others.**

Hen Harrier Payments were not made to seven participants totalling €58,004. There are several reasons why funds may not have been disbursed. The primary ones were that the participant passed away or there were issues with bank account details. Funds were held for an agreed length of time before being returned to DAFM or until these issues were resolved, whichever happened first.

**Details of dissemination of project findings**

Dissemination of information to raise public awareness and provide technical advice to farmers and environmental managers was an important part of the Hen Harrier Project. Dissemination of the project findings was important to increase knowledge in the scientific and policy arena on the importance of farming to Hen Harrier conservation, how future support mechanisms could work better using result-based schemes and labour-saving methods to determine habitat quality which fed into agri-environment programme implementation. Details of staff dissemination activities are listed in Appendix 1.

Dissemination of the project and its findings were achieved at a broad level through the use of a website (www.henharrierproject.ie) and social media (Hen Harrier Project on Facebook and @HenHarrierProj on Twitter/X) and at a local level through public meetings, farm walks and information guides. The Facebook page was particularly successful at engaging with farmers and other members of local communities. On a national and international level, the project team have facilitated college visits, postgraduate studies, information meetings combined with farm walks and by engaging in conferences.

Two Scientific Papers were published by members of the Project Team on the lessons learned in the operation of the Hen Harrier Project. These were 'Management of high nature value farmland in the Republic of Ireland: 25 years evolving toward locally adapted results-orientated solutions and payments' https://www.ecologyandsociety.org/vol26/iss1/art20/ and 'The delivery of ecosystem services through results-based agri-environment payment schemes (RBPS): three Irish case studies'
Biology and Environment
https://www.jstor.org/stable/10.3318/bioe.2020.13refreqid=excelsior%3Ad4ed2da6d3c4710cf64f2e63ca1076e7#metadata_info_tab_contents.

The project will maintain a website presence into the foreseeable future and information and reports will be accessible from this. As the Project team is continuing work through the ACRES Mid-West Southern Uplands (MWSU) and ACRES North Connaught Ulster (NCU) Co-operation Projects which cover all the Hen Harrier SPA areas, personnel can still be contacted to provide information or support to other projects.





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# Conclusions and Recommendations

**Results-based approach works for farmers**

The Results-based approach resulted in an increase in scores from year one to year five across all habitats, though the changes in wet grassland and peatland fields are the most significant since they represent a land area of ~40,000ha. The 0.65 increase in the wet grassland scores probably represents a bigger change in some fields than it appears, as even improved agricultural grassland with little prospect of improvement are included in these numbers. Additionally, peatland scores increased by 0.94. These improvements were voluntary by the farmers and, where this type of scheme continues, would likely continue to improve also. This was the case in the Burren Programme which ran for longer.

**Bonus payment is effective for engaging communities**

The bonus payment was effective in showing communities that farming landscapes used by Hen Harrier are valuable, that the bird was a resource. The timing of the issuing of the Hen Harrier bonus payments was key also. It followed the field scores from the previous season and arrived in bank accounts around the same time that the Hen Harrier was returning to their breeding grounds. While the payments weren't huge, they were substantial enough to feel meaningful and to change a negative sentiment toward the Hen Harrier to something more positive.

**Technological solutions are key for effective rollout**

The timing of the Hen Harrier Project EIP was ideal for optimising the advent of mobile applications for the delivery of a detail-oriented results-based agri-environment scheme. The programme would not have been possible at scale within meaningful timeframes without the ability to develop and roll out the app and the CRM for managing the data in the background.

The scoring of over 17,500 fields (both private and commonage) on a regular basis, screening almost 8,000 supporting actions and ensuring participants received the various payments that they were eligible for, in a timely manner, all required technological solutions without which, the roll out of this type of programme at scale, would not have been possible.

**Flexible local actions funds are key for innovating and engaging**

The local actions fund was very valuable for two reasons. It allowed the team to trial ideas from both the project team and the farmers. The ideas that were trialled were all successful and were either incorporated into the next national agri-environment scheme or were commercially successful (farmers in the Slievefelims still order feed buckets from Devenish every year). Having an adaptable and flexible fund that encouraged innovative thinking was very powerful. It also engaged the local communities beyond farmers. This was very important for changing attitudes to Hen Harrier throughout the SPAs.



