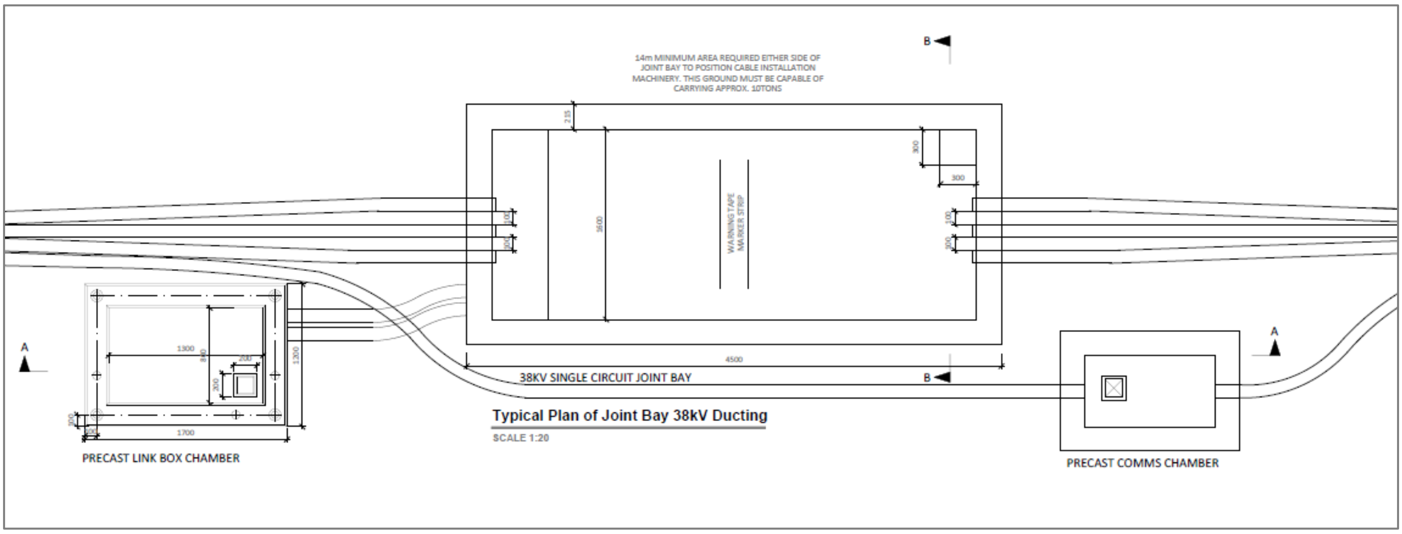

Figure 10 Proposed 38kV Single Circuit Joint Bay and Link Box Plan Details

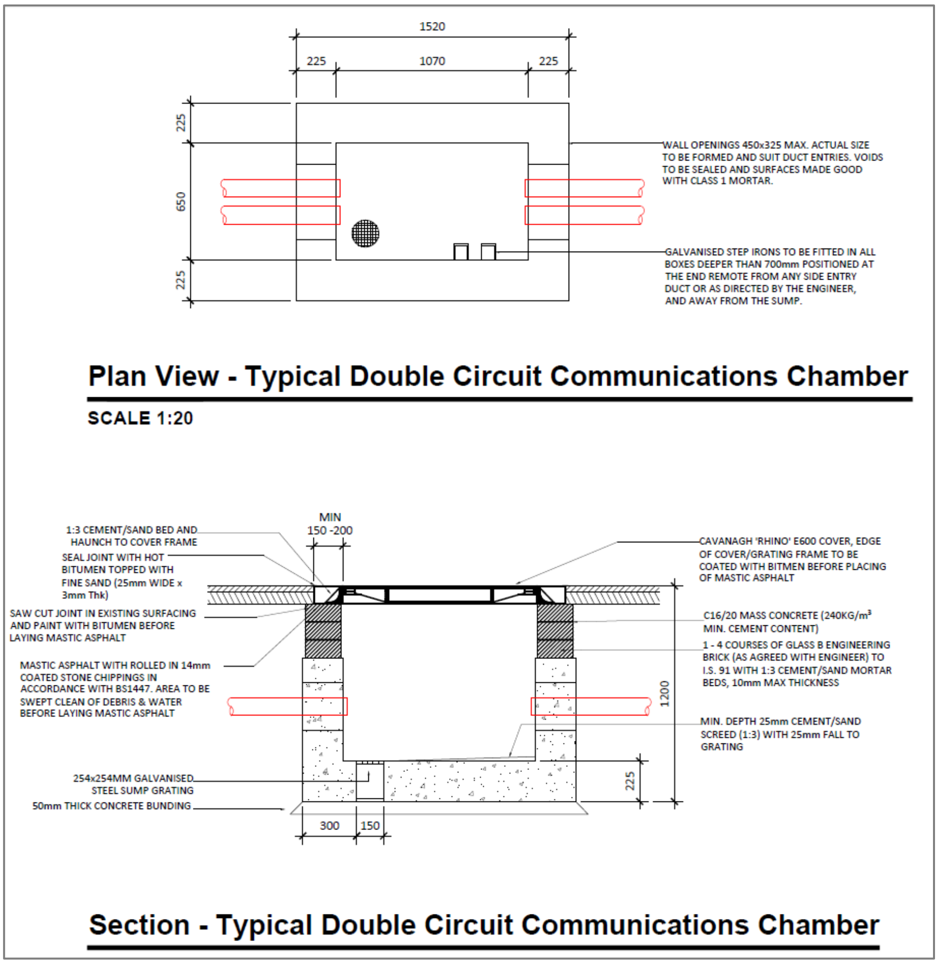

Figure 11 - Typical Communications Chamber

8.0 Watercourse Crossings

Nine watercourse crossing locations were identified along the cable route. All of the watercourse crossings identified are culverts and no bridge crossings have been identified. It is proposed to cross all watercourses using open trenching with either an undercrossing or an overcrossing, depending on the depth of the culvert. A schedule of the culverts identified and the proposed crossing method to be implemented is detailed in Appendix A of this report. A detailed site survey of all watercourses/culverts will be completed as part of the next phase of the project prior to construction. The proposed culvert crossing methods are detailed in Figures 12 and 13 below, the number of ducts will vary between a single and double circuit connection.

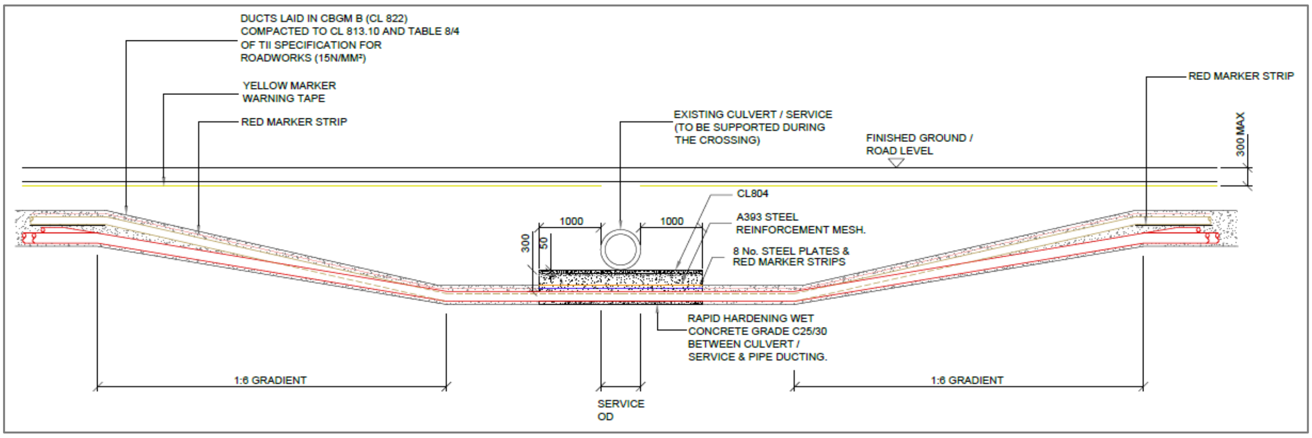

Figure 12 – 38kV Double Circuit Culvert Undercrossing

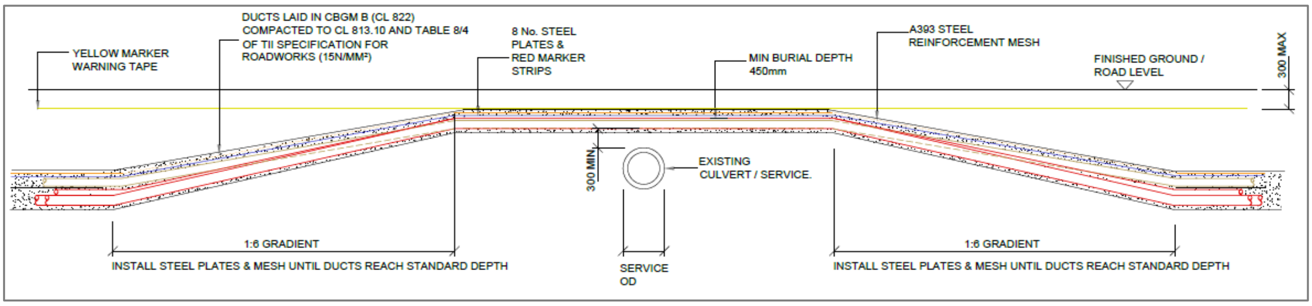

Figure 13 - 38kV Double Circuit Culvert Overcrossing

Where the cable route intersects with existing watercourses, a detailed construction method statement will be prepared by the Contractor prior to the commencement of construction and is to be approved by the Local Authority and relevant environmental agencies as required.

Inland Fisheries Ireland have published guidelines relating to construction works along water bodies entitled 'Requirements for the Protection of Fisheries Habitats during Construction and Development Works at River Sites", and these guidelines will be adhered to during the construction of the proposed development.

8.1 Horizontal Direction Drilling (HDD)

It is not currently proposed to implement Horizontal Directional Drilling (HDD) for any crossings. However, following confirmatory site investigations prior to construction it may be necessary to utilise HDD for some crossings.

Horizontal Direction Drilling (HDD) is a method of drilling under obstacles such as bridges, culverts, railways, water courses, etc. in order to install cable ducts under the obstacle. This method is employed where installing the ducts using standard installation methods is not possible. The proposed HDD methodology is as follows: -

1. A works area of circa .40m^2 will be fenced on both sides of a crossing
2. The drilling rig and fluid handling units will be located on one side of the bridge and will be stored on double bunded 0.5mm PVC bunds which will contain any fluid spills and storm water run-off.
3. Entry and exit pits (1m x 1m x 2m) will be excavated using an excavator, the excavated material will be temporarily stored within the works area and used for reinstatement or disposed of to a licensed facility.
4. A 1m x 1m x 2m steel box will be placed in each pit. This box will contain any drilling fluid returns from the borehole.
5. The drill bit will be set up by a surveyor, and the driller will push the drill string into the ground and will steer the bore path under the watercourse.
6. A surveyor will monitor drilling works to ensure that the modelled stresses and collapse pressures are not exceeded.
7. The drilled cuttings will be flushed back by drilling fluid to the steel box in the entry pit.
8. Once the first pilot hole has been completed a hole-opener or back reamer will be fitted in the exit pit and will pull a drill pipe back through the bore to the entry side.
9. Once all bore holes have been completed, a towing assembly will be set up on the drill and this will pull the ducting into the bore.
10. The steel boxes will be removed, with the drilling fluid disposed of to a licensed facility.
11. The ducts will be cleaned and proven and their installed location surveyed.
12. The entry and exit pits will be reinstated to the specification of ESB Networks and the landowner.
13. A joint bay or transition chamber will be installed on either side of the bridge following the horizontal directional drilling as per ESB requirements.

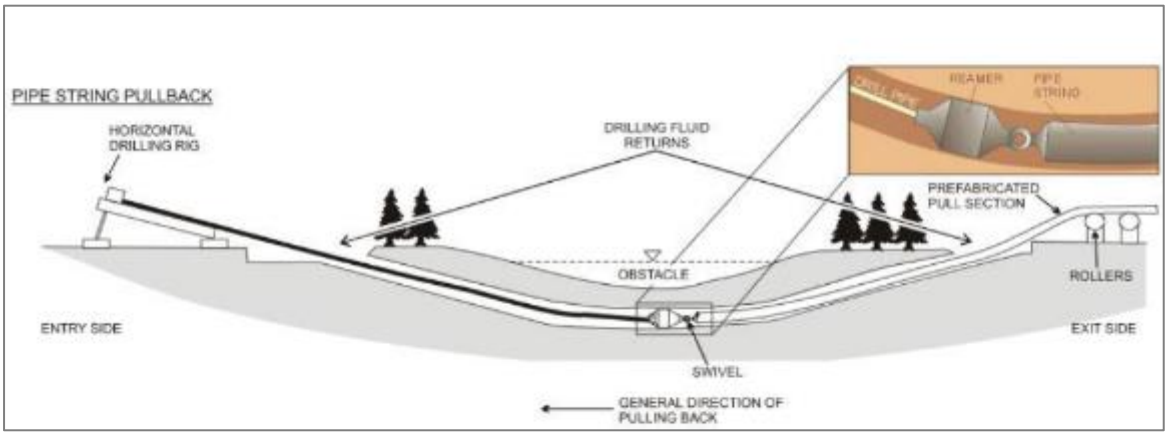

Figure 14 - Typical HDD Installation

9.0 Best Practice Design and Construction & Environmental Management Methodology

Prior to commencement of construction works the contractor will draw up detailed Method Statements which will be informed by this Construction Methodology, environmental protection measures included within the planning application, measures proposed within the CEMP, and the guidance documents and best practice measures listed below. This method statement will be adhered to by the contractors and will be overseen by the Project Manager, Environmental Manager and ECoW where relevant.

The following documents will contribute to the preparation of the method statements in addition to those measures proposed below:

- Inland Fisheries Ireland (2016) *Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters*. Inland Fisheries Ireland*, Dublin,*
- *National Roads Authority (2008) Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes*. National Roads Authority, Dublin;
- E. Murnane, A. Heap and A. Swain. (2006) *Control of water pollution from linear construction projects.* Technical guidance (C648). CIRIA;
- E. Murnane et al., (2006) *Control of water pollution from linear construction projects*. Site guide (C649). CIRIA.
- Murphy, D. (2004) Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites. Eastern Regional Fisheries Board, Dublin;
- H. Masters-Williams et al (2001) *Control of water pollution from construction sites. Guidance for consultants and contractors* (C532);
- Enterprise Ireland (unknown). *Best Practice Guide (BPGCS005) Oil storage guidelines;*
- Law, C. and D'Aleo, S. (2016) *Environmental good practice on site pocket book*. (C762) 4th edition. CIRIA;
- CIRIA *Environmental Good Practice on Site (fourth edition) (C741) 2015*.

The proposed works will be carried out by employing accepted good work practices during construction, and environmental management measures such as those discussed below. Please note that the following measures will be supplemented by further specific environmental protection measures that will be included in method statements prepared for specific tasks during the works and will form part of the final CEMP. These method statements will be prepared prior to the construction phase of the proposed wind farm and will incorporate all of the mitigation measures identified in the EIAR and NIS as well as the requirements of any relevant planning conditions, including any additional mitigation measures which are conditioned.

- All materials required for the ducting works shall be stored at the temporary construction compounds within the Croagh Wind Farm site and transported to the works zone immediately prior to construction;
- Where drains and watercourses are crossed with underground cables, the release of sediment will be prevented through the implementation of best practice construction methodologies (See Section 4.7 of EIAR).

- Weather conditions will be taken into account when planning construction activities to minimise risk of run off from site;
- Provision of 50m exclusion zones and barriers (silt fences) between any excavated material and any surface water features to prevent sediment washing into the receiving water environment;
- If dewatering is required as part of the proposed works e.g. in trenches for underground cabling or in wet areas, water must be treated prior to discharge;
- The contractor shall ensure that silt fences are regularly inspected and maintained during the construction phase;
- If very wet ground must be accessed during the construction process bog mats/aluminium panel tracks will be used to enable access to these areas by machinery, the requirement for bog mats will be confirmed prior to construction. However, works will be scheduled to minimise access requirements during winter months;
- The contractor shall ensure that all personnel working on site are trained in pollution incident control response. A regular review of weather forecasts of heavy rainfall is required and the Contractor is required to prepare a contingency plan for before and after such events;
- Daily visual inspections of drains and outfalls will be performed during the construction period to ensure suspended solids are not entering streams and rivers on site, to identify any obstructions to channels and to allow appropriate maintenance of the drainage regime. Should the suspended solids levels measured during construction be higher than the existing levels, the source will be identified and additional mitigation measures implemented;
- Excavations will be left open for minimal periods to avoid acting as a conduit for surface water flows.
- Only emergency breakdown maintenance will be carried out on site. Emergency procedures and spillage kits will be available and construction staff will be familiar with emergency procedures.
- Appropriate containment facilities will be provided to ensure that any spills from vehicles are contained and removed off site. Adequate stocks of absorbent materials, such as sand or commercially available spill kits shall be available;
- Concrete or potential concrete contaminated water run-off will not be allowed to enter any watercourses. Any pouring of concrete (delivered to site ready mixed) will only be carried out in dry weather. Washout of concrete trucks shall be strictly confined to a designated and controlled wash-out area within the Croagh Wind Farm site; remote from watercourses, drainage channels and other surface water features;
- Entry by plant equipment, machinery, vehicles and construction personnel into watercourses or wet drainage ditches shall not be permitted. All routes used for construction traffic shall be protected against migration of soil or waste water into watercourses;
- Cabins, containers, workshops, plant, materials storage and storage tanks shall be located within the temporary construction compounds and will not be located near any surface water channels and will be located beyond the 50m hydrological buffer at all times.

10.0 Relocation of Existing Services

In order to facilitate the installation of the proposed UGC, it may be necessary to relocate existing underground services such as water mains or existing cables. In advance of any construction activity, the contractor will undertake additional surveys of the proposed route to confirm the presence or otherwise of any services. If found to be present, the relevant service provider will be consulted with in order to determine the requirement for specific excavation or relocation methods and to schedule a suitable time to carry out works.

10.1 Underground Cables

If existing low voltage underground cables are found be present, a trench will be excavated, and new ducting and cabling will be installed along the new alignment and connected to the network on either end. The trench will be backfilled with suitable material to the required specification. Warning strip and marking tape will be laid at various depths over the cables as required. Marker posts and plates will be installed at surface level to identify the new alignment of the underground cable, the underground cables will then be re-energised.

10.2 Water Mains

The water supply will be turned off by the utility so work can commence on diverting the service. The section of existing pipe will be removed and will be replaced with a new pipe along the new alignment of the service. The works will be carried out in accordance with the utility standards.

11.0 Implementation of Environmental Protection Measures

All environmental protection measures contained with the EIAR and NIS which accompanies the planning application will be incorporated into the final CEMP and construction method statements prior to the commencement of development and will be implemented in full during the construction phase. The Project Manager and Site Manager will be responsible for the implementation of measures following consultation with the Environmental Manager and ECoW where necessary.

The implementation of environmental protection measures, invasive species management and waste management will be addressed within the CEMP. Please see Appendix 4.4 of the EIAR for the initial CEMP.

Appendix A – Culvert Crossing Schedule

Culvert Crossing Schedule					
Culvert No.	Dimensions (mm)	Material	Approx. Cover (mm)	Proposed Crossing Methodology	Photo
1.	300 Ø	HDPE	450	Under Crossing	
2.	400 Ø	HDPE	840	Under Crossing	
3.	600 Ø	Concrete	1810	Over Crossing	
4.	Unknown [TBC follow SI]	Concrete	970	Under Crossing	*No photo available*
5.	1050Ø	Concrete	2600	Over Crossing	
6.	400 Ø	Concrete	2300	Over Crossing	
7.	Unknown [TBC follow SI]	Box Culvert	2000	Over Crossing	
8.	Unknown [TBC follow SI]	Box Culvert	1100	Under Crossing	
9.	1300 Ø	Unknown [TBC follow SI]	2500	Over Crossing	

APPENDIX 5-1

WIND FARMS & HEALTH LITERATURE REVIEW - CHAPMAN 2015

Summary of main conclusions reached in 25 reviews of the research literature on wind farms and health.

Compiled by Prof Simon Chapman, School of Public Health and Teresa Simonetti, Sydney University Medical School

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Updated 10 April 2015.

1. Council of Canadian Academies (2015). Understanding the evidence. Wind Turbine Noise.
2. Schmidt JH, Klokker M (2014) Health effects related to wind turbine noise exposure: a systematic review. PLoS ONE 9(12): e114183. doi:10.1371/journal.pone.0114183
3. 2014: McCunney RJ, Mundt KA, Colby WD, Dobie R, Kaliski K, Blais M. Wind turbines and health: a critical review of the scientific literature. Journal of Occupational & Environmental Medicine 2014; 56(11):pe108-130.
4. 2014: Knopper LD, Olson CA, McCallum LC, Whitfield Aslund ML, Berger RG, Souweine K, McDaniel M. Wind turbines and human health. Frontiers in Public Health 2014; 19 June
5. 2014: Arra I, Lynn H, Barker K, Ogbuneke C, Regalado S. Systematic review 2013: association between wind turbines and human distress. Cureus 6(5): e183. doi:10.7759/cureus.183 [Note: this review is a very poor quality paper published in a non-indexed, pay-to-publish journal. A detailed critique of it can be found at the end of this file.]
6. 2014: National Health and Medical Research Council (Australia). University of Adelaide full report (296pp) and draft consultation report (26pp). Final Report (Feb 15 2015)
7. 2013: VTT Technical Research Centre of Finland. (in Finnish) – summary at end of document
8. 2013: Department of Health, Victoria (Australia) Wind farms, sound and health.
9. 2012: Massachusetts Department of Environmental Protection. Independent Expert Science Panel Releases Report on Potential Health Effects of Wind Turbines
10. 2012: Oregon Wind Energy Health Impact Assessment.
11. 2011: Fiumicelli D. Windfarm noise dose-response: a literature review. Acoustics Bulletin 2011; Nov/Dec:26-34 [copies available from simon.chapman@sydney.edu.au]
12. 2011: Bolin K et al. Infrasound and low frequency noise from wind turbines: exposure and health effects. Environmental Res Let 2011;
13. 2010: Knopper LD, Ollsen CA. Health effects and wind turbines: a review of the literature. Environmental Health 2010; 10:78
14. 2010: UK Health Protection Agency Report on the health effects of infrasound
15. 2010: NHMRC (Australia) Rapid Review of the evidence
16. 2010: Chief Medical Officer of Health in Ontario
17. 2010: UK Health Protection Agency. Environmental noise and health in the UK. A report by the Ad Hoc Expert Group on Noise and Health. (this report is about all environmental noise)

18. 2009: Minnesota Department of Health. Environmental Health Division. Public Health Impacts of Wind Turbines.
19. 2009: Colby et al. Wind Turbine Sound and Health Effects: An Expert Panel Review.
20. 2008: Chatham-Kent Public Health Unit.
21. 2007: National Research Council (USA): Impact of wind energy development on humans (Chapter 4: pp97-120) of: Environmental Impacts of Wind-Energy Projects.
22. 2006: Context and Opinion Related to the Health Effects of Noise Generated by Wind Turbines, Agence Française de Sécurité Sanitaire de l'Environnement et du Travail(Affset), 2006. (in French only)
23. 2005: Jakobsen J. Infrasound emission from wind turbines. *J Low Frequency Noise, Vibration and Active Control* 2005; 24(3):145-155
24. 2004: Leventhall G. Low frequency noise and annoyance. *Noise & Health 2004;*.6(23):59-72
25. 2003: Eja Pedersen's Review for the Swedish EPA

Reviews of the evidence - extracted highlights

Direct health effects from noise and WTS

- "There is no consistent evidence that noise from wind turbines—whether estimated in models or using distance as a proxy—is associated with self-reported human health effects. Isolated associations may be due to confounding, bias or chance." NHMRC (2014) full report

- "There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines." *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects." *Source: Colby 2009 review* http://199.88.77.35/EFiles/docs/CD/PlanCom/10_0426_IT_100416160206.pdf

- "... surveys of peer-reviewed scientific literature have consistently found no evidence linking wind turbines to human health concerns." *Source: CanWEA* http://www.canwea.ca/pdf/CanWEA%20-%20Addressing%20concerns%20with%20wind%20turbines%20and%20human%20health.pdf

- "There is insufficient evidence that the noise from wind turbines is directly... causing health problems or disease." *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- “There is no reason to believe, based on the levels and frequencies of the sounds and... sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences.” *Source: Colby 2009 review* http://199.88.77.35/EFiles/docs/CD/PlanCom/10_0426_IT_100416160206.pdf

- “... while some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects. The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct health effects...” *Source: Ontario CMOH Report* http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf

- “... the audible noise created by a wind turbine, constructed at the approved setback distance does not pose a health impact concern.”*Source: Chatham-Kent Public Health Unit* http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf

- There is no evidence for a set of health effects, from exposure to wind turbines that could be characterized as a "Wind Turbine Syndrome." *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- “... there is not an association between noise from wind turbines and measures of psychological distress or mental health problems.” *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- “Evidence that environmental noise damages mental health is… inconclusive.” *Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

- “…no association was found between road traffic noise and overall psychological distress…”*Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

- “To date, no peer reviewed scientific journal articles demonstrate a causal link between people living in proximity to modern wind turbines, the noise (audible, low frequency noise, or infrasound) they emit and resulting physiological health effects.” *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf
  “... there is no scientific evidence that noise at levels created by wind turbines could cause health problems other than annoyance...” *Source: Eja Pedersen 2003 Review* http://www.naturvardsverket.se/Documents/publikationer/620-5308-6.pdf

  “None of the... evidence reviewed suggests an association between noise from wind turbines and pain and stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and headache/migraine." *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

"...there are no evidences that noise from wind turbines could cause cardiovascular and psycho-physiological effects." *Source: Eja Pedersen 2003 Review* http://www.naturvardsverket.se/Documents/publikationer/620-5308-6.pdf

"…there was no evidence that environmental noise was related to raised blood pressure…"*Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

- "The health impact of the noise created by wind turbines has been studied and debated for decades with no definitive evidence supporting harm to the human ear." *Source: Chatham-Kent Public Health Unit* http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf

- "The electromagnetic fields produced by the generation and export of electricity from a wind farm do not pose a threat to public health..."*Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "... no consistent associations were found between wind turbine noise exposure and symptom reporting, e.g. chronic disease, headaches, tinnitus and undue tiredness." *Source: Bolin et al 2011 Review* http://iopscience.iop.org/1748-9326/6/3/035103/pdf/1748-9326_6_3_035103.pdf

- "... low level frequency noise or infrasound emitted by wind turbines is minimal and of no consequence... Further, numerous reports have concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines." *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "... renewable energy generation is associated with few adverse health effects compared with the well documented health burdens of polluting forms of electricity generation..." *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "Although opposition to wind farms on aesthetic grounds is a legitimate point of view, opposition to wind farms on the basis of potential adverse health consequences is not justified by the evidence." *Source: Chatham-Kent Public Health Unit* http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf

- "What is apparent is that numerous websites have been constructed by individuals or groups to support or oppose the development of wind turbine projects, or media sites reporting on the debate. Often these websites state the perceived impacts on, or benefits to, human health to support the position of the individual or group hosting the website. The majority of information posted on these websites cannot be traced back to a scientific, peer-reviewed source and is typically anecdotal in nature. In some cases, the information contained on and propagated by internet websites and the media is not supported, or is even refuted, by scientific research. This serves to spread misconceptions about the potential impacts of wind energy on human health..." *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf

- Afsset was mandated by the Ministries responsible for health and the environment to conduct a critical analysis of a report issued by the *Académie nationale de medicine* that advocated the use of a minimum 1,500 metre setback distance for 2.5 MW wind turbines or more. The Affset report concluded that "It appears that the noise emitted by wind turbines is not sufficient to result in direct health consequences as far as auditory effects are concerned. [...] A review of the data on noise measured in proximity to wind turbines, sound propagation simulations and field surveys demonstrates that a permanent definition of a minimum 1,500 m setback distance from homes, even when limited to windmills of more than 2.5 MW, does not reflect the reality of exposure to noise and does not seem relevant."

Annoyance

- "... wind turbine noise is comparatively lower than road traffic, trains, construction activities, and industrial noise."*Source: Chatham-Kent Public Health Unit* http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf
- "There is consistent evidence that noise from wind turbines—whether estimated in models or using distance as a proxy—is associated with annoyance, and reasonable consistency that it is associated with sleep disturbance and poorer sleep quality and quality of life. However, it is unclear whether the observed associations are due to wind turbine noise or plausible confounders" NHMRC (2014) full report
- "The perception of noise depends in part on the individual - on a person's hearing acuity and upon his or her subjective tolerance for or dislike of a particular type of noise. For example, a persistent "whoosh" might be a soothing sound to some people even as it annoys others."*Source: NRC 2007* http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf
- "... some people might find [wind turbine noise annoying. It has been suggested that annoyance may be a reaction to the characteristic "swishing" or fluctuating nature of wind turbine sound rather than to the intensity of sound." *Source: Ontario CMOH Report*

http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf

- "… being annoyed can lead to increasing feelings of powerlessness and frustration, which is widely believed to be at least potentially associated with adverse health effects over the longer term."*Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

- "Wind turbine annoyance has been statistically associated with wind turbine noise, but found to be more strongly related to visual impact, attitude to wind turbines and sensitivity to noise." *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf

- "... self reported health effects like feeling tense, stressed, and irritable, were associated with noise annoyance and not to noise itself..." *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf

- "... many of the self reported health effects are associated with numerous issues, many of which can be attributed to anxiety and annoyance." *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf

- "To date, no peer reviewed articles demonstrate a direct causal link between people living in proximity to modern wind turbines, the noise they emit and resulting physiological health effects. If anything, reported health effects are likely attributed to a number of environmental stressors that result in an annoyed/stressed state in a segment of the population." *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf

- "… some community studies are biased towards over-reporting of symptoms because of an explicit link between…noise and symptoms in the questions inviting people to remember and report more symptoms because of concern about noise." *Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

- "... it is probable that some persons will inevitably exhibit negative responses to turbine noise wherever and whenever it is audible, no matter what the noise level." *Source: Fiumicelli review abstract*

- "The major source of uncertainty in our assessment is related to the subjective nature of response to sound, and variability in how people perceive, respond to, and cope with sound." *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- "... sleep difficulties, as well as feelings of uneasiness, associated with noise annoyance could be an effect of the exposure to noise, although it could just as well be that respondents with sleeping difficulties more easily appraised the noise as annoying." *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "Even noise that falls within known safety limits is subjective to the recipient and will be received and subsequently perceived positively or negatively."*Source: Chatham-Kent Public Health Unit* http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf

- "... annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape..." *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "Respondents tended to report more annoyance when they also noted a negative effect on landscape, and ability to see the turbines was strongly related to the probability of annoyance."*Source: Minnesota Health Dept 2009* http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf

- "[It is proposed that annoyance is not a direct health effect but an indication that a person's capacity to cope is under threat. The person has to resolve the threat or their coping capacity is undermined, leading to stress related health effects... Some people are very annoyed at quite low levels of noise, whilst other are not annoyed by high levels." *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- "Further, sounds, such as repetitive but low intensity noise, can evoke different responses from individuals… Some people can dismiss and ignore the signal, while for others, the signal will grow and become more apparent and unpleasant over time… These reactions may have little relationship to will or intent, and more to do with previous exposure history and personality." *Source: Minnesota Health Dept 2009* http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf

- "Stress and annoyance from noise often do not correlate with loudness. This may suggest [that other factors impact an individual's reaction to noise… individuals with an interest in a project and individuals who have some control over an environmental noise are less likely to find a noise annoying or stressful." *Source: Minnesota Health Dept 2009* http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf

- "There is a possibility of learned aversion to low frequency noise, leading to annoyance and stress..." *Source: Leventhall 2005 review* http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2004;volume=6;issue=23;spage=59;epage=72;aulast=Leventhall

- “Noise produced by wind turbines generally is not a major concern for humans beyond a half mile or so because various measures to reduce noise have been implemented in the design of modern turbines.”*Source: NRC 2007*
  http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

- “Noise… levels from an onshore wind project are typically in the 35-45 dB(A) range at a distance of about 300 meters... These are relatively low noise or sound-pressure levels compared with other common sources such as a busy office (~60 dB(A)), and with nighttime ambient noise levels in the countryside (~20-40 dB(A)).” *Source: NRC 2007*
  http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

- “Complaints about low frequency noise come from a small number of people but the degree of distress can be quite high. There is no firm evidence that exposure to this type of sound causes damage to health, in the physical sense, but some people are certainly very sensitive to it.” *Source: Ad Hoc Expert Group on Noise and Health*
  http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

- “… there is the theoretical possibility that annoyance may lead to stress responses and then to illness. If there is no annoyance then there can be no mechanism for any increase in stress hormones by this pathway… if stress-related adverse health effects are mediated solely through annoyance then any mitigation plan which reduces annoyance would be equally effective in reducing any consequent adverse health effects. It would make no difference whether annoyance reduction was achieved through actual reductions in sound levels, or by changes in attitude brought about by some other means.” *Source: Ad Hoc Expert Group on Noise and Health*
  http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

Infrasound

- “Infrasound is audible when the sound levels are high enough. The hearing threshold for infrasound is much higher than other frequencies. Infrasound from wind farms is at levels well below the hearing threshold and is therefore inaudible to neighbouring residents. There is no evidence that sound which is at inaudible levels can have a physiological effect on the human body . This is the case for sound at any frequency, including infrasound.”
  http://docs.health.vic.gov.au/docs/doc/5593AE74A5B486F2CA257B5E0014E33C/$FILE/Wind%20farms,%20sound%20and%20%20health%20-%20Technical%20information%20WEB.pdf

- "Claims that infrasound from wind turbines directly impacts the vestibular system have not been demonstrated scientifically... evidence shows that the infrasound levels near wind turbines cannot impact the vestibular system."
  http://www.mass.gov/dep/public/press/0112wind.htm
- “There is no evidence that infrasound ... [from wind turbines ... contributes to perceived annoyance or other health effects.” *Source: Bolin et al 2011 Review*
  http://iopscience.iop.org/1748-9326/6/3/035103/pdf/1748-9326_6_3_035103.pdf

- “There is no consistent evidence of any physiological or behavioural effect of acute exposure to infrasound in humans.” *Source: UK HPA Report* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1265028759369

- “... self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from infrasound.” *Source: Knopper&Ollson review* http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf

- “... infrasound from current generation upwind model turbines [is well below the pressure sound levels at which known health effects occur. Further, there is no scientific evidence to date that vibration from low frequency wind turbine noise causes adverse health effects.” *Source: Ontario CMOH Report* http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf

- “It would appear... that infrasound alone is hardly responsible for the complaints... from people living up to two km from the large downwind turbines.” *Source: Jakobsen 2005 review* http://multi-science.metapress.com/content/w6r4226247q6p416/

- “From a critical survey of all known published measurement results of infrasoundfrom wind turbines it is found that wind turbines of contemporary design with therotor placed upwind produce very low levels of infrasound. Even quite close to theseturbines the infrasound level is far below relevant assessment criteria, including thelimit of perception.”*Source: Jakobsen 2005 review* http://multi-science.metapress.com/content/w6r4226247q6p416/

- “With older downwind turbines, some infrasound also is emitted each time a rotor blade interacts with the disturbed wind behind the tower, but it is believed that the energy at these low frequencies is insufficient to pose a health hazard.” *Source: NRC 2007* http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

Shadow flicker

- “Scientific evidence suggests that shadow flicker [from the rotating blades of wind turbines does not pose a risk for eliciting seizures as a result of photic stimulation.” *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- Shadow flicker from wind turbines… is unlikely to cause adverse health impacts in the general population. The low flicker rate from wind turbines is unlikely to trigger seizures in people with photosensitive epilepsy. Further, the available scientific evidence suggests that very few individuals will be annoyed by the low flicker frequencies expected from most modern wind turbines.” *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpa ctAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- “Flicker frequency due to a turbine is on the order of the rotor frequency (i.e., 0.6-1.0 Hz), which is harmless to humans. According to the Epilepsy Foundation, only frequencies above 10 Hz are likely to cause epileptic seizures.” *Source: NRC 2007* http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

Community & social response to wind turbines

- The perception of sound as noise is a subjective response that is influenced by factors related to the sound, the person, and the social/environmental setting. These factors result in considerable variability in how people perceive and respond to sound... Factors that are consistently associated with negative community response are fear of a noise source... [and noise sensitivity...” *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- “Wind energy developments could indirectly result in positive health impacts... if they increase local employment, personal income, and community-wide income and revenue. However, these positive effects may be diminished if there are real or perceived increases in income inequality within a community.” *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- “Effective public participation in and direct benefits from wind energy projects (such as receiving electricity from the neighboring wind turbines) have been shown to result in less annoyance in general and better public acceptance overall.” *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- “... people who benefit economically from wind turbines [are less likely to report noise annoyance, despite exposure to similar sound levels as those people who [are not economically benefiting.” *Source: NHMRC 2010* http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

- “Landowners... may perceive and respond differently (potentially more favorably) to increased sound levels from a wind turbine facility, particularly if they benefit from the facility or have good relations with the developer...” *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- “The level of annoyance or disturbance experienced by those hearing wind turbine sound is influenced by individuals' perceptions of other aspects of wind energy facilities, such as turbine visibility, visual impacts, trust, fairness and equity, and the level of community engagement during the planning process." *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- "Wind energy facilities... can indirectly result in positive health impacts by reducing emissions of [green house gases and harmful air pollutants, and... Communities near fossil-fuel based power plants that are displaced by wind energy could experience reduced risks for respiratory illness, cardiovascular diseases, cancer, and premature death." *Source: Oregon review* http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf

- "The environmental and human-health risk reduction benefits of wind-powered electricity generation accrue through its displacement of electricity generation using other energy sources (e.g., fossil fuels), thus displacing the adverse effects of those other generators." *Source: NRC 2007* http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

- "Community engagement at the outset of planning for wind turbines is important and may alleviate health concerns about wind farms. Concerns about fairness and equity may also influence attitudes towards wind farms and allegationsabout effects on health. These factors deserve greater attention in future developments." *Source: Ontario CMOH Report* http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf

Summary of 2013 VTA Finnish report

VTT Technical Research Centre of Finland has published a new study with a conclusion that wind turbines do not cause any adverse health effects. The study consisted of a review of nearly 50 scientific research articles conducted in Europe, USA, Australia and New Zealand over the past 10 years.

Due to the increased number of wind power projects in Finland, a growing concern has arisen among the public regarding the possible negative impacts wind energy production may have on human health. VTT Technical Research Centre of Finland conducted a comprehensive literature review covering nearly 50 scientific research articles. The review concluded that in the light of current scientific research, there is no evidence to show that the infrasound produced by modern wind turbines is anything but harmless.

The sound of a nearby wind farm is does not possess such qualities or volume that it would cause physical symptoms to humans. The study also concluded that the infra sounds below the auditory threshold does not constitute a health hazard. Additionally, most of the infra sound caused by a wind farm is mixed with other infra sound from the environment and does therefore not cause any additional exposure. According to the research articles reviewed, the low frequency sound with potential hazardous health impacts would have to be of a higher volume than that caused by wind farms, in order to have an impact on our health. Also, concern that shadow flicker may cause epileptic seizures are overruled in the research material. Such seizures cannot be caused by the type of flicker the slow rotation speed of the wind turbine blades produce.

Commentary: Major problems with recent systematic review on wind farms and distress.

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At least 20 reviews of the evidence on whether wind turbines cause health problems including stress have been published since 2003 (1). Cureus recently published another (2) where the authors referenced none of these.

Highlights of the findings of these reviews may be found here (1). The most recent (2014) review by Australia's peak health and medical agency, The National Health and Medical Research Council (3) concluded:

"There is no consistent evidence that noise from wind turbines… is associated with self reported human health effects. Isolated associations may be due to confounding, bias or chance. There is consistent evidence that noise from wind turbines—whether estimated in models or using distance as a proxy—is associated with annoyance, and reasonable consistency that it is associated with sleep disturbance and poorer sleep quality and quality of life. However, it is unclear whether the observed associations are due to wind turbine noise or plausible confounders."

and

"The association between estimated noise level and annoyance was significantly affected by the visual attitude of the individual (i.e. whether they found wind farms beautiful, or ugly and unnatural) in the three studies that assessed this as a potential confounding factor. Residents in [one] study with a negative attitude to the visual impact of wind farms on the landscape had over 14 times the odds of being annoyed compared with those people without a negative visual attitude. …This means that factors other than the noise produced by wind turbines contribute to the annoyance experienced by survey respondents."

Against this background, I was curious to see what a new systematic review would conclude. According to the Cureus website, the new paper was peer reviewed. This is difficult to understand because of the sheer volume of major and minor problems it contains. Together, these make its contribution valueless to scholarly understanding of the phenomenon of noise and health complaints about wind farms. The paper shows many signs of poor understanding of the subject matter of their review, of critical appraisal methods, of some basic conventions in systematic reviewing, of structuring in scientific writing, and much more besides.

The problems commence in the first line of the abstract where the confusing statement is made that "the proximity of wind turbines to residential areas has been associated with a higher level of complaints compared to the general population." I assume here that they are trying to say that those living near turbines have a higher prevalence of health complaints like sleep disturbance and general "human distress" than in the wider population. The prevalence of sleeping problems in general populations is as high as 33% (4) and reference material exists that quantifies the prevalence of many health problems in general populations (5, 6). Instead, the authors support their statement with a reference to a small qualitative study of 15 people both affected and unaffected by turbines (7). No conclusions about the prevalence of health problems in communities near turbines or in matched comparison populations can be drawn from that paper. I know of no published evidence that would allow such a statement to be made.

The authors state that their search strategy located 18 eligible papers but that these were based on six original studies. They explain that the 12 non-original "studies" (several of which were reviews or commentaries) were then excluded. Yet in their "key results" they proceed to describe the characteristics of all 18 papers and thus act as if these were not excluded ("All 18 peer-reviewed studies captured in our review found an association…").

The authors do not appear to understand what an "outcome" is. The abstract lists "outcome" variables that are not outcomes at all (such as study quality and journal name). These are independent variables, not dependent ones.

Their eligibility criteria for study selection are perplexing. What for example, is the difference between "peer-reviewed studies" and "studies published in peer-reviewed journals"? So too, is their noting that they searched the Cochrane Library for relevant studies. The Cochrane Library is a repository of reviews of evidence for health interventions, not for data on the prevalence of health complaints.

The authors seem not to understand the difference between studies and trials. For obvious reasons, there have been no trials conducted in this area.

Their main conclusions are that:

An association exists between wind turbines and distress in humans.

The existence of a dose-response relationship (between distance from wind turbines and distress) and the consistency of the association across studies .. argues for the credibility of this association.

The first conclusion is very imprecise and sweeping and ripe for being megaphoned by anti-wind farm interest groups as if it actually meant something. One of the six original studies reviewed (Salt & Hullar) (8) should have never been included in this review – see below. The Nissenbaum et a study (9) is listed as of moderate quality with a low risk of bias. Yet all three authors and two out of three reviewers of that paper are members of Society for Wind Vigilance, an anti-wind organization. Nissenbaum has been raising health concerns in study areas for several years, potentially biasing collected data. Neither of these problems is mentioned in this review. Two critiques of this study were published in Noise and Health pointing out the very poor quality of the results, analysis and the overstatements of conclusions (10, 11).

The Shepherd et al study (12) which the authors rate as of "high" quality, failed to make any mention that the small wind farm community involved had for years been subjected to a local wind farm opposition group fomenting anxiety about health issues (13). Indeed, with one exception (14), the five studies referenced were performed in areas where complaints of annoyance were being raised. But such farms are unlikely to be representative of all wind farms. As our work shows, over nearly 65% of wind farms in Australia have never received a single complaint (15), and 73% of complainants in Australia are concentrated around just 6/51 farms. The failure of the authors to note this fundamental problem of study sample selection bias is another major problem.

Among the five "original" studies they considered satisfied their selection criteria was a paper by Salt & Hullar (8). This paper is not in any way a "study" of "the association between wind turbines and human distress." It reports no original empirical data and is essentially a backgrounder on infrasound and the "possibility" that wind turbine might create auditory distress. It is unfathomable why this paper was included in the data set.

Table 2 purports to be a meaningful summary of the findings of these six studies on the association between turbine exposure and "distress". I would defy anyone to make any sense of the Table, particularly the column headed "does [sic] response".

By way of comparison to the lack of detail provided by the authors of this review, it is instructive to look at the results from the Dutch study which formed the basis of the

Pedersen 2009 paper(14) which were further analysed by Bakker et al (16) who noted that sleep disturbance was assessed by a question dealing with the frequency of sleep disturbance by environmental sound ("how often are you disturbed by sound?"). Two thirds of all respondents reported not being disturbed by any sound at all. Disturbance by traffic noise or other mechanical sound was reported by 15.2% of the respondents. Disturbance by the sound of people and of animals was reported by 13.4% of the respondents. Relevantly, disturbance by the sound of wind turbines was reported by only 4.7% of the respondents (6% in areas deemed to be quiet and 4% in areas deemed to be noisy). Bakker and colleagues (16) note that it was not clear from the study if there was a primary source causing sleep disturbance and how respondents attributed being awakened by different environmental sound sources. What was clear was that wind turbines were less frequently reported as a sleep disturbing sound source, than other environmental sounds irrespective of the area type (quiet versus noisy). Analysis showed that among respondents who could hear wind turbine sound, annoyance was the only factor that predicted sleep disturbance. The authors speculated that being annoyed might contribute to a person's sensitivity for any environmental sound, and the reaction might be caused by the combination of all sounds present. It might also be the case that people annoyed by wind turbine noise attribute their experience of sleep disturbance to wind turbine noise, even if that was not the source of their awakening.

Swathes of the paper are given over to descriptions of their efforts to rate the levels of evidence in the four reviewed studies. But they never ever describe their approach in any way that might permit replication of how they went about such rating. How was level of evidence actually determined? It should have been explicitly defined in the text. Their discussion of the risk of bias across studies is bizarre. "The quality of the study could be confounded by journal name and author". Surely the authors mean here that the evaluation of the quality of the study could be biased by this knowledge. The term "confounded" has another meaning.

Their "key results" consist of no more than five bullet points. These read like draft notes-to-self (eg: None of these studies captured in our review found any association (potential publication bias)".

The authors chose to use the term "distress" instead of "annoyance". The American Medical Dictionary defines distress as 1. Mental or physical suffering or anguish or 2. Severe strain resulting from exhaustion or trauma. Annoyance on the other hand is defined as 1. The act of annoying or the state of being annoyed or 2. A cause of irritation or vexation; a nuisance. (The American Heritage Dictionary of the English Language, Fourth Edition copyright 2000) and is generally identified as a highly subjective state in medical literature. It is clear that the authors chose a stronger term than was used by the majority of studies. Most literature refers to annoyance, while the referenced alternative of "Wind Turbine Syndrome" was coined in a vanity press published case study with extraordinary weaknesses of selection bias, methodology and analysis (17). Similarly, "extreme annoyance" is rarely used in the literature. Annoyance is by far the most commonly used term in the material referenced, so it is unclear why “distress” was chosen.

The paper is riddled with imprecise, mangled and contradictory language. For example: key finding 1: “All 18 peer-reviewed studies captured in our review found an association…” and key finding 2: “None of these studies captured in our review found any association (potential publication bias)”; infelicitous prose: “these complaints are coined in research”; “There might be a theoretical incline to give studies in high impact journals higher quality…”; basic grammatical errors: “the study’s principle outcome”; “there was no missing data.” It is unconventionally structured with extremely scant results and methods sections providing no adequate explanations of how key decisions on quality or bias were made.

The publication of this very poor paper is regrettable.

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APPENDIX 5-2

HOUSE PRICES STUDY – CXC SCOTLAND 2016

Scotland's centre of expertise connecting climate change research and policy

Impact of wind turbines on house prices in Scotland

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October 2016

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Summary

This report presents the main findings of a research project estimating the impact on house prices from wind farm developments. It is based on analysis of over 500,000 property sales in Scotland between 1990 and 2014.

The methodology builds on research on the impact from wind farms on house prices in England (Gibbons 2014). This study improves the way the impact is estimated by looking at the impact of both single turbines and whole wind farms.

To control for the normal fluctuations in house prices we used a 'control group' that closely resembles the characteristics of the dwellings in the study but without being exposed to a wind farm. This provides prices that can be used to interpret a wind farm's impact on the price of dwellings nearby. As such a result showing no effect means that the house price of the property with a wind farm close by has increased or decreased at the same rate as the properties in the control group.

The study looked at both natural landscape and built environment in relation to how exposed a dwelling is to the visual impact of the wind farm.

Key findings

1. **No evidence of a consistent negative effect on house prices:** Across a very wide range of analyses, including results that replicate and improve on the approach used by Gibbons (2014), we do not find a consistent negative effect of wind turbines or wind farms when averaging across the entire sample of Scottish wind turbines and their surrounding houses. Most results either show no significant effect on the change in price of properties within 2km or 3km, or find the effect to be positive.