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**Actions to carry forward**

The Hen Harrier Project EIP farm plans finished in December 2022. This coincided with the commencement of the new agri-environment scheme ACRES. The Hen Harrier Project SPAs are part of the ACRES MWSU and ACRES NCU Co-operation Projects. The Hen Harrier Project Ltd tendered successfully to be the Co-operation team for both those regions and so will carry on working with farmers in managing and conserving the rich ecological, archaeological, geological and cultural heritage of these areas. Therefore, the results-based approach operated by the Hen Harrier Project will continue for the next 5 years. Lessons learned and knowledge acquired by the Hen Harrier Project team will continue into the new ACRES scheme aided by the experience of the Hen Harrier Project EIP. The Hen Harrier Project manager and deputy manager were members of the Farming for Nature Technical Group (FFNTG), under the auspices of the HNV Ireland programme. This brought together a range of initiatives and pilot programmes in Ireland working on High Nature Value farming, high status objective water bodies, testing and developing novel agri-environment schemes. This allowed the experiences of the Hen Harrier Project to feed directly into policy and the new national agri-environment scheme (ACRES).

Overall, the new ACRES scheme, with its results-based approach, and Non-Productive Investments (NPIs) to assist with improving scores, ensures the continuity of the maintenance and enhancement of important Hen Harrier habitats, while working with the same experienced project team.





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Appendix 1. A list of many of the dissemination events that the Hen Harrier Project team were involved in during the project term

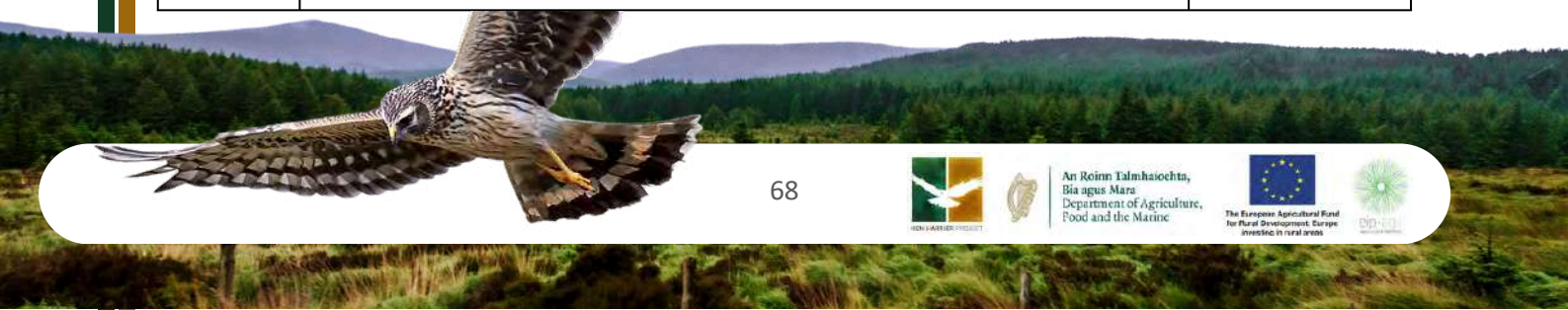
| Date | Event | Staff Involved |
|---|---|---|
| 15/06/2017 | RBAPS Conference in IT Sligo | Fergal Monaghan and Caroline Sullivan |
| 28/06/2017 | Visit to KerryLIFE Project | All staff |
| 04/07/2017 | Meeting with National Rural Network | Fergal Monaghan |
| 12/09/2017 | Invited to speak at RDP Monitoring Committee | Fergal Monaghan |
| 18/09/2017 | National Ploughing Championship 2017 | Fergal Monaghan |
| 04/10/2017 | Pine Marten Workshop organised by NPWS | Caroline Sullivan |
| 27/10/2017 | Guest speaker at the Burren Winterage School | Fergal Monaghan |
| 04/12/2017 | Foodwise 2025 conference | Fergal Monaghan |
| 27/01/2018 | Presentation on the Hen Harrier Programme at the Irish Raptor Study Group Conference | Caroline Sullivan |
| 31/01/2018 | Invited to address the Oireachtas Agriculture Committee | Fergal Monaghan |
| 13/02/2018 | Paying for 'results' in agri-environment schemes Conference in Blaenafon, Torfaen, Wales | Caroline Sullivan |
| 22/02/2018 | Lecture to Master's Course in NUIG Biodiversity and Landscape Management on Results-based Agri-environment Schemes | Caroline Sullivan |
| 05/06/2018 | Attended a HNV Link meeting in Tully, Co. Galway | Caroline Sullivan |
| 22/06/2018 | RBAPS Conference in Athlone. Delivered a talk on the development of the Hen Harrier Project. | Fergal Monaghan |
| 22/08/2018 | Launch of Droimeann Cattle Herd Book Fermoy | Fergal Monaghan |
| 05/09/2018 | Dawn Meats Open Day on their demonstration farm in Athenry, Co. Galway | Fergal Monaghan and Eoin McCarthy |
| 06/09/2018 | EIP Agri Group briefing about the progress of the Hen Harrier | Fergal Monaghan |
| 04/10/2018 | Irish Uplands Forum in Mulranny, Co. Mayo | Evelyn Joyce |
| 25/10/2018 | Invited speaker at the Teagasc National Agri-Environment Conference held in Gort | Fergal Monaghan |
| 26/10/2018 | Burren Winterage School field trip to a Hen Harrier Programme farm | Caroline Sullivan |
| 02/11/2018 | IFA meeting on the rollout of the Hen Harrier Programme | Fergal Monaghan and Eoin McCarthy |
| 12/11/2018 | Talk at Listowel Food Festival | Fergal Monaghan |
| 28/11/2018 | Attended a conference, "Rewarding the Delivery of Public Goods Conference", Edinburgh, Scotland | Caroline Sullivan |
| 29/11/2018 | Invited to address the Cross-Party Group in the Scottish Parliament on Rural Policy on "Why a focus on public funding for public groups" | Caroline Sullivan |
| 17/01/2019 | Attended and spoke at the meeting on "2018 Wildfire Lessons Learned" meeting held in the National Emergency Co-ordination Centre | Fergal Monaghan |
| 12/02/2019 | Presentation at a training event for DAFM inspectors in the Hodson Bay Hotel in Athlone | Fergal Monaghan |
| 21/02/2019 | Chaired a session "Payment for Ecosystem Services" at the National Biodiversity Conference Dublin Castle | Caroline Sullivan |