2. **Results vary across areas:** The results vary across different regions of Scotland. Our data do not provide sufficient information to enable us to rigorously measure and test the underlying causes of these differences, which may be interconnected and complex.

Our results persist under a variety of assumptions:

- whether or not we account for the visibility of turbines;
- whether we base the analysis on individual turbines or entire wind farms;
- whether we account for building heights or use only the natural terrain when estimating turbine visibility; and
- whether we follow individual dwellings over time or use postcode averages.

The complexity of the findings may be due to:

- attitudes towards wind farms and their benefits potentially varying across regions and different social and economic groups;
- Scotland having a higher proportion of its turbines located in remote areas; and
- the fact that some wind farms provide economic or leisure benefits (e.g. community funds or increasing access to rural landscapes through providing tracks for cycling, walking or horse riding).

Additionally these factors are not mutually exclusive. It is likely that they affect house prices simultaneously, and to varying degrees in different locations.

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Introduction and background

The Scottish Government has committed to a target for renewables to generate the equivalent of 100% of Scotland's electricity demand by 2020[5]. Onshore wind power is playing a central part in decarbonising Scotland's energy supply.

The rapid growth in onshore wind (both in Scotland and globally) has been accompanied by an interest in understanding the impacts of onshore wind development, both positive and negative. The overall economic benefits of investment and spending are relatively straightforward to measure[6]; impacts on communities less so. Survey-based approaches consistently show a majority in favour of renewable power generation in principle but paint a more mixed picture for those directly affected by nearby wind farm development[7].

There is now a substantial body of research on the local impacts of wind farms. Some of this research has looked at measurable effects on house price in order to understand the objective effects on communities, beyond stated views. Have properties near to, or in sight of, new wind farm developments seen price changes that differ from other houses? Until recently, all extant studies had consistently found no robust evidence of any such price impact. One of the most recent studies, by RenewableUK and the Centre for Economics and Business Research, used seven wind farm case studies across England and Wales, and came to the same conclusion: either no impact or even a slight positive one[8].

Very shortly after that study, however, Steve Gibbons looked again at English and Welsh wind farms using a larger data-set and property prices between 2000 and 2012, and found evidence for negative price impacts[9]. In Gibbons' analysis of previous house price studies[10], the key problem he identifies is sample size: while some studies contain many properties, the number of observations actually used to estimate the price impact tends to be too low to be statistically reliable. Many also do not compare price changes across time. Gibbons' research design allows for comparison of much larger groups of property prices before and after wind farms became operational, allowing for more robust results.

The present study bases its price impact analysis on Gibbons' approach, including his use of a landscape analysis to determine whether properties can likely see a turbine[11], or whether line of sight is blocked. Line of sight analysis allows us to test whether visibility of turbines affects house prices differently to proximity alone, by separating visible and non-visible turbines into two groups. We have also explored ways of improving on Gibbons' approach, greatly increasing the resolution and precision of the data. These improvements are listed below:

1. Whilst we replicate Gibbons' approach using average house price per postcode and postcode-centre for housing location, we also repeat the analysis using individual property prices based on full address locations.
2. We use a dataset of wind turbines that includes their exact location and tip height, rather than the centre-point of wind farms. Relying on the centre-point of wind farms might be particularly problematic in a Scottish context where some wind farms are very spread out. When turbines are dispersed in this way, it is possible for a house to be a very long way from the centre of the wind farm, but very close to a peripheral turbine.
3. Our landscape analysis uses 5 metre grid squares (versus 200 metre in Gibbons). Combined with the exact property locations and turbine locations, this gives much more accurate lines of sight.

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[7] See e.g. Christopher R. Jones and J. Richard Eiser, 'Understanding "Local" Opposition to Wind Development in the UK: How Big Is a Backyard?', *Energy Policy* 38, no. 6 (2010): 3106–17.
[8] RenewableUK, 'The Effect of Wind Farms on House Prices', 2014, http://ruk.pixl8-hosting.co.uk/en/publications/index.cfm/RenewableUK-Cebr-Study-The-effect-of-wind-farms-on-house-prices.
[9] Stephen Gibbons, 'Gone with the Wind: Valuing the Visual Impacts of Wind Turbines through House Prices', *Journal of Environmental Economics and Management* 72 (July 2015): 177–96, doi:10.1016/j.jeem.2015.04.006.
[10] Ibid. p.179
[11] Why 'likely'? - The real landscape may differ in ways the model has not captured - for example, vegetation may be blocking a view.

4. Taking advantage of this higher resolution, we have also added building height data (where available) to test whether buildings may block a property's view.

The following section describes the data used in more detail, and then explains the two key steps in producing the analysis: the line of sight analysis and the econometric house price analysis. The full results are then presented, before concluding with some possible explanations for the findings.

Details of the house price impact analysis

Overview of the data and method

In this section, we outline the data sources for the project and explain how they were used to produce the house price impact analysis. The following four sub-sections describe the **four sources of data** used:

1. House price data for Scotland from January 1990 to March 2014.
2. Wind turbines that became operational between November 1995 and December 2014.
3. Digital Elevation Model (DEM) data for the Scottish landscape, giving height above sea-level for 5-metre grid squares covering the whole of Scotland.
4. Building height data, added to the DEM data.

We shall then detail the two steps of data preparation and analysis. The first step was to carry out a line of sight analysis identifying which houses could most likely see at least one turbine. This provided full details for each house of the number of visible turbines and their distance. The second step was to use this information, along with property price change over time (and a number of other control variables; see below), to produce the final house price impact analysis.

House price data

Data for property prices in Scotland comes from two previously unlinked versions of price data from Registers of Scotland (RoS). By linking these, the house price record covers just over 23 years (1990 to March 2014). While RoS record every Scottish sale, the analysis here drops any sales that, for a number of reasons, were not suitable. For example, not all properties could be exactly geocoded because the RoS record contained insufficient address information to obtain a location match and had to be excluded.

Only repeat sales (properties that sold more than once within the time period of the data) were used in the house price analysis. Following properties over time in this way helps us to compare like with like when estimating the house price impact of turbines being constructed. One limitation of this repeat sales approach is that we do not know whether there have been major changes to the dwelling over time. However, provided changes to dwellings are fairly randomly distributed across all dwellings in the data, this should not have a big effect on the results. In total, the RoS data provided 637,000 repeat-sale properties, accounting for just over 1.7 million sales.

Following Gibbons, we restricted the properties used in the analysis to those within 15km of at least one turbine (i.e. within the green circles in Figure 2). This is done, as Gibbons says, because "as the distance to the wind farm increases, the number of other potential coincident and confounding factors increases, making any attempt to identify wind farm impacts less credible"[12]. This reduces the total number of properties in the analysis to 509,275.

Wind turbines

Three sources have been combined to produce the wind turbine dataset:

1. Precise wind turbine locations were acquired from Ordnance Survey's "Points of interest" (POI) data, freely available through an academic license[13]. Its latest incarnation (as of late 2015) is much more comprehensive than previous versions. This data is collated for Ordnance Survey by PointX (www.pointx.co.uk). The POI turbine data itself is mainly supplied to Ordnance Survey by RenewableUK.
2. Dates that wind farms became operational were 'scraped' from RenewableUK's website (www.renewableuk.com) and then matched to turbines.

[12] Gibbons, 'Gone with the Wind'. p.180

[13] Code and guidance for extracting specific types of POI data are accessible at the Sheffield Methods Institute github page: github.com/SheffieldMethodsInstitute/windfarmsHousePrices

3. Turbine tip height information was collated through direct research of planning applications and other publicly available sources[14].

Figure 1 shows the cumulative rise in the number of turbines becoming operational in Scotland from 1995 onwards; the total reaches just over 2,500 turbines by the end of 2014.

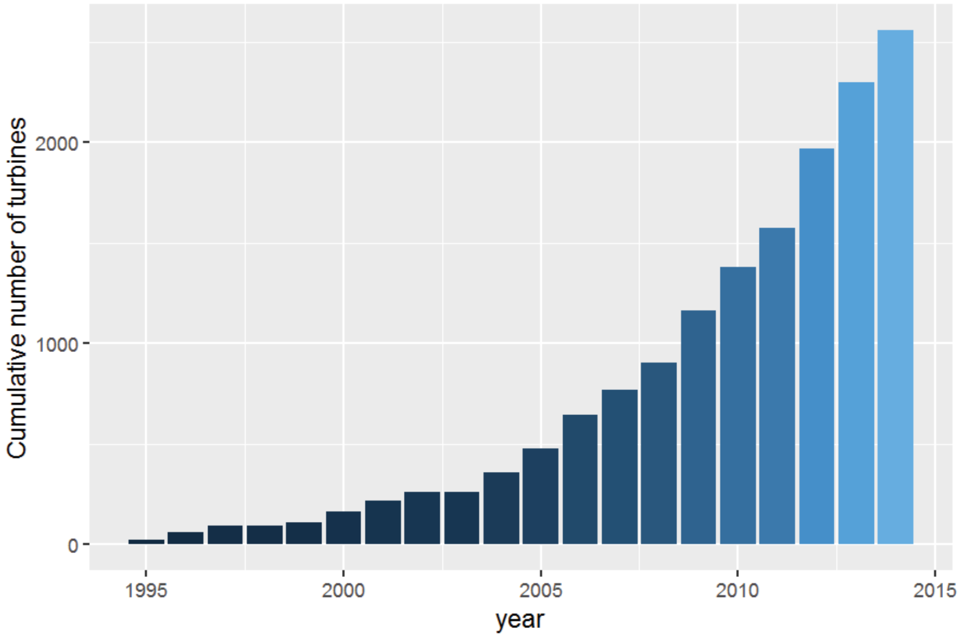

Figure 1: Number of operational wind turbines in Scotland, cumulative from 1995 to 2014

Landscape and building height data

To determine whether a turbine is likely to be viewable from a particular property, we need to know if any landscape features intervene to block the view. This requires using a 3D 'Digital Elevation Model' (DEM) of the Scottish terrain, onto which houses and turbines can be added. We use Ordnance Survey's "OS Terrain 5" DEM, which provides height above sea level for every 5-by-5 metre grid point.

The OS Terrain 5 data can be used to identify which houses have their lines of sight blocked by the physical landscape, but this does not account for the effect of other buildings. To correct for this, we also use building height data for the majority of properties in Scotland, combining Ordnance Survey's Mastermap with LIDAR data from the Centre for Environmental Data Analysis (CEDA). The OS Terrain 5 DEM data's 5 metre resolution is fine enough to allow addition of building footprints and heights derived from the Mastermap and CEDA data.

On the map of Scotland in Figure 2, areas for which we used building data are shown with the yellow (Mastermap) and red (CEDA) grid areas. Where both sources covered the same area, we used the slightly better quality Mastermap data. These two sources do not cover all buildings in Scotland, but because data exists for all the larger conurbations, 84% percent of properties have a line of sight that crosses building height data and so could potentially have that view blocked. Calculations are run both with and without building heights for comparison, with the latter using the 84% subset of houses that may have had a line of sight blocked by a building.

[14] The majority of the work tracking down tip heights was done by Dr Ellie Bates, University of Edinburgh.

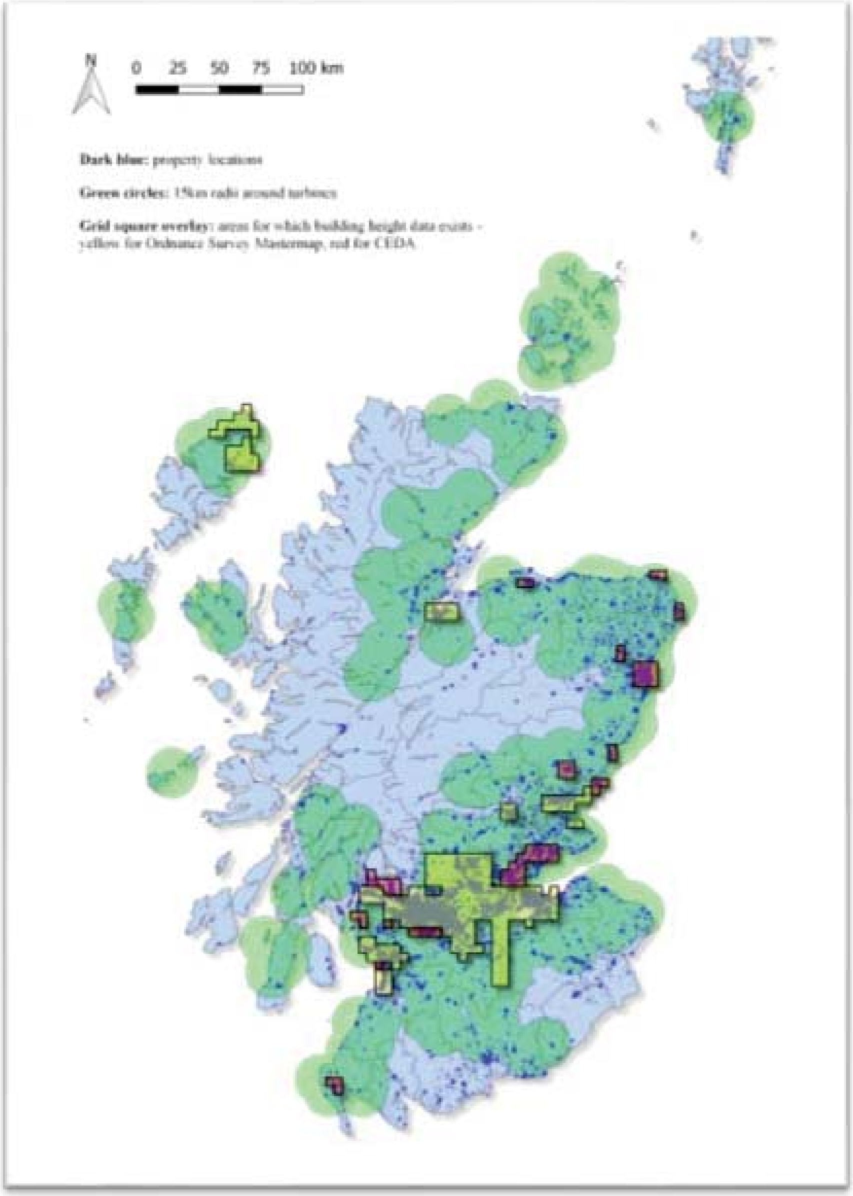

Figure 2: Scotland - housing data location (dark blue), turbine 15km radii and building height data location

Analysis step 1: Which houses can likely see turbines? 'Line of sight' analysis

The econometric analysis requires the following information for each repeat-sale property:

- Which turbines, if any, are within 15km?
- How close is each of them to the property?
- Of those turbines within this 15km range, which are visible to this property and which likely cannot be seen?

We used Pythagoras' Theorem to compute distances between each dwelling and turbine. To estimate turbine visibility, we used 'line of sight' analysis (also known as "intervisibility" analysis)[15]. Figure 3 and Figure 4 illustrate how this process is carried out using the example of a particular property in Glasgow that has its line of sight blocked by another building. 136 batches of housing, turbine and landscape data are processed - these figures use a batch covering the Cathkin Braes wind turbine, installed in 2013[16]. (Other batches process larger groups of turbines together, e.g. the Whitelee wind farm to south of Glasgow in Figure 3 is processed in one batch.)

The dotted line on the map of Glasgow in Figure 3 marks an 8.7km line of sight between this example property and the Cathkin Braes turbine. Figure 4 gives the landscape cross-section for this same line (with horizontal distance at 1/8th scale, relative to height), showing how the DEM landscape data - both with and without building heights - is used. The line starts two metres above ground level on the site of the house[17] and 'looks' towards the turbine blade tip height. If the highest point of the tip is visible above landscape and buildings, the line of sight is clear. In this example, for landscape alone, the house (left-hand side of graph) has a clear line of sight. If building heights are used, however (green in Figure 4), line of sight is blocked.

This process was repeated for all properties. The addition of building height data blocked a great many more from view of a turbine. Without building heights, 80% of properties within 15km of a turbine are identified as having a line of sight to at least one. This drops to 32% when building heights are used - an unsurprising result given how many properties are located in conurbations. Note that this binary visibility result says nothing about a turbine's actual visual impact which will depend on proximity. For example, a visible turbine will presumably have a much bigger visual impact when viewed from nearby properties compared with the view from houses 15km away. As Gibbons says:

> "Existing literature based on fieldwork suggests that large turbines are potentially perceptible up to 20km or more in good visibility conditions, but 10 to 15km is more typical for a casual observer and details of individual turbines are lost by 8km."[18]

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[15] Code and guidance for this is available at the Sheffield Methods Insitute github page: github.com/SheffieldMethodsInstitute/windfarmsHousePrices

[16] See e.g. "£5m city turbine will be visible around world (From Evening Times)." 2013. www.eveningtimes.co.uk/news/13256714.__5m_city_turbine_will_be_visible_around_world

[17] The building data for the house is discounted: for the building height check, line of sight is only checked once the line has got past the building's edge.

[18] Gibbons p.180

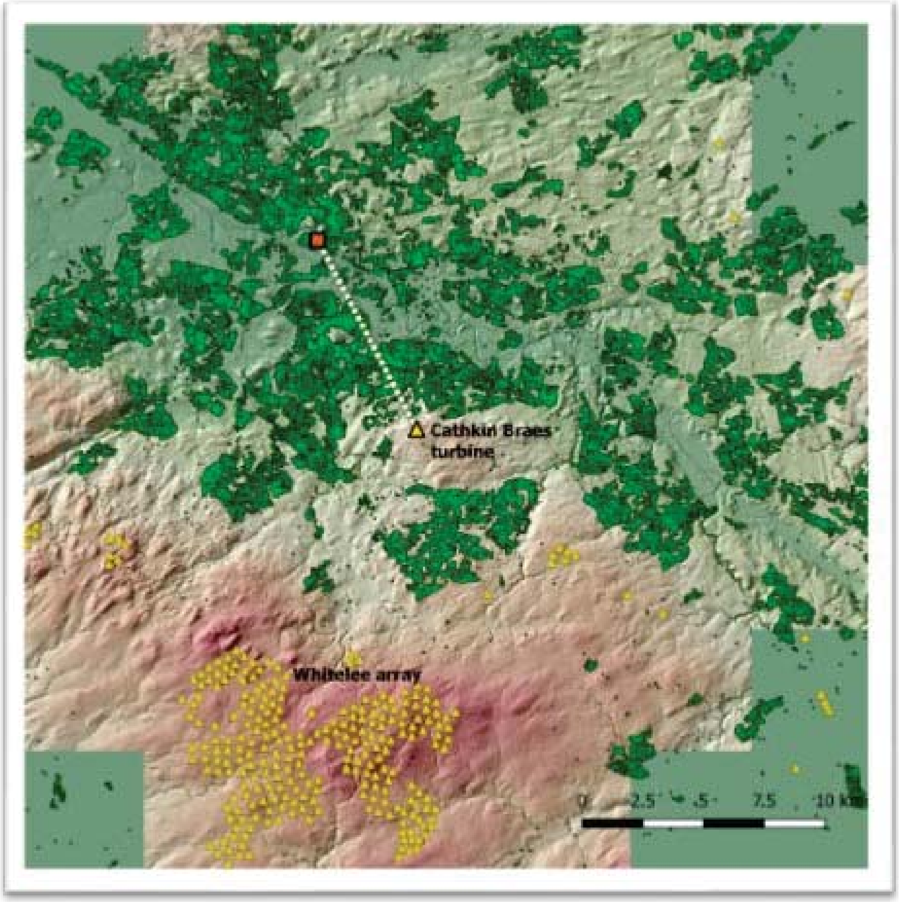

Figure 3: Digital Elevation Model for Glasgow area. Repeat-sales properties in green. Wind turbines are yellow triangles. Dotted line is an example line of sight (matches figure below) for a sample Glasgow property to Cathkin Braes turbine tip.

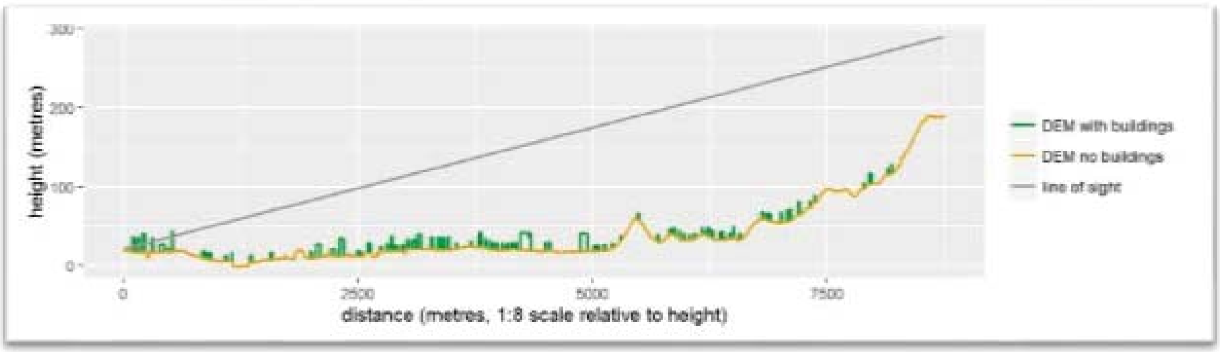

Figure 4: example line of sight blocked by buildings that would not be blocked by landscape alone. Matches dotted line in above figure. Property on left, Cathkin Braes turbine tip on right. Note horizontal distance is 1/8 of actual scale, relative to height.

Analysis step 2: house price impact using 'difference in differences'

The aim of the econometric analysis described in this section is to assess the house price impact as distance increases, both for visible and non-visible turbines and wind farms.

We use a "difference in differences" approach to identify the causal effect of wind turbine proximity and visibility. This approach seeks to estimate how rates of change in house prices differ between properties "exposed" to wind turbines (through proximity and/or visibility) compared with those that are not exposed. We use only `repeat sale' properties, as described above. We label properties exposed to wind turbines - those we want to identify any price impact for - as the "treatment group".

To measure the causal effect of wind turbine exposure, we would ideally like to know how the same dwelling's change in price over time is affected by the presence or absence of a wind farm. Clearly, observing both states at the same time is not possible. Instead, we construct a "control group" that closely resembles the characteristics of the treatment group but has not been exposed to a wind farm. The control group thus provides us with a counterfactual dwelling price, which we interpret as what the price would have been if the treatment group had not been in proximity to, or in sight of, wind turbines. This setup allows us to compare the average change in 'exposed' dwellings' house price to the average change in 'unexposed' dwellings' house price before and after turbines become operational - a so called *difference-in-differences* framework.

The first difference is how much the treatment and control groups change price between the chosen time periods. The second difference is how these two changes compare. This second difference is labelled the "treatment effect", i.e. the causal impact of wind farm developments on house price growth. If we were to produce the same findings as Gibbons, with the treatment group's price increasing **less** than the control group, then the impact of wind turbines on house price growth would be negative. For example, if we find a house price impact of -10%, this means that prices in the treatment group went up by 10% less than they did in the control group. On the other hand, if we find a positive effect, say 10%, this means that prices in the treatment group went up by 10% more than in the control group.

Note that a key assumption in the difference-in-differences framework is that the treatment and control groups show the same trends in house price growth in the pre-treatment period (the 'common trends assumption'), which means that they are subject to the same influences on price before the turbine is installed.

For all results, we repeated our difference-in-differences analysis using a large variety of additional controls that control for possible unobserved factors. This is the same as the "fixed effects" approach used by Gibbons (2014). The essential principle of a fixed effects approach is to allow fixed (i.e. constant over time) differences in subsets of the data to be accounted for. Including fixed effects allows the analysis to control for factors that we cannot easily measure (such as cultural differences or unknown economic, political or physical factors) but are likely to be fairly constant over time and may cause different price trends. The most intuitive fixed effects are regional. For example, there might be different house price trends across NUTS2 regions because of differences in the fixed characteristics across regions, such as their physical geography. These differences can be controlled for using fixed effects even if we do not have detailed data on the different underlying characteristics. This may be important if wind farms are sited taking these features into account.

All of the results presented in this report include basic fixed effects that control for variations in overall house price trends and differences in property characteristics. We use annual and quarterly fixed-effect controls to flexibly account for house price trends. Since we are looking at repeat sales, our estimations further include a set of house fixed effects - allowing each property its own trend line - that absorb any time-invariant house characteristics such as its footprint size or number of bedrooms. These are the "basic" controls used in all the results reported here.

We then add a number of additional controls to the models in order to test sensitivity. First, a number of geographic controls are added, allowing different house price effects over time by including fixed effects for slope (for each individual property), elevation (height above sea level for each property) and aspect (which compass direction the property's slope is facing, indicating which direction their predominant view is likely to be). Second, we add controls for different price effects across distance rings. These controls are in line with the ones used by Gibbons (2014). In addition, we allow house prices to differ between Scotland's four NUTS2 regions and include a set of region-by-year interactions. These additional fixed effects results are provided in the appendices.

Results

We present three sets of results. We start with the Gibbons (2014) approach, which is based on postcode averages for house prices and computes proximity and visibility using the centre point of entire wind farms (rather than individual turbines). We then compare these baseline results with outputs based on more fine-grained analysis that follows individual dwellings over time and calculates turbine proximity and visibility based on individual wind turbines. This is done both for visibility based just on terrain, and also visibility that also accounts for any buildings that may block the view.

Result #1: Analysis based on Postcode Averages & Wind Farm Centre Points ('centroids') (Gibbons)

Figure 5 shows the percentage impact on house price growth of a dwelling close to a wind farm being able to see the wind farm (blue line) compared with not being able to see the wind farm (red line). The approach used to derive this first set of results is similar to Gibbons (2014). They are based on:

- the change in average house prices in a given postcode before and after a wind farm became operational (rather than individual dwellings); and
- the effect of entire wind farms (rather than individual turbines).

Compared to the individual-property-level repeat sales analysis, one may think of this as a repeat sales estimation at the postcode level. However, instead of looking at the same house selling multiple times, we now look at multiple transactions in the same postcode. The implicit assumption is that houses within the same postcode unit are very similar and could be used interchangeably.

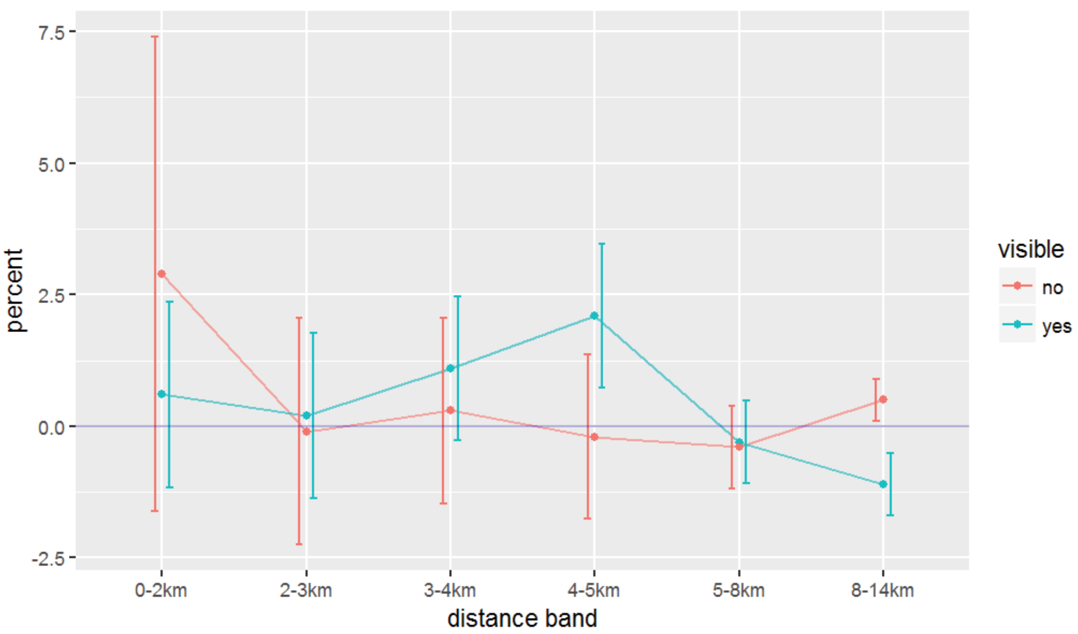

Figure 5: Result #1: Percent difference in the change of house price

(Postcode/wind farm centroids[19], **whole wind farm** visible/not visible.)

The horizontal axis shows the distance between the postcode of dwellings and the centre of the wind farm. These distances are grouped into 6 bands: (i) 0-2km, (ii) 2-3km, (iii) 3-4km, (iv) 4-5km, (v) 5-8km, and (vi) 8-14km. The vertical bars show the confidence intervals for each estimate. If the confidence interval is narrow, depicted by a short vertical bar, it means the estimate is precise. The longer the bar, the wider the confidence interval,[20] and the less precise the estimate is. If this vertical bar is entirely above zero, it means the result suggests a significant[21] positive effect on house price change caused by the construction of the wind farm. If the vertical bar lies entirely below zero, it means that the effect is significantly negative. If the vertical bar extends above and below zero, as is the case for most of the estimates in Figure 5, it means that there is no significant effect, either positive or negative. In other words, we cannot rule out a zero effect at the 95% confidence level.

A zero effect does not mean that house price growth has flat-lined. Rather it means that the treatment group (those properties that are in close proximity to a wind turbine) have a similar house price growth trajectory as the control group (those properties that are not in close proximity to a wind turbine).

The results in Figure 5 suggest that visible turbines have a positive effect on house prices (the blue line is above zero for the first four distance bands). However, the majority of confidence intervals extend above and below zero. This suggests that there is no significant house price effect in the first three distance bands, but a possible slight positive effect for visible turbines in the 4-5km band, dropping to a negative effect in the 8-14km band.

As discussed above, we repeated our analysis using a large variety of different specifications that control for a variety of possible unobserved factors using the same "fixed effects" approach used by Gibbons (2014). The results of the key variations from this exercise are presented in Figure A1 in the appendix, where Figure 5 is replicated in Figure A1(A) for comparison. We can see that the results are broadly consistent with Figure 5 in that none of the graphs show significant negative impacts of wind turbines on house price growth in the first three distance bands. Some graphs do, however, suggest a significant **positive** impact on house price growth, particularly in the second distance band (2-3 km), and particularly for visible turbines (see graphs (B), (C), (D), (F), and (H) of Figure A1). A more detailed description of the results in Figure A1 is presented in the Appendix.

Result #2: Analysis based on Repeat Sales & Individual Turbines

Figure 6 shows results based on the repeat sales of individual properties and the impact on house price growth after individual turbines become operational[22]. Here we see a significant positive impact on house price growth in the first distance band (1-2km) for properties that cannot see any turbines, but this effect is much smaller and statistically insignificant for properties in the same distance band that can see turbines. Note that the positive effect on properties, for which turbines are visible, becomes statistically significant in the second, third and fourth distance bands. The two furthest distance bands, however, do indicate negative price impacts. Though these results are mixed, as confidence intervals for visible/not visible turbines cross or touch the zero line.

Results of the sensitivity analysis—comparison with a variety of different fixed effects—are presented in Figure A2 in the appendix. Again, these different versions of the results tell a similar story with the positive impact on house price growth

[19] Centroid means centre point of an aerial unit (e.g. postcode) or multiple points.
[20] Based on the 95% level of confidence, which is the standard threshold used in statistical studies.
[21] Statistical "significance", in this context, means that there is less than a 5% chance that an estimated negative or positive house price impact is purely due to random variation in the data.
[22] Again, this is replicated in the appendix, figure A2(A).

tending to diminish with distance for properties that cannot see turbines, but rising then falling with distance for properties that can see turbines.

Crucially, there are no consistent signs of negative impacts on house price growth in the first three distance bands. In these results, the negative signal in the furthest two bands is again mixed, with no completely consistent pattern either side of zero.

Note that at shorter distances, confidence intervals tend to be larger. This is unsurprising, as sample sizes at shorter distances are smaller (there are not many houses very close to turbines) and so there will necessarily be more uncertainty in our estimates at close distances.

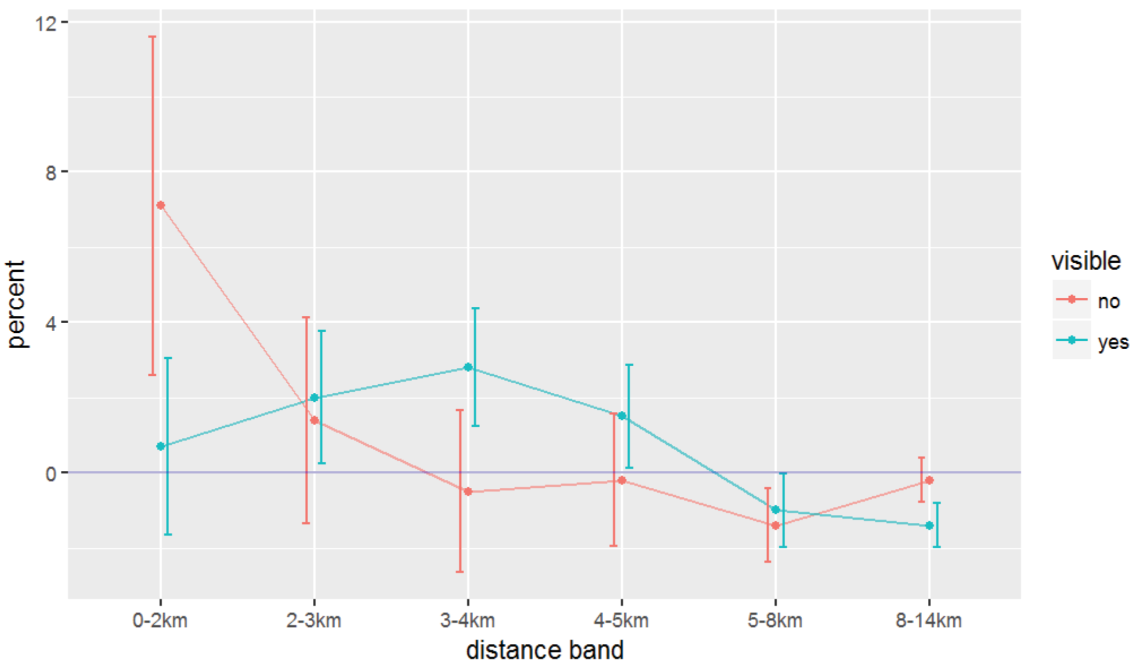

Figure 6: Result #2: Percent difference in the change of house price

(All repeat sales, turbine visible / not visible)

Results for individual repeat sales properties (Figure A2, appendix) show much the same pattern, but with larger percentage effects. The larger non-visible turbine effects at very close distance do, again, have large confidence intervals - but these do not cross the zero line. For both the centroid and repeat-sales results, any impact on house price growth tends to drop off as distances increase, though there is a great deal of variability in this response.

Repeat-sales results take advantage of having individual turbine data to distinguish between responses to turbines over and under 100 metres to tip height (appendix, figures A2(E) and A2(F); A3(E) and A3(F)). Sub-100 metre turbines are associated with consistent negative house price impacts, if they can be seen - but, again, confidence intervals cross the zero line. This is not the case for those out of sight, however.

Turbines over 100 metres in height are very similar to the main results - with perhaps a more clear decay of positive effect over distance for non-visible turbines. It is worth noting that: (a) Aberdeenshire has a large proportion of the sub-100 metre turbines and (b) most of the above 100 metre turbines were built after 2006, so this difference in response could be rooted in these different times and places.

Result #3: Analysis based on Repeat Sales & Individual Turbines, Taking into Account Building Heights

One disadvantage with both Result #1 (the Gibbons approach) and Result #2 (the individual houses/turbines approach) is that the visibility estimates do not take into account the possibility of buildings (as opposed to natural features) blocking the line of sight to turbines and wind farms.

Figure 7 shows the results of an analysis based on the repeat sales of individual properties and the impact on house price change after individual turbines become operational taking into account the height of buildings that might block the view of turbines. (Again, the appendix shows the results of the sensitivity analysis for these results in Figure A3). While the main findings remain similar to Results #1 and #2 in that there are no consistent signs of negative house price effects in the first three distance bands, it is clear that the estimates of impacts of visible and non-visible turbines on house price changes appear to be much closer in Result #3. Looking across all the results in Appendix figure A3, for both visible and non-visible turbines, the impact on house price growth seems to be more positive in the second distance band (2-3km) than in the closest distance band (0-2km), but then declines in distance bands three and four. As with the previous result, there appear to be negative price impacts in the last two distance bands, particularly for visible turbines, but these results are less consistent in the sensitivity analysis.

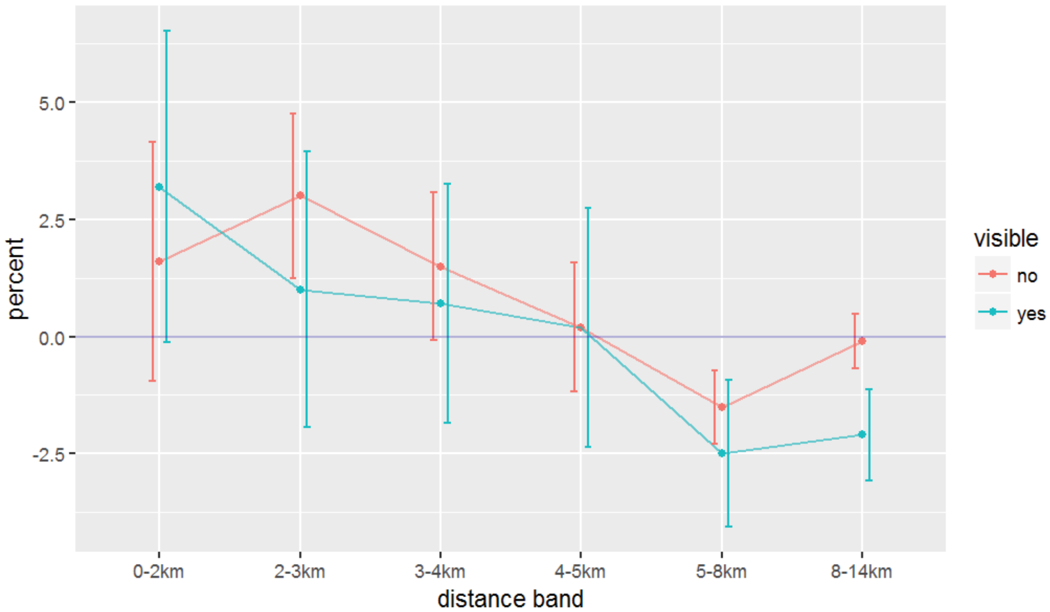

Figure 7: Result #3 Percent difference in the change of house price

(All repeat sales, turbine visible / not visible, using building height data for line-of-sight)

While results using building height data in Figure 7 are broadly similar to those relying on terrain-based line of sight, for some of these regressions there are quite different results even for properties that cannot "see" a turbine. This is because it uses a different sample of houses - only those that have lines of sight that cross areas that have available building height data. If this is not done, it is impossible to know whether a property has a clear line of sight due to no buildings blocking it, or just that no building height data was available. As mentioned above, this still accounts for 84% of properties - but these are all in the larger conurbations. The properties that "can see" and "cannot see" are, of course, also different. The building height results, then, say more about the impact of wind turbines in urban areas than the non-building height sample.

The main difference in the building height result is in the nearest distance band where the effects on house price growth for properties whose line of sight is blocked by a building are noticeably smaller in comparison to those with line of sight blocked by terrain. With terrain only, visible and non-visible appeared to show a quite different response (Figure 6), but when the building height data are included (Figure 7), the impact of visible and non-visible turbines both have the same direction of change as distance is increased (though again, the wide confidence intervals mean there is considerable uncertainty surrounding the estimates).

The pattern of difference between sub-100-metre turbines (Figure A3(E)) and those over (Figure A3(F)) is similar to the terrain-based results once the uncertainty surrounding estimates is taken into account. For turbines less than 100 metres that can be seen despite building height, there appear to be large impacts on the price growth of properties in close proximity, and these impacts diminish at further distances, but the confidence intervals are so wide, we cannot be sure that the effects are different to zero for any of the distance bands, visible or non-visible. Much more precise results are available for turbines over 100m with statistically significant positive effects for the second distance band (2-3km) in Figure A3(F).

Summary and possible explanations for the results

In summary, we have not found any consistent evidence of a negative impact of wind turbines on house price growth. Generally speaking the effect is either positive at particular distance bands (2-3km) or not distinguishable from zero.

Note again that a zero effect does not mean that house price growth has flat-lined. Rather, it means that there is no significant difference between the house price growth of the treatment group (properties close to turbines) and that of the control group (properties far away from turbines).

A positive effect means that the treatment group has a higher rate of house price growth than the control group. The repeat sales analysis, for example, finds a positive effect of 2% for houses in the 2-3km distance band that can see a turbine (Figure 6). This means that the value of those houses went up by 2% more than the increase in value of dwellings in the control group.

We also find some evidence that that the impact of wind turbines on house price growth appears to vary across different regions of Scotland. This finding has not, as far as we are aware, been systematically tested in previous UK studies using the rigorous methods applied here.

There is some evidence from the results that property prices respond differently to wind turbines in different parts of Scotland. It must be emphasised, this finding is somewhat tentative. Using the current method, sample sizes are too small to be fully reliable. However, it does suggest that while some areas see the positive impacts described above, others may see negative impacts.

Results for Angus/Dundee and Clackmannanshire/Fife regions, all clustered north of the Firth of Forth, appear to see some negative impacts for visible turbines, though most of these have confidence intervals crossing or just touching zero. In contrast, North and South Lanarkshire show the most positive price impacts at close distances. Other regions either produce no geographical results due to data limitations, or are very mixed.

Our data do not provide sufficient information to enable us to rigorously measure and test the underlying causes of these differences which may be interconnected and complex. Differential impacts may arise, for example, from interactions between variations in physical terrain, urban social structures, local approaches to turbine development policy and community engagement.

We now conclude the report by offering a number of possible explanations for our findings.

Heterogeneous and changing preferences

The reason our results are consistently different to those reported by Gibbons (2014) might be because attitudes towards wind farms may be different in Scotland than in other parts of the UK, and may also vary significantly within Scotland, and between individuals. Attitudes may also have varied over time – e.g. in response to public debates about energy futures or rural economic development. So our complex findings may reflect genuine complexity and fluidity in the preferences and attitudes of homeowners across Scotland over the time period considered.

Location of turbines

In Scotland, a much higher proportion of turbines are likely to be located on moors and mountains, and in much more remote areas than in England and Wales. These differences in terrain might be another important reason for the discrepancies between our results and those of Gibbons (2014), as might the potential alternative uses of the land on which turbines are constructed. For example, in remote mountain locations, there may be fewer alternative commercially viable uses for the land and so the opportunity cost in terms of foregone alternative revenue streams from the land may be smaller. In contrast, high quality farmland locations in England and Wales may well have more valuable alternative uses that have to be foregone, both now and in the future, if turbines are constructed. This may itself affect the attitudes of, and financial impact on, local residents and businesses.

Amenity and economic benefits

The positive house price impacts presented above may also reflect the fact that some wind farms provide economic and leisure benefits to the surrounding areas.

- E.g.1: The Whitelee wind farm had 25,000 visitors in the first two years of opening[23] and provides 130kms of tracks for walkers, cyclists, horse riders and dog walkers. These benefits may be substantial and may offset any negative aesthetic or noise effects. The positive effect of such amenities might be particularly strong if the previous land use was essentially barren and of little aesthetic merit. The effects, positive and negative, are likely to vary geographically but not necessarily in the same way.
- E.g.2: Some renewable energy companies provide community and development funds to fund a range of projects that benefit the locality and potentially generate employment. The SSE Clyde wind farm fund[24], for example, is expected to provide a total of £17.5 million for local projects that boost local investment and employment, offer training, prevent poverty, or benefit the local or social environment in some way. Such initiatives may improve the quality of life of local residents and increase house prices accordingly.

Patterns of social stratification

Attitudes towards wind turbines and the economic benefits may vary across different social and economic groups. If the location of these groups relative to the location of wind farms varies (e.g. because affluent households are more concentrated in the outskirts in some cities than in others) then the house price responses might vary depending on location.

For example, Kavanagh, Lee and Pryce (2016)[25] find that poverty is much more concentrated in the inner city in Dundee than it is in Edinburgh. The maps in Figure 11 below make the same point using the Scottish Index of Multiple Deprivation. Note also that Kavanagh, Lee and Pryce (2016) identify significant change in the geographic patterns of poverty between 2001 and 2010. Since wind turbines tend to be located in rural areas, households living near the edge of the city are most likely to be affected, either positively or negatively, and variations in the pattern of wealth over time and between cities might affect the pattern of house price impact.

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[23] http://www.pfr.co.uk/cloich/15/Wind-Power/23/Tourism/
[24] See for example http://www.southlanarkshire.gov.uk/info/200168/getting_involved_in_your_community/571/sse_clyde_wind_farm_fund
25 Kavanagh, L., Lee, D. and Pryce, G. (forthcoming) Is Poverty Decentralising? Quantifying Uncertainty in the Decentralisation of Urban Poverty. Annals of the American Association of Geographers, freely available here: http://bit.ly/2dAihAX

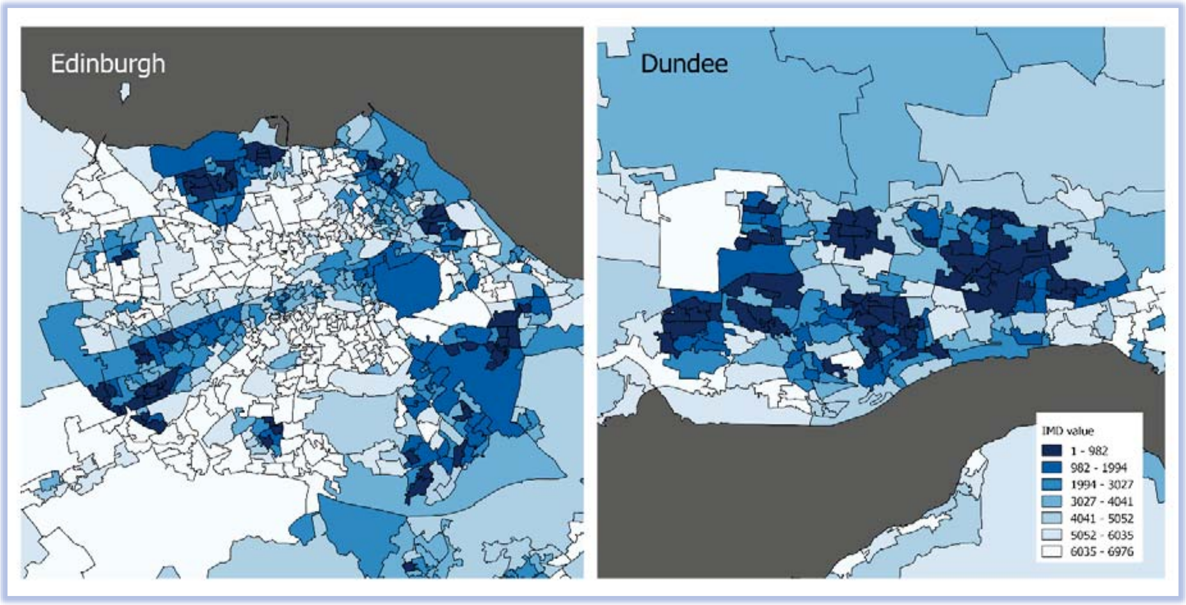

Figure 11: 2011 Scottish Index of Multiple Deprivation in Edinburgh and Dundee. Lower values (darker blue) are more deprived areas, higher values are less deprived.

Overall, those who are likely to be able to see a wind turbine typically live in lower value houses (and presumably have lower incomes) than those who cannot (Figure 12). It may be that those on lower incomes are less averse to wind turbines, perhaps because the marginal benefit of any community fund or other positive spillover from wind farm projects is larger relative to their disposable income.

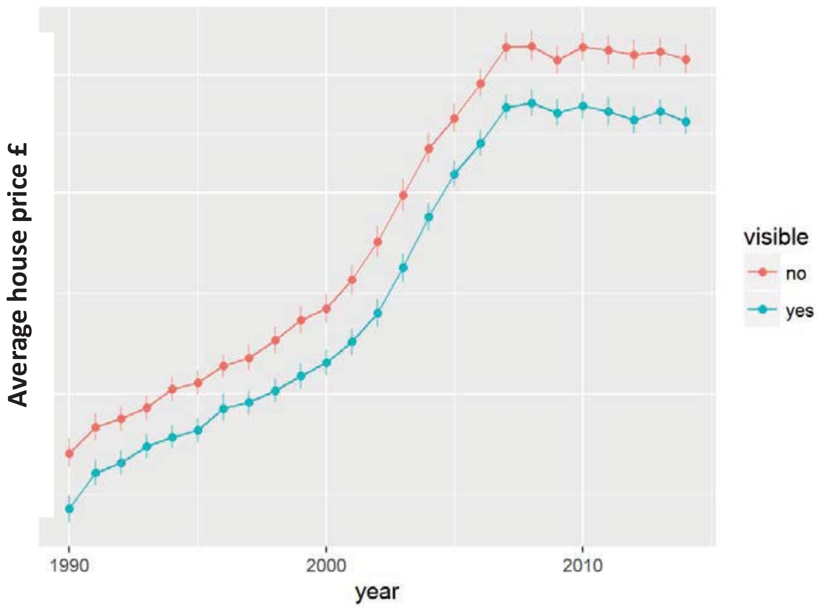

Figure 12: Average annual house prices (plotted on log scale) for houses that will have a turbine in sight at some point within the timeframe of the study vs. those that do not

Interactions between multiple causes

These explanations are not mutually exclusive. It is likely that they affect house prices simultaneously, and to varying degrees in different locations.