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| Date | Event | Staff Involved |
|---|---|---|
| 21/03/2019 | Speaker at an International Conference on Hen Harrier held in Groningen University in the Netherlands High-Level Conference | Ryan Wilson-Parr |
| 06/04/2019 | Bucharest. Invited presentation on the development of the Hen Harrier Project demonstrating feasibility of large-scale results-based programs as part of CAP | Fergal Monaghan |
| 09/04/2019 | Hen Harrier Project jointly chaired a meeting on fire resilience strategy for the Slieve Blooms and improved cross-sector co-operation | Fergal Monaghan |
| 15/04/2019 | Launch of publication and exhibition on Environmental Innovation | Fergal Monaghan |
| 17/04/2019 | Partnerships / Locally Led Environmental Schemes in Ireland. Presentation to delegates to showcase the innovation in the Hen Harrier Programme | Fergal Monaghan |
| 21/08/2019 | Hosted a visit from NUIG Geography students | Fergal Monaghan |
| 21/10/2019 | England Wales Wildfire Forum in Cardiff | All staff |
| 21/11/2019 | Addressed international wildfire experts on agriculture and conservation, highlighting fire resilience strategies | Fergal Monaghan |
| 17/02/2020 | Interview on RTE Mooney Goes Wild radio show | Fergal Monaghan |
| 20/02/2020 | Lecture to Master's Course in NUIG on Results-based Agri-environment Schemes | Caroline Sullivan |
| 22/04/2020 | Presentation on ecosystem services at the Chartered Institute of Ecology and Environmental Management Conference | Caroline Sullivan |
| 22/09/2020 | Presentation on the Hen Harrier Project at the Northern Real Farming Conference | Ryan Wilson-Parr |
| 26/11/2020 | Participated in a workshop on post-2020 CAP, eco-schemes, and biodiversity indicators | Fergal Monaghan |
| 10/12/2020 | Presentation to the Galway Environmental Network on Hen Harrier Project | Fergal Monaghan |
| 28/01/2021 | Presentation on agriculture, wildlife, and biodiversity to Transition Year students in Presentation Secondary School Tralee | Padraig Cronin |
| 28/01/2021 | Webinar with senior Welsh Govt officials on RBPS approach | Caroline Sullivan |
| 01/02/2021 | Presentation on Irish Wildlife Trust Webinar - Birds on the Edge | Ryan Wilson-Parr |
| 09/02/2021 | Webinar with senior Natural Resources Wales staff on RBPS approach | Caroline Sullivan |
| 11/02/2021 | Presentation to the Scottish Environment LINK roundtable: The Future of Rural Support in Scotland (session 3 - supporting skills and knowledge transfer). | Caroline Sullivan |
| 16/02/2021 | Presentation to Teagasc staff on Extensive Farming – Feedback on Learnings from EIPs to Teagasc. | Fergal Monaghan |
| 17/02/2021 | Mooney Goes Wild Programme interview about the work of the Hen Harrier Project | Fergal Monaghan |
| 18/02/2021 | Presentation to the CAP Consultative Committee on the need for a Results Based, landscape level approach to ta future Agri-Environment and Climate Measure in the next CAP. | Fergal Monaghan |
| 24/02/2021 | Participated in Structured Approaches for Forest fire Emergencies in Resilient Societies. International User Requirements Workshop (SAFERS IURW2021). | Fergal Monaghan |
| 25/02/2021 | Presentation to the Upland EIP meeting o the work of the Hen Harrier Project. | Fergal Monaghan |
| 25/02/2021 | Webinar presentation with major farming/landowning bodies (Farmers' Union of Wales, National Farmers Union Cymru, National Sheep Association and Country Landowners Association Wales) in Wales, | Caroline Sullivan |
| 04/03/2021 | RTE News showed the Horse in the Gorse Grazing trial in Musheramore. This included a short interview with the Project Manager, the local Project Officer and with the farmer hosting the trial. | Fergal Monaghan and Padraig Cronin |
| 04/03/2021 | RTE Nuacht with regard to the grazing trial and management of gorse in the Musheramore SPA in Ballymakeera Cork | Padraig Cronin |