These forces may also reinforce or negate each other. They may each wax and wane over time and have different effects at different spatial scales leading to a complex and fluid set of potential outcomes at each point in time.

Further research would be needed to identify which of these effects is most prevalent and persistent. However, it should be noted that the data we collated for this project are unlikely to be sufficient to disentangle these effects in a robust way.

Appendix: Sensitivity analysis

Introduction

We noted above that we use a “fixed effect” methodology to control for a wide range of factors that we cannot observe or measure directly. Provided these factors remain fairly constant over time, we can control for their impact on price trends by introducing additional categorical variables into the analysis. All of the results presented in this report include basic fixed effects that control for differences in dwelling attributes, such as number of bedrooms, which we assume remain constant over time.

We also experimented with a wide number of additional controls. This allows us to test whether our results are robust to changes in how the analysis is set up. For example, we included fixed effects that allow different house price effects to occur over time for: the land gradient (for each individual property); elevation (height above sea level for each property); and aspect (which compass direction the property's slope is facing, indicating which direction their predominant view is likely to be). We also included controls for different price effects across distance rings and we allowed house prices to differ between Scotland's four NUTS2 regions and include a set of region-by-year interactions.

The impacts of these different specifications are presented in the graphs below for each of main categories of results presented under the labels A1, A2, and A3 which relate to the headings used in the main body of the report:

- Figure A1 reports sensitivity analysis for Result #1: Analysis based on Postcode Averages & Wind Farm Centre-Points (‘centroids’) (Gibbons),
- Figure A2 reports sensitivity analysis for Result #2: Analysis based on Repeat Sales & Individual Turbines
- Figure A3 reports sensitivity analysis for Result #3: Analysis based on Repeat Sales & Individual Turbines, Taking into Account Building Heights

You will see that each of the three figures contains eight sub-graphs, labelled (A) to (H) which give results for each type of fixed effects analysis. The labels for each are explained below:

The first sub-figure, labelled (A), is the "basic" fixed effects used in all analyses:

- **(A) “properties”**: includes fixed effects for time and properties. Note that these results are the same as the results used in the main sections above: they include the same time fixed effects and the property-level fixed effects as those used in Figures 5, 6 and 7 and follow the method described in the "Analysis Step 2" section above. We reproduce them below for ease of comparison with the additional results.

Sub-figures (B) to (D) in Figures A1, A2 and A3 below each add an extra fixed effect on top of the last. In order, these are:

- **(B) "geography":** fixed effects for slope, elevation and aspect;
- **(C) "rings"**: fixed effects for properties in each distance ring from turbines (or wind farms for figure A1);
- **(D) "NUTS2"**: fixed effects for Scotland's four NUTS2 regions.

Each sensitivity analysis includes a further four sub-figures. These run separate analyses on a particular subset of the data, with each of them using the full set of fixed effects. All three break down properties by their distance from the Scottish coast:

- **(G) “Coast < 2km”**: contains only coastal properties – i.e. those within 2km of the coast;
- **(H) “Coast > 2km”**: contains only inland properties – i.e. those located 2km or more beyond any coastal point.

Sub-figures (E) and (F) vary depending on whether the analysis is based on postcodes/wind farm centre-points or individual dwellings/turbines:

In **Figure A1** the analysis is based on postcode and wind farm centre-points and the results are broken down by wind farm size:

- **A1(E) "Single turbines"**: looks just at single turbine sites;
- **A1(F) "More than one turbine"**: looks at sites with more than one turbine.

In **Figures A2 and A3**, the analysis is based on individual turbines (rather than entire wind farms), and so we can estimate the impact of turbine height:

- **A2(E) and A3(E) "Turbines < 100m"**: plots the impact of turbines that are less than 100m tall;
- **A2(F) and A3(F) "Turbines < 100m"**: plots the impact of turbines over 100m tall.

Note that all graphs in the appendix have the same scale for the vertical axis, which is limited to the plus/minus 15% price change interval. This was done to make each sub-figure directly comparable. Any confidence intervals (i.e. the vertical bars plotted for each estimate) beyond this range are cut off at the 15% limit.

Sensitivity analysis for result #1: based on Postcode Averages & Wind Farm Centre-Points ('centroids') (Gibbons)

The results in the graphs (E) and (F) of Figure A1 allow us to compare the effects of "wind farms" consisting of single turbines (graph A1(E)) and those with two turbines or more (graph A1(F)). Single-turbine effects have wider confidence intervals making the estimates less precise and not statistically different from zero. The estimates are also noticeably less precise for coastal locations (A1(G)) than for inland properties (A1(H)). Controlling for "geography" using fixed effects for slope, elevation and aspect (A1(B)), distance rings (A1(C)) and NUTS2 region (A1(D)) yields relatively precise positive house price effects particularly for the 2-3km distance band.

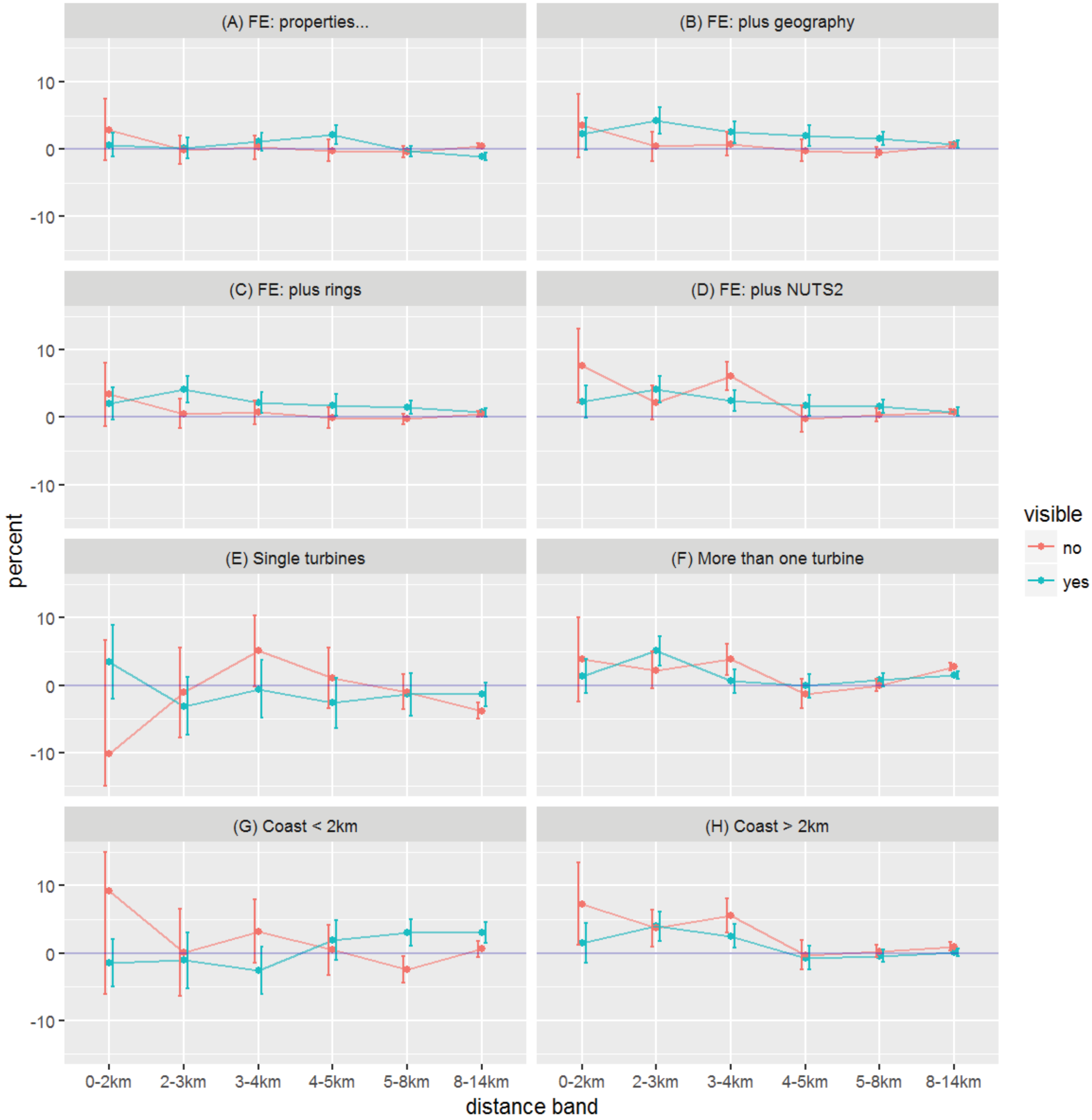

Figure A1: Percent difference in the change of house price

(Postcode/wind farm centroids, whole wind farm visible / not visible)

Sensitivity analysis for result #2: based on Repeat Sales & Individual Turbines

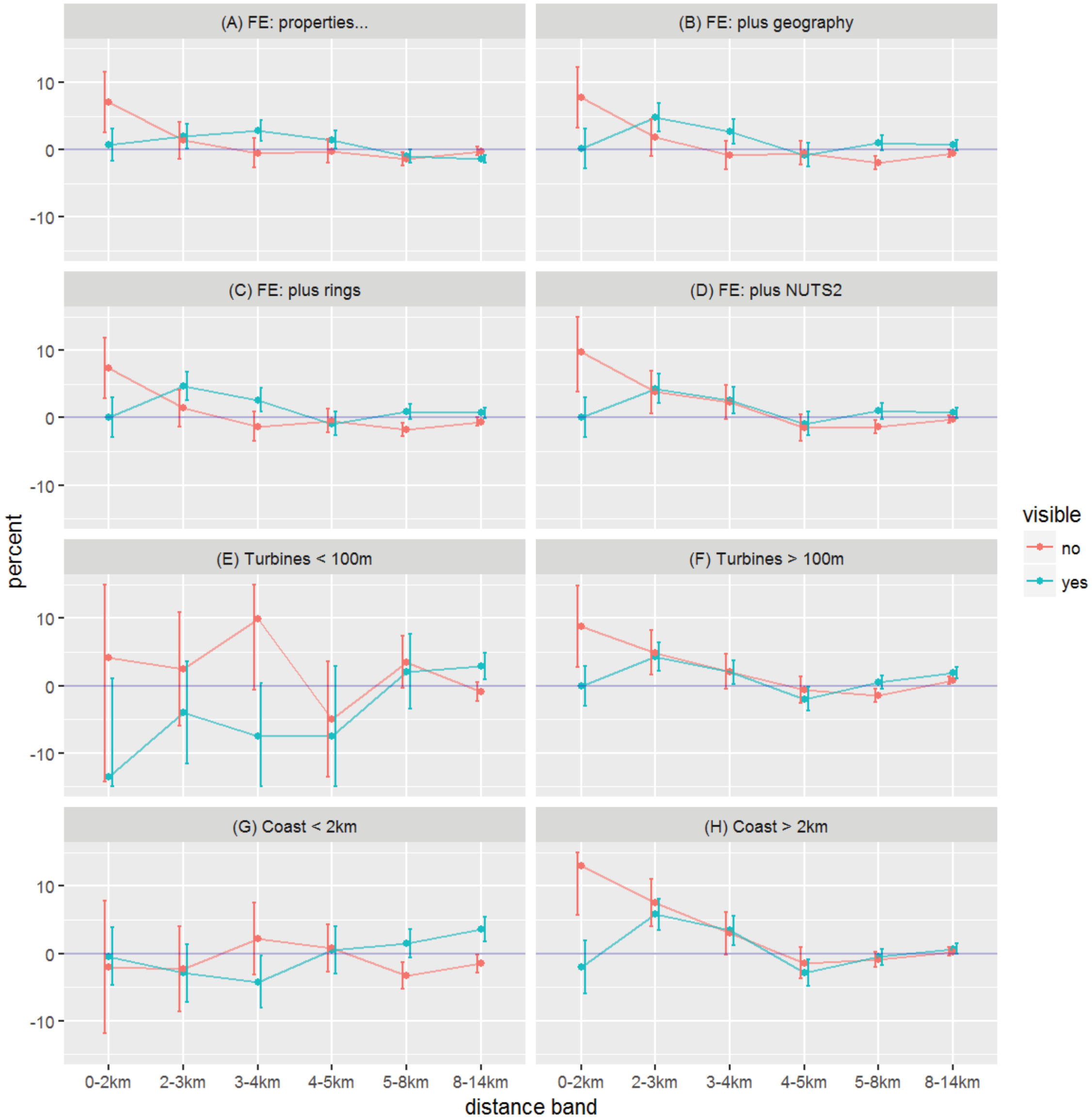

Figure A2: Percent difference in the change of house price

(All repeat sales, turbine visible / not visible)

Sensitivity analysis for result #3: based on Repeat Sales & Individual Turbines and Taking into Account Building Heights

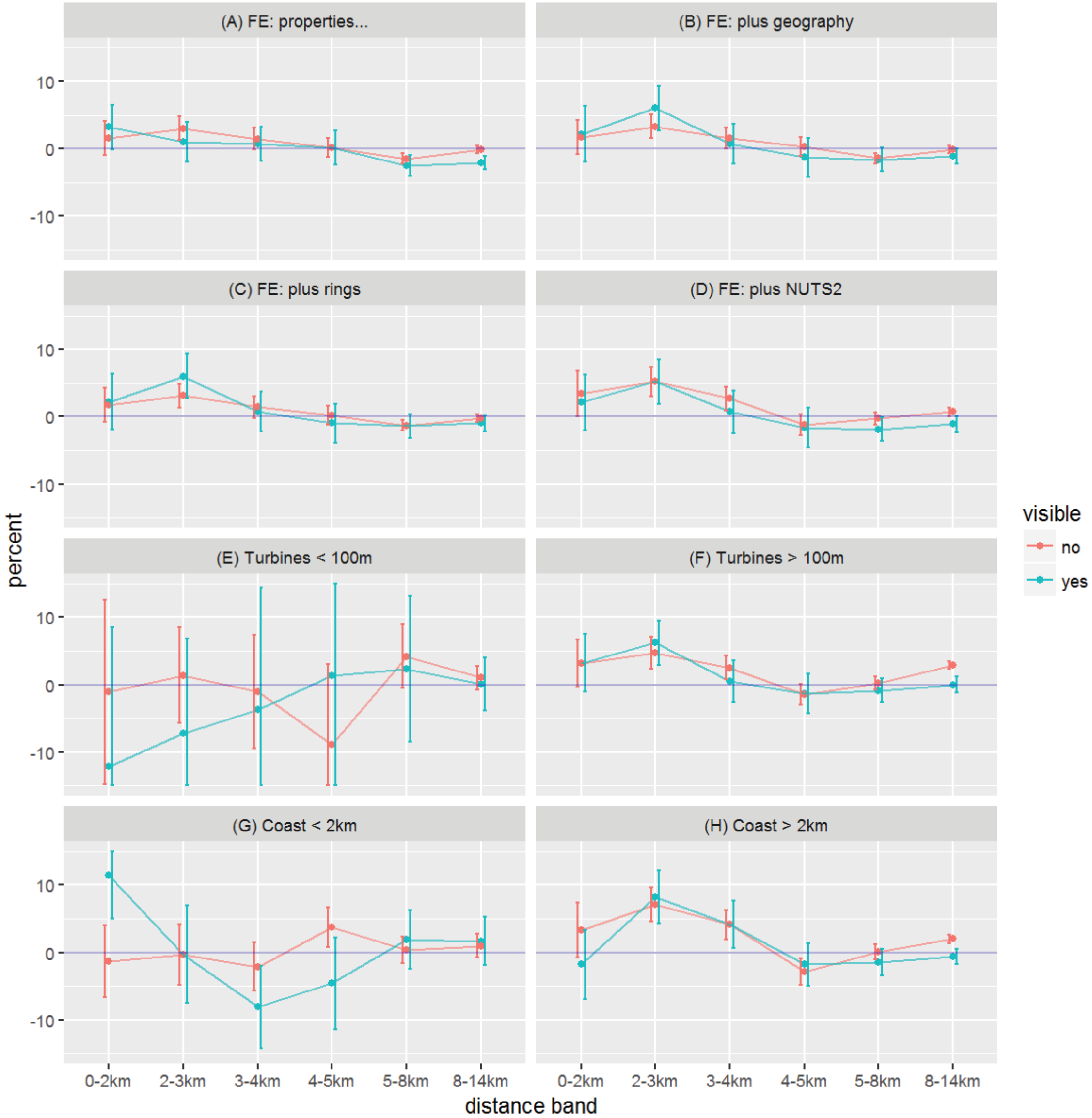

Figure A3: Percent difference in the change of house price

(All repeat sales, turbine visible / not visible accounting for building heights)

Acknowledgements

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APPENDIX 6-1

DEDICATED HABITAT AND VEGETATION COMPOSITION SURVEY

Appendix 6-1 – Botanical study

Botanical Survey, Croagh Wind Farm

DOCUMENT DETAILS

Client: **Croagh Wind Farm**

Project Title: **Botanical Survey, Croagh Wind Farm**

Project Number: **170511**

Document Title: **Appendix 6-1 – Botanical study**

Document File Name: **BS - F – 2020.07.07 - 180511**

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1. INTRODUCTION

1.1 Introduction

MKO were commissioned to undertake detailed botanical surveys to determine the nature of the habitats occurring within the EIAR study area boundary at the proposed Croagh windfarm. The detailed assessments focussed on the development footprint, particularly the turbine base at T1, as this is located on peatland habitat. As the remainder of the infrastructure is located within mature or second rotation forestry and existing forestry access tracks, a description of these habitats are provided in Section 6.6.1, Chapter 6 of the EIAR. Where habitats of high conservation value, including Poor fen and flush (PF2) and Transition mire and quaking bog (PF3) were recorded within the study area, but outside of the proposed development footprint, these were subject to assessment and are included in this report. The results of these surveys provided additional data on habitats occurring within EIAR study area boundary. The detailed botanical surveys were undertaken on the 24th & 26th April 2019, 5th July 2019 and 14th August 2019.

2. SURVEY METHODS

Each area described below was chosen to provide as accurate a description of the habitat types recorded within the development footprint as possible. A minimum of three relevés were recorded of the most commonly occurring habitats within the site which were spatially and botanically representative of the habitat type.

A total of 14 relevés were undertaken at habitats of conservation value within the EIAR study area. Relevés that were undertaken in peatland followed methods that were set out in the following document:

- *Perrin, P.M, Martin, J.R., Barron, J.R., Roche & O' Hanrahan, B. (2014) Guidelines for a national survey and conservation assessment of upland vegetation and habitats in Ireland. Version 2.0. Irish Wildlife Manuals, No. 79. National Parks and Wildlife Service.*

All species were readily identifiable during the survey. Plant nomenclature for vascular plants follows '*New Flora of the British Isles*' (Stace, 2010), while mosses and liverworts nomenclature follows '*Mosses and Liverworts of Britain and Ireland - a field guide'* (British Bryological Society, 2010).

2.1 Statement of Authority

Field surveys were undertaken by James Owens (BSc., MSc.) on the 24th & 26th April 2019, 5th July 2019 and 14th August 2019. James has over 5 years' consultancy experience and is a competent expert in undertaking ecological surveys. In addition to the below botanical data, the lands within the wider study area were also surveyed in detail during habitat mapping survey work and walkover surveys. These surveys also informed the ecological constraints identification process.

3. RESULTS

Detailed botanical surveys of the entire turbine infrastructure footprint was undertaken during site visits undertaken on the 24th & 26th April 2019, 5th July 2019 and 14th August 2019. As all but one turbine, T1, is located within highly modified coniferous plantation forestry, the below sections provide the detailed quadrat data for the peatland and flush habitats occurring around T1. In addition, examples of the wet grassland habitat along the site access track is also provided.

The remaining turbines located within coniferous plantation forestry were found to be dominated by Sitka spruce and some lodgepole pine. The forestry within the site varies in its 'crop' cycle comprising of mature forestry, semi-mature forestry, second rotation forestry and clear-fell. An example of the forestry occurring within the site is provided in Plate 3-1.

Plate 3-1 Example of second rotation forestry (WD4) occurring within the proposed development site, with mature forestry in the background.

3.1 Quadrat 1 – Proposed access road to Turbine 1

Table 3-1 Botanical Survey

	Grid reference: E183600 N323608	Date: 26/04/2019
Common Name	Scientific Name	% Cover
Ling heather	*Calluna vulgaris*	45
Carnation sedge	*Carex panicea*	0.5
Cross-leaved heath	*Erica tetralix*	1
Common cottongrass	*Eriophorum angustifolium*	0
Hare's-tail cottongrass	*Eriophorum vaginatum*	30
Soft rush	*Juncus effusus*	0.5
Deergrass	*Trichophorum cespitosum germanicum*	0.5
Bilberry	*Vaccinium myrtillus*	0.5
	Hylocomium splendens	1
	Sphagnum capillifolium	3
	Rhytidiadelphus loreus	30
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Vaccinium myrtillus - Racomitrium lanuginosum (HE3F)*

Plate 3-2 Example of recolonising bare peat within the study area around T1

3.2 Quadrat 2 – Example of raised bog habitat at Turbine 1

Table 3-2 Botanical Survey – Quadrat 2

Quadrat 2	Grid reference: E183540 N323611	Date: : 26/04/2019
Common Name	Scientific Name	% Cover
Ling heather	*Calluna vulgaris*	80
Cross-leaved heath	*Erica tetralix*	0.5
Hare's-tail cottongrass	*Eriophorum vaginatum*	5
Purple moor-grass	*Molinia caerulea*	10
Bilberry	*Vaccinium myrtillus*	0.5
	Cladonia portentosa	10
	Hylocomium splendens	10
	Sphagnum capillifolium	5
	Rhytidiadelphus loreus	3
	Polytrichum commune	0.5
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Erica cinerea - Calluna vulgaris* (HE2D)

Plate 3-3 Example of blanket bog vegetation within the study area around T1

3.3 Quadrat 3 – Example of vegetation within forestry ride east of Turbine 1

Table 3-3 Botanical Survey – Quadrat 3

Quadrat 3	Grid reference: G 83694 23615	Date: 26/04/2019
Common Name	Scientific Name	% Cover
Sweet vernal grass	*Anthoxanthum odoratum*	1
Ling heather	*Calluna vulgaris*	15
Common sedge	*Carex nigra*	0.5
Hare's-tail cottongrass	*Eriophorum vaginatum*	40
Tormentil	*Potentilla erecta*	0.5
	Hylocomium splendens	40
	Sphagnum palustre	5
	Rhytidiadelphus loreus	10
	Rhytidiadelphus squarrosus	0.5
	Polytrichum commune	5
	Scleropodium purum	5
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Vaccinium myrtillus - Racomitrium lanuginosum* (HE3A)

+ indicates presence, below 1% cover


Plate 3-4 Example of vegetation within forestry ride west of Turbine 1

3.4 Quadrat 4 – Proposed access road to Turbine 1

Table 3-4 Botanical Survey – Quadrat 4

Quadrat 4	Grid reference: IG 83591 23647	Date: 05/07/2019
Common Name	Scientific Name	% Cover
Ling heather	*Calluna vulgaris*	65
Cross-leaved heath	*Erica tetralix*	2
Hare's-tail cottongrass	*Eriophorum vaginatum*	10
Bilberry	*Vaccinium myrtillus*	5
	Hylocomium splendens	5
	Sphagnum capillifolium	40
	Rhytidiadelphus loreus	3
	Scleropodium purum	1
	Hypnum jutlandicum	0.5
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Vaccinium myrtillus - Racomitrium lanuginosum [HE3F]*

Plate 3-5 Example of blanket bog vegetation within the study area around T1

3.5 Quadrat 5 - Proposed access road to Turbine 1

Table 3-5 Botanical Survey – Quadrat 5

Quadrat 5	Grid reference: IG 83572 23650	Date: 05/07/2019
Common Name	Scientific Name	% Cover
Creeping bentgrass	*Agrostis stolonifera*	1
Bottle sedge	*Carex rostrata*	2
Common cottongrass	*Eriophorum angustifolium*	15
Yorkshire fog	*Holcus lanatus*	5
Jointed rush	*Juncus articulatus*	5
Bogbean	*Menyanthes trifoliata*	55
Marsh cinquefoil	*Potentilla palustris*	3
Common sorrel	*Rumex acetosa*	0.5
	Hylocomium splendens	5
	Sphagnum palustre	1
	Sphagnum fallax	25
	Rhytidiadelphus squarrosus	0.5
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Menyanthes trifoliata – Potentilla palustris* [FE2E]

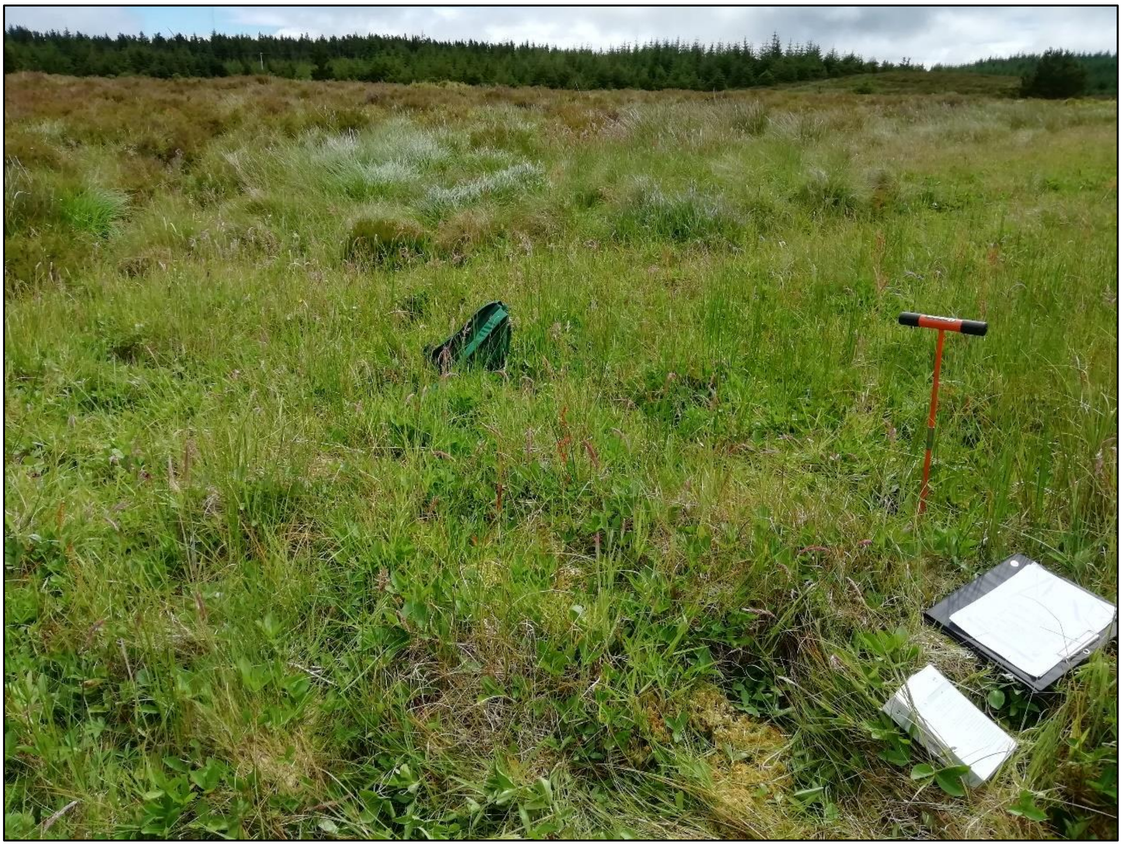

Plate 3-6 Example of flush habitat within the study area around T1

3.6 Quadrat 6 – Blanket bog west of Turbine 1

Table 3-6 Botanical Survey – Quadrat 6

Quadrat 6	Grid reference: IG 83373 23629	Date: 05/07/2019
Common Name	Scientific Name	% Cover
Creeping bentgrass	*Agrostis stolonifera*	5
Sweet vernal grass	*Anthoxanthum odoratum*	10
Ling heather	*Calluna vulgaris*	3
Star sedge	*Carex echinata*	2
Common sedge	*Carex nigra*	0.5
Heath spotted orchid	*Dactylorhiza maculata*	2
Wavy hair grass	*Deschampsia flexuosa*	10
Marsh willowherb	*Epilobium palustre*	1
Yorkshire fog	*Holcus lanatus*	5
Jointed rush	*Juncus articulatus*	2
Soft rush	*Juncus effusus*	2
Heath woodrush	*Luzula multiflora*	2
Heath milkwort	*Polygala serpyllifolia*	0.5
Tormentil	*Potentilla erecta*	15
Devils-bit scabious	*Succisa pratensis*	25
	Hylocomium splendens	5
	Sphagnum fallax	10
	Rhytidiadelphus squarrosus	10
	Polytrichum commune	1
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Nardus stricta - Galium saxatile* [GL4D]

Plate 3-7 Example of more grass dominated vegetation within the blanket bog to the east of T1

3.7 Quadrat 7 - Blanket bog west of Turbine 1

Table 3-7 Botanical Survey – Quadrat 7

Quadrat 7	Grid reference: IG 83361 23616	Date: 05/07/2019
Common Name	Scientific Name	% Cover
Ling heather	*Calluna vulgaris*	60
Wavy hair grass	*Deschampsia flexuosa*	0.5
Hare's-tail cottongrass	*Eriophorum vaginatum*	15
Tormentil	*Potentilla erecta*	2
Bilberry	*Vaccinium myrtillus*	4.5
	Hylocomium splendens	5
	Sphagnum palustre	2
	Sphagnum fallax	5
	Sphagnum capillifolium	1
	Rhytidiadelphus loreus	20
	Scleropodium purum	10
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Vaccinium myrtillus - Racomitrium lanuginosum* [HE3F]

+ indicates presence, below 1% cover

Plate 3-8 Example of raised bog vegetation within the study area around T1

3.8 Quadrat 8 - Blanket bog south of Turbine 3

Table 3-8 Botanical Survey – Quadrat 8

Quadrat 8	Grid reference: IG 83821 23472	Date: 05/07/2019
Common Name	Scientific Name	% Cover
Ling heather	*Calluna vulgaris*	90
Wavy hair grass	*Deschampsia flexuosa*	0.5
Sitka spruce	*Picea sitchensis*	2
Bilberry	*Vaccinium myrtillus*	10
	Cladonia portentosa	0.5
	Sphagnum capillifolium	25
	Rhytidiadelphus loreus	20
	Scleropodium purum	1
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Vaccinium myrtillus - Racomitrium lanuginosum* [HE3A]

Plate 3-9 Example of vegetation occurring within coniferous forestry plantation south of T3

3.9 Quadrat 9 – Example of fen habitat south east of Turbine 1

Table 3-9 Botanical Survey – Quadrat 9

Quadrat 9	Grid reference: IG 83583 23590	Date: 14/08/2019
Common Name	Scientific Name	% Cover
Bottle sedge	*Carex rostrata*	5
Heath spotted orchid	*Dactylorhiza maculata*	0.5
Wavy hair grass	*Deschampsia flexuosa*	3
Common cottongrass	*Eriophorum angustifolium*	2
Hare's-tail cottongrass	*Eriophorum vaginatum*	1
Sharp-flowered rush	*Juncus acutiflorus*	2
Yorkshire fog	*Holcus lanatus*	15
Bogbean	*Menyanthes trifoliata*	60
Common sorrel	*Rumex acetosa*	0.5
Cranberry	*Vaccinium oxycoccos*	1
	Sphagnum palustre	5
	Sphagnum fallax	30
	Mean vegetation height	25cm
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Menyanthes trifoliata – Sphagnum recurvum agg. Mire* [FE2E]

Plate 3-10 Example of fen habitat south east of Turbine 1

3.10 Quadrat 10 - Example of poor fen habitat southeast of Turbine 1

Table 3-10 Botanical Survey – Quadrat 10

Quadrat 10	Grid reference: IG 83569 23588	Date: 14/08/2019
Common Name	Scientific Name	% Cover
Sharp-flowered rush	*Juncus acutiflorus*	55
Yorkshire fog	*Holcus lanatus*	5
Soft Rush	*Juncus effusus*	3
Tormentil	*Potentilla erecta*	25
Common sorrel	*Rumex acetosa*	10
Devils-bit scabious	*Succisa pratensis*	4
	Sphagnum fallax	15
	Rhytidiadelphus squarrosus	35
	Polytrichum commune	0.5
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Agrostis canina/vinealis - Rhytidiadelphus squarrosus* [GL4D]

+ indicates presence, below 1% cover

Plate 3-11 Example of poor fen habitat southeast of Turbine 1

3.11 Quadrat 11 – Example of fen and mire habitat southwest of Turbine 1

Table 3-11 Botanical Survey – Quadrat 11

Quadrat 11	Grid reference: IG 83520 23599	Date: 14/08/2019
Common Name	Scientific Name	% Cover
Bottle sedge	*Carex rostrata*	5
Wavy hair grass	*Deschampsia flexuosa*	10
Hare's-tail cottongrass	*Eriophorum vaginatum*	50
Yorkshire fog	*Holcus lanatus*	15
Bogbean	*Menyanthes trifoliata*	2
Common sorrel	*Rumex acetosa*	10
	Sphagnum fallax	25
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Menyanthes trifoliata – Sphagnum recurvum agg. Mire* [FE2E]

Plate 3-12 Example of fen and mire habitat southwest of Turbine 1

3.12 Quadrat 12 - Example of blanket bog habitat southwest of Turbine 1

Table 3-12 Botanical Survey – Quadrat 12

Quadrat 12	Grid reference: IG 83527 23606	14/08/2019
Common Name	Scientific Name	% Cover
Ling heather	*Calluna vulgaris*	10
Hare's-tail cottongrass	*Eriophorum vaginatum*	15
Bilberry	*Vaccinium myrtillus*	10
	Hylocomium splendens	5
	Sphagnum fallax	10
	Rhytidiadelphus loreus	30
	Scleropodium purum	5
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Calluna vulgaris - Hylocomium splendens* [HE3A]

Plate 3-13 Example of blanket bog habitat southwest of Turbine 1

3.13 Quadrat 13 – Example of wet grassland along site access road

Table 3-13 Botanical Survey – Quadrat 13

Quadrat 13	Grid reference: IG 91600 23328	Date: 14/08/2019
Common Name	Scientific Name	% Cover
Creeping bentgarss	*Agrostis stolonifera*	5
Sweet vernal grass	*Anthoxanthum odoratum*	5
Common mouse-ear	*Cerastium fontanum*	0.5
Marsh thistle	*Cirsium palustre*	1
Meadowsweet	*Filipendula ulmaria*	0.5
Yorkshire fog	*Holcus lanatus*	10
Jointed rush	*Juncus articulatus*	65
Soft rush	*Juncus effusus*	3
Water forget-me-not	*Myosotis scorpioides*	0.5
Ribwort plaintain	*Plantago lanceolata*	5
Tormentil	*Potentilla erecta*	3
Meadow buttercup	*Ranunculus acris*	2
Yellow rattle	*Rhinanthus minor*	0.5
Common sorrel	*Rumex acetosa*	2
Red clover	*Trifolium pratense*	3
Marsh ragwort	*Senecio aquaticus*	0.5
Devils-bit scabious	*Succisa pratensis*	3
	Rhytidiadelphus squarrosus	15
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Juncus effusus - Holcus lanatus* [GL2B]

+ indicates presence, below 1% cover

Plate 3-14 – Example of wet grassland along site access road

3.14 Quadrat 14– Example of wet grassland along site access road

Table 3-14 Botanical Survey – Quadrat 14

Quadrat 14	Grid reference: IG 91464 23227	Date: 14/08/2019
Common Name	Scientific Name	% Cover
Creeping bentgarss	*Agrostis stolonifera*	5
Sweet vernal grass	*Anthoxanthum odoratum*	1
Carnation sedge	*Carex panicea*	5
Common mouse-ear	*Cerastium fontanum*	0.5
Marsh thistle	*Cirsium palustre*	1
Marsh willowherb	*Epilobium palustre*	0.5
Marsh bedstraw	*Galium palustre*	0.5
Yorkshire fog	*Holcus lanatus*	15
Jointed rush	*Juncus articulatus*	40
Ragged robin	*Lychnis flos cuculi*	2
Meadow buttercup	*Ranunculus acris*	3
Lesser spearwort	*Ranunculus flammula*	1
Red clover	*Trifolium pratense*	20
Devils-bit scabious	*Succisa pratensis*	1
Common dandelion	*Taraxacum officinale agg*	0.5
	Rhytidiadelphus squarrosus	15
Habitat Classification as per the Irish Vegetation Classification (IVC)		*Juncus acutiflorus - Rhytidiadelphus squarrosus* {GL1E}

Plate 3-15 – Example of wet grassland along site access road

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APPENDIX 6-2

BAT SURVEY REPORT

Appendix 6-2 Bat Survey Report

Croagh Wind Farm

DOCUMENT DETAILS

Client: **Coillte**

Project Title: **Croagh Wind Farm**

Project Number: **180511**

Document Title: **Appendix 6-2 Bat Survey Report**

Document File Name: **BR Final – 09.07.2020 - 180511**

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1. INTRODUCTION

MKO was commissioned to complete a comprehensive assessment of the potential effects on bats of a proposed wind farm at Croagh, Co. Leitrim and Co. Sligo. This report provides details of the bat surveys undertaken, including survey design, methods and results, and the assessment of potential effects of the development on bats. Where necessary, mitigation is prescribed to minimise likely significant effects.

Bat surveys were undertaken throughout 2019 and were designed in accordance with Scottish Natural Heritage's guidance Bats and onshore wind turbines: survey, Assessment and mitigation (SNH, 2019). Bat surveys employed a combination of methods, including desktop study, habitat and landscape assessments, roost inspections, manual activity surveys and static detector surveys at ground level and at height.

1.1 Background

Wind energy provides a clean, sustainable alternative to fossil fuels in generating electricity. However, wind energy development can impact wildlife, directly through mortality and indirectly through disturbance and habitat loss. Bat fatalities have been reported at wind energy facilities around the world, raising concern about the cumulative impacts of such developments on bat populations (Arnett et al. 2016). No large-scale studies have been undertaken in Ireland to date. However, a study from the UK estimated bat fatalities at 0 – 5.25 bats per turbine per month (Mathews et al. 2016). While these results are not directly applicable to Ireland due to differences in bat species and behaviour, Ireland shares more similarities with bat assemblages of Great Britain, compared to those of mainland Europe.

Investigative research in North America and mainland Europe have revealed the mechanisms for bat mortality at wind turbines. Fatalities arise from direct collision with moving turbine blades (Horn et al. 2008, Cryand et al. 2014) and barotrauma (Baer Wald et al. 2008), i.e. internal injuries caused by air pressure changes. Why bats fly in the vicinity of wind turbines has been attributed to several different behavioural and environmental factors, e.g. habitat associations, weather conditions and, species ecology.

Pre-construction bat surveys are undertaken to gain an insight into bat activity in the absence of turbines and to predict and mitigate against any future risks identified. Survey design and analyses of results at the proposed development site was undertaken with reference to the latest policy and legislation, scientific literature and industry guidelines. Any spatial, temporal or behavioural factors that may put bats at risk were fully considered.

1.2 Bat Survey and Assessment Guidance

Several guidelines for surveying bats at wind energy developments have been produced in Europe, the UK and Ireland.

At a European level, the Advisory Committee to the EUROBATS Agreement, to which Ireland is a signatory, have produced Guidelines for Consideration of Bats in Wind Farm Projects which outlines an approach for assessing the potential impacts of wind turbines on bats during planning, construction and operation phases (Rodrigues, 2015). However, these guidelines are based on continental scenarios and include more diverse species and behaviours than those typical of Ireland. As such, EUROBATS guidance may recommend a level of survey that may prove inappropriate in Irish scenarios. Nevertheless, the guidance is evidence-based and provides a useful European context, within which Member States are encouraged to produce specific national guidance, focusing on local circumstances.

Bat Conservation Ireland produced Wind Turbine/Wind Farm Development Bat Survey Guidelines (BCI, 2012a). This document provides advice to practitioners and decision makers in Ireland on necessary qualifications for surveyors, health and safety considerations, pre-construction and post-construction survey methodologies and information to be included in a report. In the absence of comprehensive Irish research, these guidelines provide generalised methodology rather than detailed technical advice.

The second edition of the UK Bat Conservation Trust *Bat Survey Good Practice Guidelines* (Hundt, 2012) includes a chapter (Chapter 10) on survey methodologies for assessing the potential impacts of wind turbines on bats. The document provides technical guidance for consultants carrying out impact assessments. However, the recommendations are not based on any research findings specific to the UK. A third edition to the guidelines, published in early 2016, removed the chapter on surveying wind turbine developments. Prior to the publication of the BCT guidelines, Natural England's Bat and Onshore Wind Turbines: Interim Guidance provided a pragmatic interpretation of the EUROBATS recommendations, as applied to onshore wind energy facilities in the UK (Natural England, 2014). In addition, the Chartered Institute of Ecology and Environmental Management (CIEEM)publishes advice on best practice as well as updates on the current state of knowledge in the Technical Guidance Series and in the quarterly publication In Practice.

In 2019, Scottish Natural Heritage published B*ats and Onshore Wind Turbines: Survey, Assessment and Mitigation* (SNH 2019). The purpose of the guidance is to help planners, developers and ecological consultants to consider the potential effects of onshore wind energy developments on bats. The emphasis is on direct impacts such as collision mortality, but there is reference throughout to the need for a full impact assessment requiring wider consideration of other (indirect) effects. The Guidance replaces previous guidance on the subject; notably that published by Natural England and Chapter 10 of the Bat Conservation Trust publication Bat Surveys: Good Practice Guidelines (2nd edition), (Hundt, 2012) and tailors the generic Eurobats guidance on assessing the impact of wind turbines on European bats (Rodrigues et al. (2014)). The document guides the user through the key elements of survey, impact assessment and mitigation.

The survey scope, assessment and mitigation provided in this report is accordance with SNH 2019 Guidance.

1.3 Statement of Authority

Scope development and project management was undertaken by Dr. Úna Nealon and John Hynes. Úna's primary expertise lies in bat ecology. She completed her PhD with the Centre for Irish Bat Research, examining the impacts of wind farms on Irish bat species. John is a full member of the Chartered Institute of Ecology and Environmental Management (CIEEM) and has over 7 years professional ecological consultancy experience and is a former member of the Bat Conservation Ireland management council

Bat surveys were conducted by MKO ecologists Claire Stephens (BSc), Aoife Joyce (BSc, MSc), Luke Dodebier (BSc), Sara Fissolo (BSc) and Daire O'Shaughnessy. Staff have relevant academic qualifications and are competent experts in undertaking bat surveys to this level.

Data analysis was undertaken by Luke Dodebier and Aoife Joyce and results were compiled by Úna Nealon. Impact assessment, the design of mitigation and final reporting was completed by Luke Dodebier and Aoife Joyce and reviewed by Pat Roberts (BSc, MCIEEM). Pat has over 14 years' experience in management and ecological assessment. He has supervised the majority of ecological assessments (300+) completed by the company, including more recently, over 200 assessments required in accordance with Article 6(3) of the Habitats Directive.

1.4 Irish Bats: Legislation, Policy and Status

Ireland has nine resident bat species, comprising more than half of Ireland's native terrestrial mammals (Montgomery et al., 2014). All Irish bats are protected under European legislation, namely the Habitats Directive (92/43/EEC). All Irish species are listed under Annex IV of the Directive, requiring strict protection for individuals, their breeding sites and resting places. The lesser horseshoe bat (*Rhinolophus hipposideros)* is further listed under Annex II of the Directive, requiring the designation of conservation areas for the species. Under this Directive, Ireland is obliged to maintain the favourable conservation status of Annex-listed species. This Directive has been transposed into Irish law through the European Communities (Birds and Natural Habitats) Regulations 2011.

In addition, Irish species are further protected by national legislation (Wildlife Acts 1976-2019 as amended). Under this legislation, it is an offence to intentionally disturb, injure or kill a bat, or disturb its roost. Any work at a roost site must be carried out with the agreement of the National Parks and Wildlife Service (NPWS).

The NPWS monitors the conservation status of European protected habitats and species and reports their findings to the European Commission every 6 years. The most recent report for the Republic of Ireland was submitted in 2019. Table 1.1 summarises the current conservation status of Irish bat species and identified threats to Irish bat populations.

Table 1.1 Irish bat species conservation status & threats (NPWS, 2019).

Bat Species	Conservation Status	Principal Threats
Common pipistrelle *Pipistrellus pipistrellus*	Favourable	**A05** Removal of small landscape features for agricultural land parcel consolidation (M) **A14** Livestock farming (without grazing) [impact of anti-helminthic dosing on dung fauna] (M) **B09** Clear–-cutting, removal of all trees (M) **F01** Conversion from other land uses to housing, settlement or recreational areas (M) **F02** Construction or modification (e.g. of housing and settlements) in existing urban or recreational areas (M) **F24** Residential or recreational activities and structures generating noise, light, heat or other forms of pollution (M) **H08** Other human intrusions and disturbance not mentioned above (Dumping, accidental and deliberate disturbance of bat roosts (e.g. caving) (M) **L06** Interspecific relations (competition, predation, parasitism, pathogens) (M) **M08** Flooding (natural processes) **D01** Wind, wave and tidal power, including infrastructure (M)
Soprano pipistrelle *Pipistrellus pygmaeus*	Favourable	
Nathusius' pipistrelle *Pipistrellus nathusii*	Unknown	
Leisler's bat *Nyctalus leisleri*	Favourable	
Daubenton's bat *Myotis daubentoni*	Favourable	
Natterer's bat *Myotis nattereri*	Favourable	
Whiskered bat *Myotis mystacinus*	Favourable	
Brown long-eared bat *Plecotus auritus*	Favourable	
Lesser horseshoe bat *Rhinolophus hipposideros*	Inadequate	

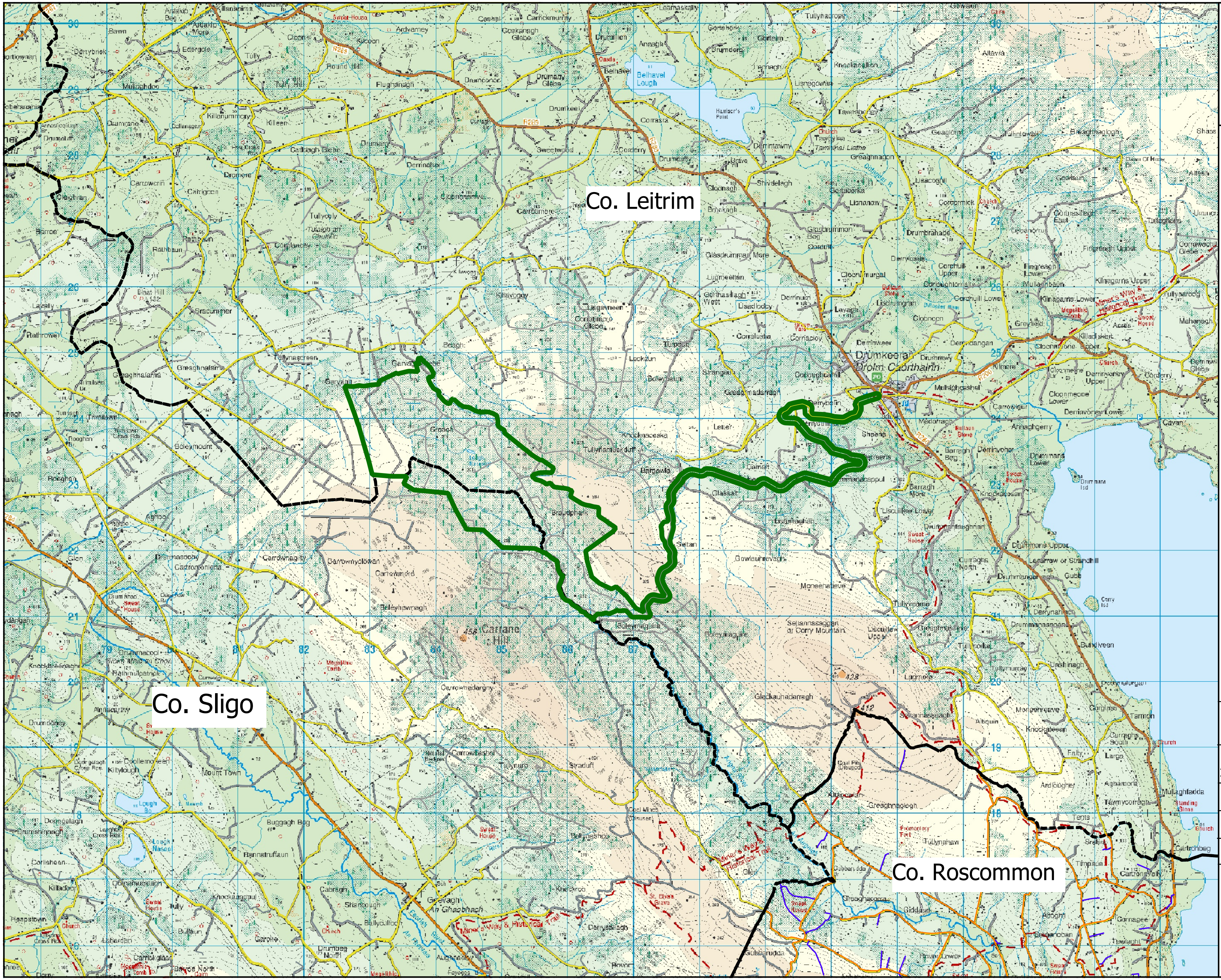
2. PROJECT DESCRIPTION

The proposed development site is located on the boundary of Counties Leitrim and Sligo, approximately 5 kilometres west of the village of Drumkeeran and 7 kilometres southeast of Dromahair. The Grid Reference coordinates for the approximate centre of the site are E 584730 N 823130 (Figure 2.1).