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| Date | Event | Staff Involved |
|---|---|---|
| 11/03/2021 | Interview on Connemara Community Radio about the use of targeted grazing by horses for the management of Gorse | Fergal Monaghan |
| 24/03/2021 | Input into the NPWS review with Michael O Cinneide. | Caroline Sullivan |
| 20/04/2021 | Webinar for farmers involved in the NPWS farm plan scheme on the issue of creating farms ponds. This event was organised by Teagasc. | Fergal Monaghan |
| 26/04/2021 | Interview on the RTE Radio 1 news about the impact of the Wildfires in Co. Kerry. | Fergal Monaghan |
| 01/07/2022 | Local Area Partnership Open Day Kerry held near Listowel on a HHP farm. | Eoin McCarthy and Padraig Cronin |
| 03/12/2022 | Guest speaker at Inagh EIP Seminar | Kristina Feeney |
| 05/07/2022 | Local Area Partnership meeting Limerick held near Abbeyfeale on a HHP farm. | Eoin McCarthy and Padraig Cronin |
| 07/10/2021 | Guest lecture to 3rd year Agricultural Science students from Munster Technological University in Tralee Co. Kerry | Padraig Cronin |
| 10/11/2021 | School visit Knocknaclarrig NS, Meenkilly NS, Knocknagoshel NS and Loughfouder NS as part of the Local Actions Fund initiative | Padraig Cronin |
| 12/04/2022 | Wildfire event, Millstreet Country Park, Co. Cork | Kristina Feeney |
| 14/10/2021 | HHP farm heifer selected to represent Ireland in Europe meat quality competition | Eoin McCarthy |
| 14/09/2022 | Hosted a study trip on results-based agri-environment schemes for a group from Wales | Fergal Monaghan |
| 14/10/2021 | Cork Wildfire Co-operative Group meeting in Musheramore- field trip to grazing trial sites in the SPA | Fergal Monaghan and Padraig Cronin |
| 22/02/2022 | Cork Wildfire Co-operative Group meeting in Musheramore | Padraig Cronin |
| 24/08/2021 | DAFM field visit to Stacks Complex – Margaret Murray last Steering Group meeting | All staff |
| 24/09/2021 | School visit Muinefliuch NS and Clondrohid NS Co. Cork as part of the Local Actions Fund initiative at project delivery phase | Padraig Cronin |
| 26/06/2021 | Write-up in Irish Examiner on the success of grazing trials in Musheramore and the recent success of hen harrier numbers in the area https://www.irishexaminer.com/farming/arid-40321646.html | Padraig Cronin |
| 28/02/2023 | Guest Lecture to students in Environmental Science in National University of Galway | Caroline Sullivan |
| 28/09/2022 | Talk on results-based agri-environment schemes to Welsh government | Caroline Sullivan |
| 30/06/2022 | Local Area Partnership Open Day Cork held near Millstreet on a HHP farm. | Eoin McCarthy and Padraig Cronin |
| 30/10/2021 | HHP Beef tasting dinner – Horseshoe Restaurant Listowel Co.Kerry | Eoin McCarthy, Fergal Monaghan and Padraig Cronin |
| 31/10/2022 | Presentation on Hen Harrier Project at a farmer meeting as part of Listowel food fair | Eoin McCarthy |