The site is accessed via a series of small unnamed local roads that can be accessed by traveling north on the R280. The land-use/activities within the proposed site comprise of commercial forestry. The surrounding landscape is also dominated by commercial forestry, wind energy and, agriculture. A number of wind energy developments are in operation including Geevagh and Carranne Hill to the west and Black Banks and Garvagh to the East.

The Proposed Development comprises:

1. *Construction of 10 No. wind turbines with a maximum overall blade tip height of up to 170 metres, and associated hardstand areas;*
2. *1 no. 38kV permanent electrical substation including a control building with welfare facilities, all associated electrical plant and equipment, security fencing, all associated underground cabling, waste water holding tank and all ancillary works;*
3. *1 no. permanent Meteorological Mast with a maximum height of up to 100 metres;*
4. *All associated underground electrical and communications cabling connecting the turbines to the proposed wind farm substation;*
5. *All works associated with the connection of the proposed wind farm to the national electricity grid, via underground cabling to the existing Garvagh substation;*
6. *Upgrade of existing tracks and roads, provision of new site access roads and hardstand areas;*
7. *The partial demolition and alteration of two agricultural buildings in the townlands of Sheena and associated junction access and road works to the existing yard, agricultural buildings and agricultural lands in the townlands of Sheena and Derrybofin to provide a link road primarily for construction traffic off the R280. This link road will be used for the delivery of abnormal loads to the site during the construction period and may be used during the operational period if necessary or to facilitate the decommissioning of the wind farm. Following construction, access to the link road will be closed off and the yard/agricultural building will revert to its use for agricultural purposes except if and when required for delivery of abnormal loads during the operational period of the windfarm or to facilitate the decommissioning of the wind farm;*
8. *1 no. borrow pit;*
9. *2 no. peat and spoil repository areas*
10. *2 no. temporary construction compounds;*
11. *Recreation and amenity works, including marked trails, boardwalk and viewing area provision of a permanent amenity car park, and associated recreation and amenity signage*
12. *Site Drainage;*
13. *Permanent Signage;*
14. *Ancillary Forestry Felling to facilitate construction and operation of the proposed development; and*
15. *All associated site development works*



Map Legend

EIAR Site Boundary

County Boundary

Drawing Title	
Site Location Context	
Project Title	
180511 - Croagh Wind Farm EIAR	
Drawn By: Daire O'Shaughnessy	Checked By: Eoin McCarthy
Project No.: 180511	Drawing No.: Fig 2.1
Scale: 1:75,000	Date: 12.06.2020

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3. METHODS

3.1 Consultation

A scoping exercise was undertaken as part of the EIAR for the proposed development. A Scoping Document, providing details of the application site and the proposed development, was prepared by MKO and circulated to consultees in December 2018. As part of this exercise, prominent Irish conservation groups were contacted, the National Parks and Wildlife Service (NPWS) and Bat Conservation Ireland (BCI) were specifically invited to comment on the potential of the proposed development to affect bats.

Details of consultation responses are provided in Section 4.1 below.

3.2 Desk Study

A desk study of published and unpublished material was undertaken prior to conducting field surveys. The aim was to provide context to the site in order to assist bat survey planning and assessment. This included the identification of designated sites, species of interest or any other potential risk factors within the Study Area and the surrounding region.

3.2.1 Bat Records

The National Bat Database of Ireland holds records of bat observations received and maintained by BCI. These records include results of national monitoring schemes, roost records as well as ad-hoc observations. A search of the National Bat Database of Ireland was last carried out on the 8th October 2019 and examined bat presence and roost records within a 10 km radius of a central point in the Study Area (IG E184554 N323115) (BCI 2012, Hundt 2012, SNH 2019).

3.2.2 Bat Species' Range

EU member states are obliged to monitor the conservation status of natural habitats and species listed in the Annexes of the Habitats Directive. Under Article 17, they are required to report to the European Commission every six years. In April 2019, Ireland submitted the third assessment of conservation status for Annex-listed habitats and species, including all species of bats (NPWS, 2019).

The 2019 Article 17 Reports were reviewed for information on bat species' range and distribution in relation to the location of the proposed development. The aim was to identify any high-risk species at the edge of their range (SNH, 2019).

3.2.3 Designated Sites

The National Parks and Wildlife Service (NPWS) map viewer and website provides information on rare and protected species, sites designated for nature conservation and their conservation objectives. A search was undertaken of sites designated for the conservation of bats within a 10 km radius of the Study Area (BCI 2012, Hundt, 2012, SNH 2019). This included European designated sites, i.e. SACs, and nationally designated sites, i.e. NHAs and pNHAs.

3.2.4 Landscape Features

Ordnance survey maps (OSI 1:5,000 and 1:50,000) and aerial photographs were reviewed to identify any habitats and features likely to be used by bats. Maps and images of the Study Area and general landscape were examined for suitable foraging or commuting habitats including woodlands and forestry, hedgerows, treelines and watercourses. In addition, any potential roost sites, such as buildings and bridges, were noted for further investigation.

The Geological Survey Ireland (GSI) online mapping tool and UBSS Cave Database for the Republic of Ireland were consulted for any indication of natural subterranean bat sites, such as caves, within 10 km of the proposed site (BCI, 2012) (last searched on the 22nd May 2020). Furthermore, the archaeological database of national monuments was reviewed for any evidence of manmade underground structures, e.g. souterrains, that may be used by bats (last searched on the 22nd May 2020).

3.2.5 Habitat Suitability

The National Biodiversity Data Centre (NBDC) map viewer presents "Bat Landscape" maps for individual species and for all species combined. Lundy et al. (2011) used Maximum Entropy Models to examine the relative importance of bat landscape and habitat associations in Ireland. The resulting map provides a 5-point scale, ranging from highest habitat suitability index (presented in red) to lowest suitability index (presented in green). However, squares highlighted as less favourable may still have local areas of abundance.

The location of the proposed wind farm was reviewed in relation to bat habitat suitability indices. The aim of this was to assess habitat suitability for all bat species within the Study Area. It is worth noting that these results are based on a modelling exercise and not confirmed bat species records. Regardless, they may provide a useful indication of potential favourable bat associations within the proposed site.

3.2.6 Other Wind Energy Developments

A search for existing and permitted wind energy developments within 10km of the proposed site was undertaken (SNH, 2019). The IWEA interactive wind map (iwea.com) was reviewed in conjunction with wind farm planning applications from Sligo and Leitrim County Councils.

3.2.7 Multidisciplinary Surveys

The grid connection route was visited as part of the multidisciplinary surveys undertaken on the 14th August 2019 and the 31st January 2020, outlined in the main EIAR. The habitats (including any culverts/bridges) were assessed for bat commuting, foraging and roosting suitability (see sections 4.10 and 4.11).

3.3 Ecological Appraisal

Bat walkover surveys were carried out throughout 2019. During these surveys, habitats were assessed for their suitability for bats to roost, forage and commute. Connectivity with the wider landscape was also considered. Suitability categories, as described by Collins (2016) are divided into *High*, *Moderate*, *Low* and *Negligible*, and are described fully in **Appendix 1**.

3.3.1 Roost Surveys

A search for roosts was undertaken within 200m plus the rotor radius of the boundary of the proposed development (SNH, 2019).

One structure was identified (IG Ref: 186351 321105) and was subject to a roost assessment (See Figure 3.1). This comprised a detailed inspection of the exterior to look for evidence of bat use, including live and dead specimens, droppings, feeding remains, urine splashes, fur oil staining and noises. The interior of the building was inaccessible. A dusk emergence survey was undertaken on the evening of the 7th May 2019. Two surveyors, equipped with Bat Logger M bat detectors (Elekon AG, Lucerne, Switzerland). Conditions were suitable for bat survey; dry, warm (10˚C) with light air (Beaufort Force 1). The emergence survey commenced 30 minutes before sunset and concluded 1.5 hours after sunset. No other structures within the site were identified as being, within 200m of a turbine location, or as providing roosting bat features and thus further surveys were not deemed necessary.

Any potential tree roosts were examined for the presence of rot holes, hazard beams, cracks and splits, partially detached bark, knot holes, gaps between overlapping branches and any other potential roost features (i.e. PRFs) identified by Andrews (2018).

3.3.2 Walked & Driven Transects

Manual activity surveys comprised walked and driven transects at dusk. The aim of these surveys was to identify bat species using the site and gather any information on bat behaviour and important features used by bats.

A series of representative transect routes were selected throughout the proposed wind farm site. Transect routes were prepared with reference to the proposed layout, desktop and walkover survey results as well as any health and safety considerations and access limitations. As such, transect routes generally followed existing roads and tracks. Transect routes are presented in Figures 4.1- 4.3.

Transects were walked or driven by two surveyors, recording bats in real time. Driven transects followed the methodology described by Roche et al. (2012). Surveys commenced within 30 mins before sunset and were completed within 3 hours after sunset. Surveyors were equipped with active full spectrum bat detectors, the Batlogger M bat detector (Elekon AG, Lucerne, Switzerland) and all bat activity was recorded for subsequent analysis to confirm species identifications. Transects surveys were undertaken in spring, summer and autumn 2019. Table 3.1 summarises survey effort in relation to walked and driven transects.

Table 3.1 2019 Survey Effort – Walked & Driven Transects

Date	Surveyors	Sunset	Start-End	Weather	Walked and driven transects (km)
7th May 2019	Claire Stephens & Daire O'Shaughnessy	21:15	20:45 - 00:10	8˚; very light rain; gentle breeze.	12.27
11th June 2019	Claire Stephens & Daire O'Shaughnessy	22:05	21:26 - 00:13	9-13˚; dry; light breeze.	7.48
21st August 2019	Luke Dodebier & Sara Fissolo	21:51	20:18 - 23:30	13˚; dry; light breeze.	11.61
Total Survey Effort					31.36

3.3.3 Ground-level Static Surveys

SNH required 1 detector per turbine up to 10 and then 1/3 after. Given that 10 turbines are proposed 10 detectors were deployed to ensure compliance with SNH guidance

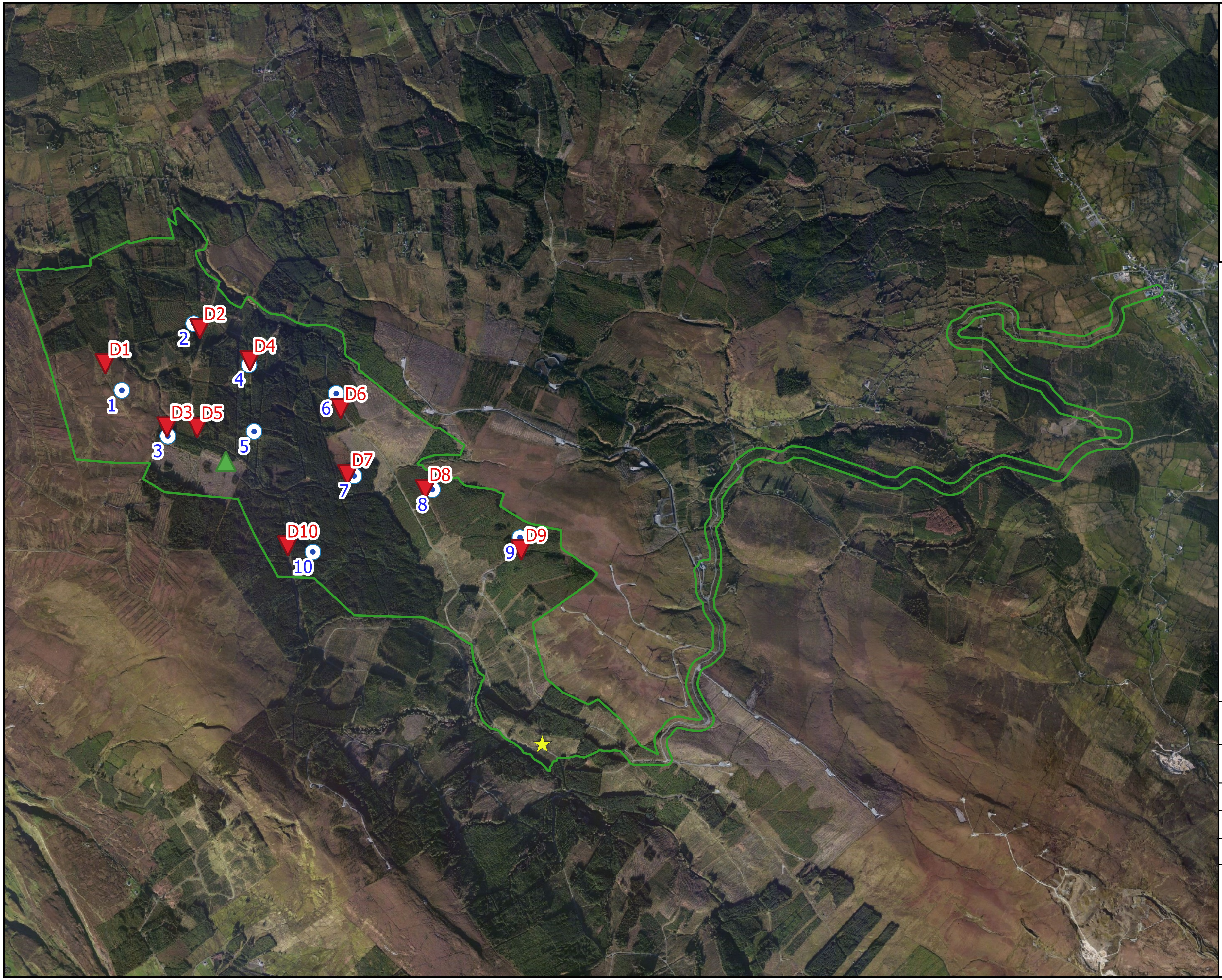
Automated bat detectors were deployed at 10 no. locations for at least 10 nights in each of spring (April-May), summer (June-mid August) and autumn (mid-August-October) (SNH, 2019). Detector locations were based on indicative turbine locations and differ slightly to the final proposed layout. As proposed turbine locations are often subject to change, static bat detectors are deployed in locations that provide a representative sample of bat activity On review of the final turbine layout static detector locations provide an accurate representation of the habitats and associated turbine locations on site. Where keyholing [1] is proposed, detectors were located along nearby forestry edge in order to more closely reflect the likely post-construction habitat. Static detector locations are described in Table 3.2 and presented in Figure 3.1.

Table 3.2 Ground-level Static Detector Locations.

ID	Location	Habitat	Presence/Absence of linear feature within 50m
D01	E183252 N323818	Conifer edge, open bog/wet grassland	Present
D02	E184947 N323039	Conifer ride	Present
D03	E183687 N323374	Conifer edge, open bog	Present
D04	E184297 N323846	Conifer edge, road verge	Present
D05	E183899 N323363	Conifer edge, road verge	Present
D06	E184918 N323500	Conifer edge, road verge	Present
D07	E184947 N323039	Clearfell	Present
D08	E185516 N322930	Conifer ride	Present
D09	E186194 N322495	Conifer edge, stream	Present
D10	E184542 N322527	Conifer ride	Present

Full spectrum bat detectors, Song Meter SM4BAT (Wildlife Acoustics, Maynard, MA, USA), were employed. Settings used were those recommended by the manufacturer for bats, with minor adjustments in gain settings and band pass filters to reduce background noise when recording. Detectors were set to record from 30 minutes before sunset until 30 minutes after sunrise. The Song Meter automatically adjusts sunset and sunrise times using the Solar Calculation Method when provided with GPS coordinates.

[1] *Keyholing involves creating open areas in commercial forestry plots as a buffer around proposed wind turbine locations. This is typically a 50m buffer from the turbine blade tip to the forestry edge. These keyholes remain open for the duration of the windfarm lifetime*



Map Legend

- Site Boundary
- Static Detector Locations
- Met Mast
- Proposed Turbine Locations
- Potential Roost

N

Drawing Title	
Static Detector Locations	
Project Title	
Croagh Windfarm	
Drawn By: LD	Checked By: JH
Project No.: 180511	Drawing No.: Figure 3.1
Scale: 1:35000	Date: 08.07.2020

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Onsite weather monitoring was undertaken concurrently with static detector deployments. One Vantage Pro 2 (Davis Instruments, CA, UCS) was deployed each season and night-time hourly data was tracked remotely to ensure a sufficient number of nights (i.e. minimum 10 no.) with appropriate weather conditions were captured (i.e. dusk temperatures above 8˚, wind speeds less than 5m/s and no or only very light rainfall). Table 3.3 summarises survey effort achieved for each of the 10 no. detector locations.

Table 3.3 2019 Survey Effort – Ground-level Static Surveys.

Season	Survey Period	Total Survey Nights per detector location	Nights with Appropriate Weather
Spring	24th April – 7th May 2019	13*	10
Summer	11th June – 25th June 2019	14	12
Autumn	21st August – 5th September 2019	15	11
Total Survey Effort		**42**	**33**

*Detector D06 (Figure 3.1) was stolen from the site during the spring deployment. A report was made to the Gardaí and additional site-wide security measures were employed during subsequent deployments to avoid any further incidents.

3.3.4 Static Surveys at Height

Monitoring at height can provide useful information on bat activity within the rotor sweep area and is particularly relevant at proposed key-holed sites (SNH, 2019). One Song Meter SM3BAT (Wildlife Acoustics, Maynard, MA, USA) was installed on a meteorological mast within the proposed site (IG Ref E184319 N323560) (Figure 3.1). The detector was equipped with two microphones; one at ground level and one at height (approx. 75 m above ground level). Table 3.4 describes survey effort in relation to surveys at height.

Table 3.4 2019 Survey Effort – Static Surveys at Height

ID	Survey Period	Total Survey Nights
Mast - 1	29th May – 11th June 2019	13
Mast - 2	11th June – 25th June 2019	14
Mast - 3	25th June – 13th July 2019	18
Mast - 4	21st August – 2nd September 2019	12
Mast - 5	5th September – 17th September 2019	12
Total Survey Effort		**69**

3.4 Bat Call Analysis

All recordings were later analysed using bat call analysis software Kaleidoscope Pro v.5.1.9 (Wildlife Acoustics, MA, USA). Bat species were identified using established call parameters, to create site-specific custom classifiers. All identified calls were also manually verified.

Echolocation signal characteristics (including signal shape, peak frequency of maximum energy, signal slope, pulse duration, start frequency, end frequency, pulse bandwidth, inter-pulse interval and power spectra) were compared to published signal characteristics for local bat species (Russ, 1999). Myotis species (potentially *M. daubentonii, M. mystacinus, M. nattereri,*) were considered as a single group, due to the difficulty in distinguishing them based on echolocation parameters alone (Russ, 1999). The echolocation of *P. pygmaeus* and *P. pipistrellus* are distinguished by having distinct (peak frequency of maximum energy in search flight) of ~55 kHz and ~ 46 kHz respectively (Jones & van Parijs, 1993).

Plate 3.1 below shows a typical sonogram of echolocation pulses for Common Pipistrelle recorded with a SM4BAT bioacoustic static bat recording device. The recorded file is illustrated using Wildlife Acoustics Kaleidoscope software.

Individual bats of the same species cannot be distinguished by their echolocation alone. Thus, 'bat passes' was used as a measure of activity (Collins, 2016). For the purposes of this survey, a bat pass was defined as a recording of an individual species/species group's echolocation containing at least two echolocation pulses and of maximum 15 seconds length.

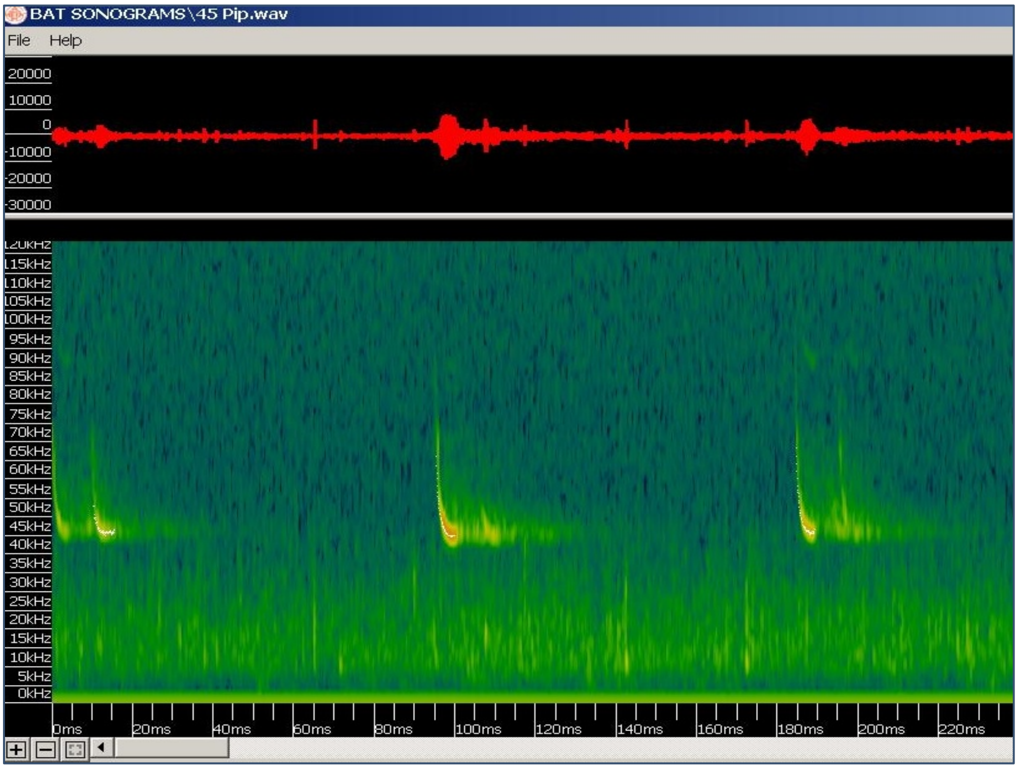


Plate 3.1 Sonogram of echolocation pulses of Common Pipistrelle (Peak Frequency 45kHz).

3.5 Assessment of Bat Activity Levels

Static detector monitoring results were uploaded to the online database tool Eco bat (ecobat.org.uk). This web-based interface, launched in August 2016, allows users to upload activity data and to contrast results with a comparable reference range, allowing objective interpretation. Uploaded data then contributes to the overall dataset to provide increasingly robust outputs.

Static detector at ground level results for the proposed wind farm were uploaded on the 14th October 2019. Database records used in analyses were limited to those within a similar time of year (within 30 days) and a within a similar geographic region (within 200 km).

Ecobat generates a percentile rank for each night of activity and provides a numerical way of interpreting levels of bat activity in order to provide objective and consistent assessments. Table 3.5 defines bat activity levels as they relate to Ecobat percentile values (SNH, 2019).

Although records of bat activity uploaded in Ireland have been increasing each year since the launch of Ecobat in 2016, there are still a limited number of datasets for objective interpretation. Guidelines in the use of Ecobat recommend a Reference Range of 2000+ to be confident in the relative activity level. Although there is an increased uptake in the use of Ecobat in Ireland, some of the reference ranges remain below 2000. The accuracy of data outputs and results will improve over time.

Table 3.5 Ecobat percentile score & categorised level of activity (SNH, 2019).

Ecobat Percentile	Bat Activity Level
81 to 100	High
61 to 80	Moderate to High
41 to 60	Moderate
21 to 40	Low to Moderate
0 to 20	Low

Results for static detector surveys at ground level and at height were uploaded in October 2019. Database records used in analyses were limited to those within a similar time of year (i.e. within 30 days) and within a similar geographic region (i.e. within 200 km).

3.6 Assessment of Collision Risk

3.6.1 Population Risk

SNH (2019) provides a generic assessment of bat collision risk for UK species, based on species behaviour and flight characteristics. In the guidelines, this measure of collision risk is used, in combination with relative abundance, to indicate the potential vulnerability of British bat populations.

In Plate 3.2, an adapted assessment of vulnerability for Irish bat populations is provided. Species' collision risk follows those described in SNH (2019). Relative abundance for Irish species was determined in accordance with Wray et al. (2010) using population data available in the 2019 Article 17 reports (NPWS, 2019).

Relative Abundance	Low Collision Risk	Medium Collision Risk	High Collision Risk
Common species			Common pipistrelle Soprano pipistrelle
Rarer species	Daubenton's bat Brown long-eared bat Lesser horseshoe bat		Leisler's bat
Rarest species	Natterer's bat Whiskered bat		Nathusius' pipistrelle

Low Population Vulnerability	Medium Population Vulnerability	High Population Vulnerability

Plate 3.2 Population vulnerability of Irish bat species (adapted from SNH, 2019)

3.6.2 Site Risk

The likely impact of a proposed development on bats is related to site-based risk factors, including habitat and development features. Plate 3.3 describes the criteria and site-specific characteristics used to determine an indicative risk level for the proposed site. All site assessment levels, as per SNH (2019) are presented in **Appendix 2**.

		Project Size		
		Small	Medium	Large
Habitat Risk	Low	1	2	3
	Moderate	2	3	4
	High	3	4	5

Low/Lowest Site Risk (1-2)	Medium Site Risk (3)	High/Highest Site Risk (4-5)

Plate 3.3 Site risk level assessment matrix (SNH, 2019)

3.6.3 Overall Risk Assessment

An overall assessment of risk was made by combining the site risk level (i.e. Medium) and Ecobat bat activity outputs, as shown in the overall risk assessment matrix table (Plate 3.4). The assessment was carried out for both median and maximum Ecobat activity categories in order to provide insight into typical bat activity (i.e. median values) and activity peaks (i.e. maximum values).

	Ecobat Activity Category					
Site Risk Level	Nil (0)	Low (1)	Low-Moderate (2)	Moderate (3)	Moderate-High (4)	High (5)
Lowest (1)	0	1	2	3	4	5
Low (2)	0	2	4	6	8	10
Medium (3)	0	3	6	9	12	15
High (4)	0	4	8	12	15	18
Highest (5)	0	5	10	15	20	25

Low Overall Risk (0-4)	Medium Overall Risk (5-12)	High Overall Risk (15-25)

Plate 3.4 Overall risk assessment matrix (SNH, 2019)

This exercise was carried out for each high collision risk species, i.e. Common, soprano and Nathusius' pipistrelles, and Leisler's bat. Overall risk assessments were also considered in the context of any potential impacts at the population level, particularly for species identified as having high population vulnerability (Table 4.5 – 4.7).

3.7 Limitations

A comprehensive suite of bat survey have been undertaken at the Proposed Development site in 2019. The surveys undertaken, in accordance with SNH Guidance, provide the information necessary to allow a complete, comprehensive and robust assessment of the potential impacts of the Proposed Development on bats receptors.

One static detector (D06) was stolen from the site during the spring deployment. A report was made to the Gardaí and additional site-wide security measures were employed during subsequent deployments to avoid any further incidents.

The information provided in this report accurately and comprehensively describes the baseline environment; provides an accurate prediction of the likely effects of the Proposed Development; prescribes mitigation as necessary; and describes the predicted residual impacts. The specialist studies, analysis and reporting have been undertaken in accordance with the appropriate guidelines.

No significant limitations in the scope, scale or context of the assessment have been identified.

4. RESULTS

4.1 Consultation

4.1.1 Bat Conservation Ireland

No response received from Bat Conservation Ireland as of the 22.0.2020.

4.1.2 Development Applications Unit - NPWS

A detailed scoping exercise was undertaken for the proposed wind farm. A response from the Department of Culture, Heritage and the Gaeltacht provided recommendations regarding nature conservation, including bats. The relevant excerpts, specifically relating to bats, are summarised below and the full results of the scoping and consultation exercise are described in the main EIAR. The response was received on the 30/01/2019 and the letter is provided in Appendix 4 of the EIAR.

1. Bat roosts
   Bat roosts may be present in trees, buildings and bridges. Bat roosts can only be destroyed under licence and such a licence would only be given if suitable mitigation measures were implemented. Any proposed migratory bat friendly lighting should be proven to be effective.

2. Post-construction monitoring
   The applicant should not use any proposed post construction monitoring as mitigation to supplement inadequate information in the assessment. The EIAR process should identify any pre and post construction monitoring which should be carried out. The post construction monitoring should include bird and bat strikes/fatalities including the impact on any such results of the removal of carcasses by scavengers. Monitoring results should be made available to the competent Authority and copied to this Department. A plan of action needs to be agreed at planning stage with the Planning Authority if the results in future show a significant mortality of birds and/or bat species. It is important to note again that unless post decision consultation with this Department is specifically stated as a condition of planning, this Department has no post consent role. However, regional staff are available for liaison regarding any associated licencing requirements and/or new information arising for specific species of concern.

3. Licences
   Where there are impacts on protected species and their habitats, resting or breeding places, licences may be required under the Wildlife Acts or derogations under the Habitats Regulations. In particular bats and otters are strictly protected under annex IV of the Habitats Directive.

   In order to apply for any such licences or derogations, the results of a survey should be submitted to the National Parks and Wildlife Service section of this Department. Such surveys are to be carried out by appropriately qualified person/s at an appropriate time of the year. Details of survey methodology should also be provided. Should this survey work take place well before construction commences, this Department recommends that an additional ecological survey of the development site should take place immediately prior to construction to ensure no significant change in the findings of the baseline ecological survey has occurred. If there has been any significant change mitigation may require amendment and where a licence has expired, there will be a need for new licence applications for protected species.

All recommendations made by the Department were fully considered in the design of bat surveys and the preparation of this report.

4.2 Desk Study

4.2.1 Bat Records

The National Bat Database of Ireland was searched for records of bat activity and roosts within a 10 km radius of the proposed site (IG Ref: G 84319 23560; last search 22/05/2020). A number of observations have been recorded including roosts (n=10), transects (n=3) and ad-hoc observations (n=7). At least six of Ireland's nine resident bat species were recorded within 10 km of the proposed works including common and soprano pipistrelle, Leisler's bat, Daubenton's bat, Natterer's bat and brown long-eared bat, as well as several records of unidentified bats. The results of the database search are provided in Table 4.1.

Table 4.1 National Bat Database of Ireland records within 10km

Type	Location	Results	Survey	Designation
Roost	Douglas River, Sligo	Type: Bridge Species: Natterer's bat	Unknown	Annex IV
	Douglas River, Sligo	Type: Bridge Species: Daubenton's bat	Unknown	Annex IV
	Dromahir, Leitrim	Type: Building Species: Pipistrelle sp. Unidentified bat	Unknown	Annex IV
	Ballintogher, Sligo	Type: Bridge Species: Natterer's bat	Unknown	Annex IV
	Ballynakill, Sligo	Type: Bridge Species: Natterer's bat	Unknown	Annex IV
	Bellarush, Sligo	Type: Bridge Species: Daubenton's bat	Unknown	Annex IV
	Camogue, Leitrim	Type: Bridge Species: Natterer's bat	Unknown	Annex IV
	Cloonemeone, Leitrim	Type: Bridge Species: Daubenton's bat	Unknown	Annex IV
	Geevagh, Sligo	Type: Bridge Species: Unidentified bat	Unknown	Annex IV
	Castlebaldwin, Sligo	Type: Building Species: Soprano pipistrelle, Brown long-eared bat	Unknown	Annex IV
Transect	Cloonemeone, Leitrim	Daubenton's bat, Unidentified bat	Waterways Survey	Annex IV
	Drumlease, Leitrim	Daubenton's bat, Unidentified bat	Waterways Survey	Annex IV
	Drumlease, Leitrim	Leisler's bat, Soprano pipistrelle, Pipistrelle sp., Unidentified bat	Car-Based Monitoring	Annex IV
Ad-Hoc	Tullycoly, Leitrim	Daubenton's bat, Soprano pipistrelle	BATLAS 2010	Annex IV

Type	Location	Results	Survey	Designation
	Drumkeeran, Leitrim	Leisler's bat, Soprano pipistrelle	BATLAS 2010	Annex IV
	Drumkeeran, Leitrim	Soprano pipistrelle	BATLAS 2010	Annex IV
	Castlebaldwin, Sligo	Leisler's bat, Soprano pipistrelle	BATLAS 2010	Annex IV
	Geevagh, Sligo	Myotis sp., Leisler's bat, Common pipistrelle, Soprano pipistrelle, Brown long-eared bat	BATLAS 2010	Annex IV
	Behavel Lough, Leitrim	Daubenton's bat, Myotis sp., Leisler's bat, Common pipistrelle, Soprano pipistrelle	BATLAS 2010	Annex IV
	Geevagh, Sligo	Daubenton's bat	EIS Surveys	Annex IV

4.2.2 Bat Species Range

The potential for negative impacts is likely to increase where there are high risk species at the edge of their range (SNH, 2019). Therefore, range maps presented in the 2019 Article 17 Reports (NWPS, 2019) were reviewed in relation to the location of the proposed development.

The main part of the proposed site is located at the edge of the current range for one species, whiskered bat. The proposed site is located outside the current range for Nathusius' pipistrelle and lesser horseshoe bat, and within range but not at the edge for all other species.

4.2.3 Designated Sites

Within Ireland, the lesser horseshoe bat is the only bat species requiring the designation of Special Areas of Conservation (SACs) and the proposed site is situated outside the known range of this species. Natural Heritage Areas (NHAs) and proposed Natural Heritage Areas (pNHAs) may be designated for any bat species. A search of NHAs and pNHAs within a 10 km radius of the Study Area found no sites designated for the conservation of bats.

4.2.4 Landscape Features

A review of mapping and photographs provided insight into the habitats and landscape features present at the proposed development site. In summary, the primary land use within the proposed site is plantation forestry, while the remainder of the wind farm infrastructure site is dominated by upland peatland habitats.

A review of the GSI online mapper did not indicate the possible presence of any subterranean sites within the study area and a search of the National Monuments Database did not reveal the presence of any manmade subterranean sites within the study area.

A search of the UBSS Cave Database for the Republic of Ireland found no caves within the proposed site. However, numerous caves occur within 10km of the site boundary, with the nearest located 2 km away (Table 4.2). No maternity, hibernation or swarming sites, or other bat presence records, were available for any caves within 10km.

A review of the NBDC bat landscape map provided a habitat suitability index of 11.11 (Green). This indicates that the proposed development area has low habitat suitability for bat species.

Table 4.2 UBSS Cave Database records within 10km

Cave Name	Description	Distance (km)
Carrowmore Caverns	540m long, 142m deep system	2.0
Polliska	None available	2.1
Brock's Cave	50m long to small streamway	2.2
Polldonon	30m long, 8m drop	2.4
Dragonfly Pot	90m deep pothole with 250m of passage	2.4
Carrownadargny-Pollnagollum	Large passage 50m to boulder choke	2.4
Carrownadargny Swallet	Pothole 50m deep, 130m long	2.6
Jumar Pot	45m deep pothole	2.7
Tap Cave – Natural Bridge	114m long streamway	3.0
Bone Hole Cave	210m long passage, 25m deep	3.0
Ailtnaseabhach Cave (4)	5m narrow rift cave	3.2
Ailtnaseabhach Cave (1)	None available	3.2
Churdhe Mhor	Large entrance to choke, 10m long	3.2
Ailtnaseabhach (2)	5m rift cave	3.7
Ailtnaseabhach (3)	5m rift cave	4.3
Foyoge's Bridge Cave	25m crawl in the stream	5.6
Whistling Eel Cave	30m through trip	7.9
Skeanada Sink	12m tight streamway	8.3
Treanmore Cave	30m rift	8.4
The Cove (Dromahair)	20m long, large stream passage	8.5
Carrickard Cave	2m crawl	8.7
Patricia's Rift	Large 7m long passage	8.7
Ballinlig Cave (1)	50m long rift	8.8
Ballinlig Cave (2)	8 m rift	8.8

Ballinlig Cave (3)	10m rift	8.8
Angela's Doubt	12m tunnel	8.8
Singing Blackbird Cave	9m long through trip	8.9
Croghmine Cave	5m pot	9.1
Ballinlig Cave (4)	3m long	9.4

4.2.5 Other Wind Energy Developments

Table 4.3 provides an overview of other wind farms in the vicinity of the proposed wind farm.

Table 4.3 Wind farm developments within 10km of the proposed site.

Wind Farm Name & Location	No. Turbines	Status
Within 5 km of proposed Croagh Wind Farm		
Geevagh, Co. Sligo	6	Existing
Carrane Hill, Co. Sligo	4	Existing
Garvagh Tullyhaw, Co. Leitrim	11	Existing
Garvagh Glebe, Co. Leitrim	13	Existing
Corry Mountain, Co. Leitrim	8	Existing
Spion Kop, Co. Leitrim	2	Existing
Moneenatieve, Co. Leitrim (Existing)	6	Existing
Black Banks I & II, Co. Leitrim	12	Existing
Derrysallagh, Co. Sligo	12	Permitted
Altagowlan, Co. Leitrim	9	Existing
Within 5-10 km of proposed Croagh Wind Farm		
Kilronan, Co. Roscommon	10	Existing
Tullynamoyle + Extensions, Co. Leitrim	15	Existing
Seltannaveeny, Co. Roscommon	2	Existing

4.3 Overview of study area & Ecological Appraisal

The majority of the study area (86.3%) is dominated by plantation forestry, comprising mainly of Sitka spruce (Picea sitchenis) and Lodgepole pine (Pinus contorta). The site is accessible via a network of existing forestry access tracks and forestry rides. The remainder of the wind farm infrastructure site is dominated by degraded Upland Blanket Bog (PB2). The haulage route to the east of the site primarily traverses areas of Wet grassland (GS4), Scrub (WS1), Conifer plantation (WD4) and existing roads. Results from the desktop review and walkover surveys were used to assess habitats for their suitability to support foraging and commuting bats, and roosting bats, according to Collins (2016). Suitability categories, divided into *High*, *Moderate, Low* and *Negligible*, are described fully in **Appendix 1.**

With regard to foraging and commuting bats, areas of closed canopy forestry as well as exposed areas of grassland and peatland habitats were considered *Negligible* suitability, i.e. negligible habitat features on site likely to be used by commuting or foraging bats (Collins, 2016). Forestry edge and scrub habitats may provide greater foraging and commuting opportunities. These habitats within the study area are connected to the wider landscape by further adjacent forestry. As such, these habitats were classified as *Moderate* suitability, i.e. habitat connected to the wider landscape that could be used by bats for foraging and commuting (Collins, 2016).

One structure, a derelict dwelling, was identified as having bat roosting potential within the site. Due to the structure's poor condition and the low suitability of the surrounding habitat, the building was assessed as *Low* suitability for roosting bats. The building was subject to a preliminary roost assessment and a dusk emergence survey. Trees present within the proposed site are commercial coniferous species with *Negligible – Low* roosting potential.

4.4 Roost Surveys

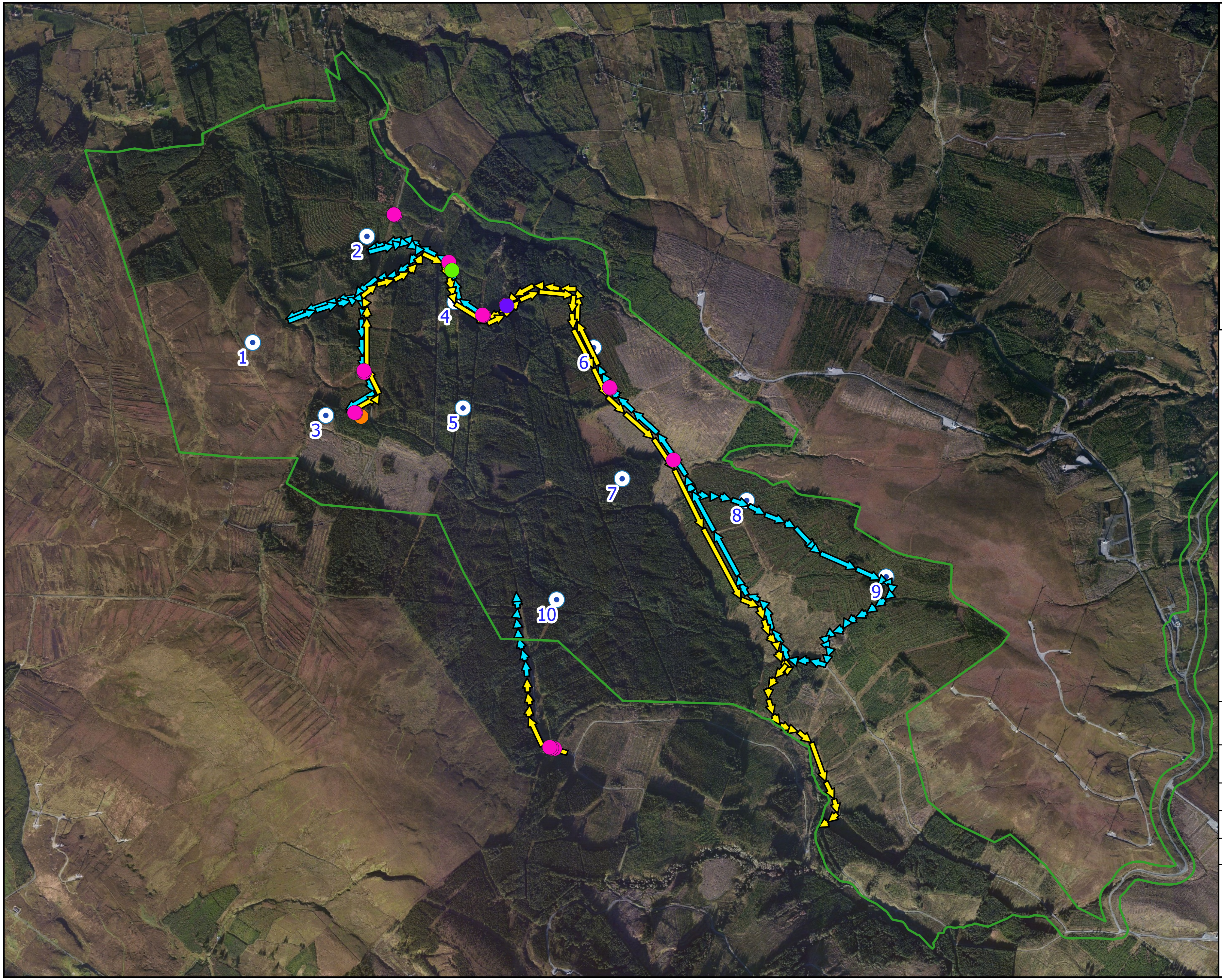
One structure was identified within the proposed site (IG Ref E186351 N321105). The derelict dwelling had a slate roof and was in a state of disrepair (Plate 4.1). Numerous potential access points were identified in broken windows and gaps in slates. The surrounding habitats were assessed as low as the building had suitable roosting features however, there was no evidence of bat use recorded during the roost assessment (Collins, 2016). In addition, no bats were recorded during a dedicated roost survey undertaken by two surveyors on the 7th May 2019. No other structures within the site were identified as being, within 200m of a turbine location, or as providing roosting bat features and thus further surveys were not deemed necessary.

Plate 4.1 Derelict dwelling located on site.

The site was checked for potential tree roosts but no trees with significant roosting features were identified within the site. Trees may have increased or decreased probability of hosting roosting bats in certain circumstances i.e. Having large broadleaf trees with cavities or other damage such as rot or loose bark increased probability whereas, Conifer plantations and young trees with little – no damage have a decreased probability of hosting bats (Kelleher and Marnell, 2006).

4.5 Manual Transects

Manual transects were undertaken in spring, summer and autumn 2019 (Fig 4.1 – 4.3). Bat activity was recorded on all surveys. Bat activity was low with just 68 bat passes in total recorded across all survey nights. Activity was particularly low during the summer transect where only 2 bat passes were recorded in total. In general, Leisler's bat was recorded most frequently. This activity was largely concentrated in the spring season. Common and soprano pipistrelle were also frequently recorded, particularly in autumn. *Myotis* sp. and brown long-eared bat were less frequently encountered. Species composition and activity levels varied significantly between surveys. Transect survey results were calculated as bat passes per km surveyed (to account for differences in survey effort). Figure 4.4 presents results for individual species per survey period.



Map Legend

- Site Boundary
- Proposed Turbine Locations
- Spring Driven Transect
- Spring Walked Transect
- Myotis species
- Leislers
- Soprano pipistrelle
- Brown long-eared

N

Drawing Title	Spring Manual Transect Results
Project Title	Croagh Windfarm
Drawn By: LD	Checked By: JH
Project No.: 180511	Drawing No.: Figure 4.1
Scale: 1:22000	Date: 08.07.2020

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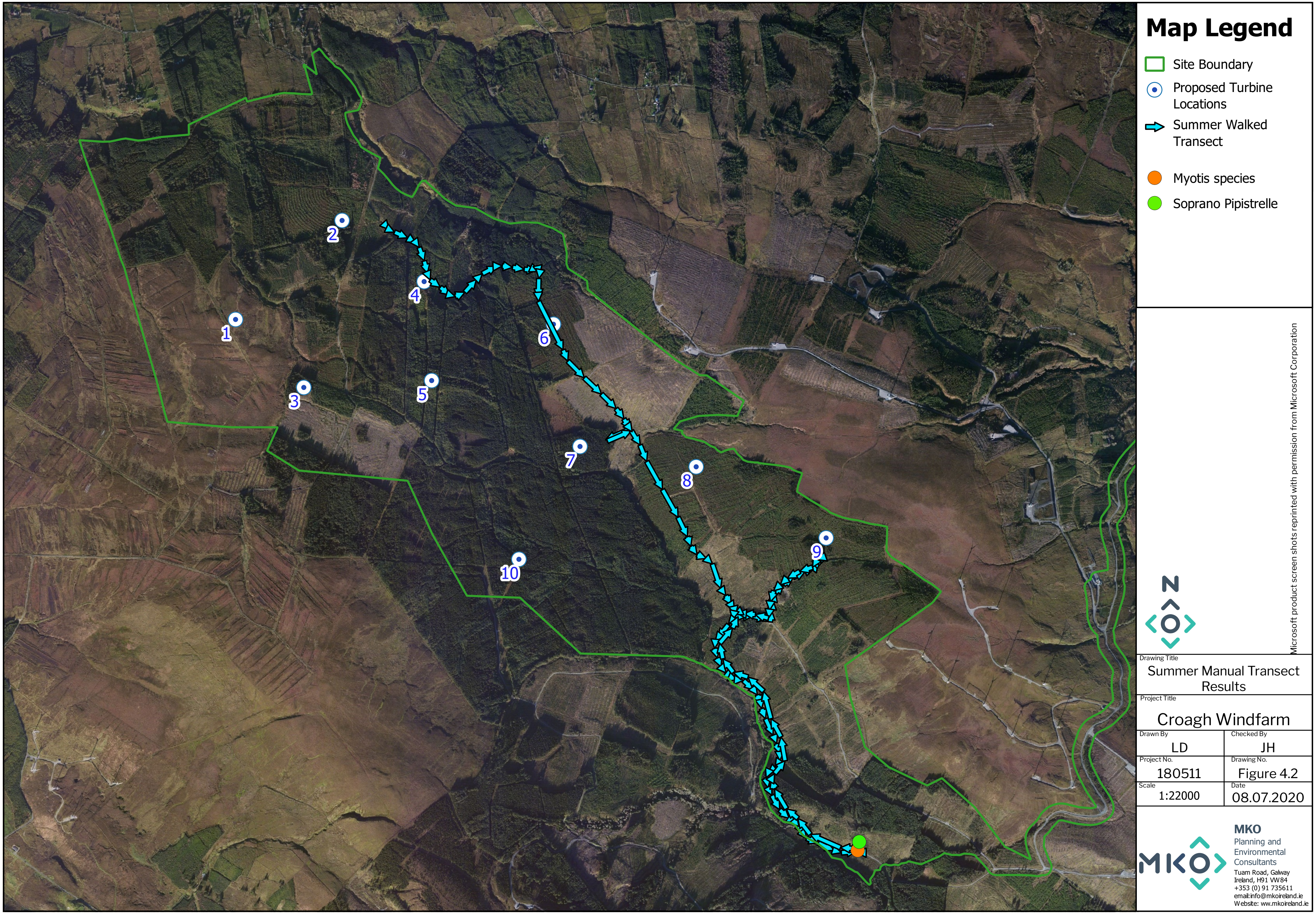

Drawing Title
Summer Manual Transect Results

Project Title
Croagh Windfarm

Drawn By	Checked By
LD	JH
Project No. 180511	Drawing No. Figure 4.2
Scale 1:22000	Date 08.07.2020

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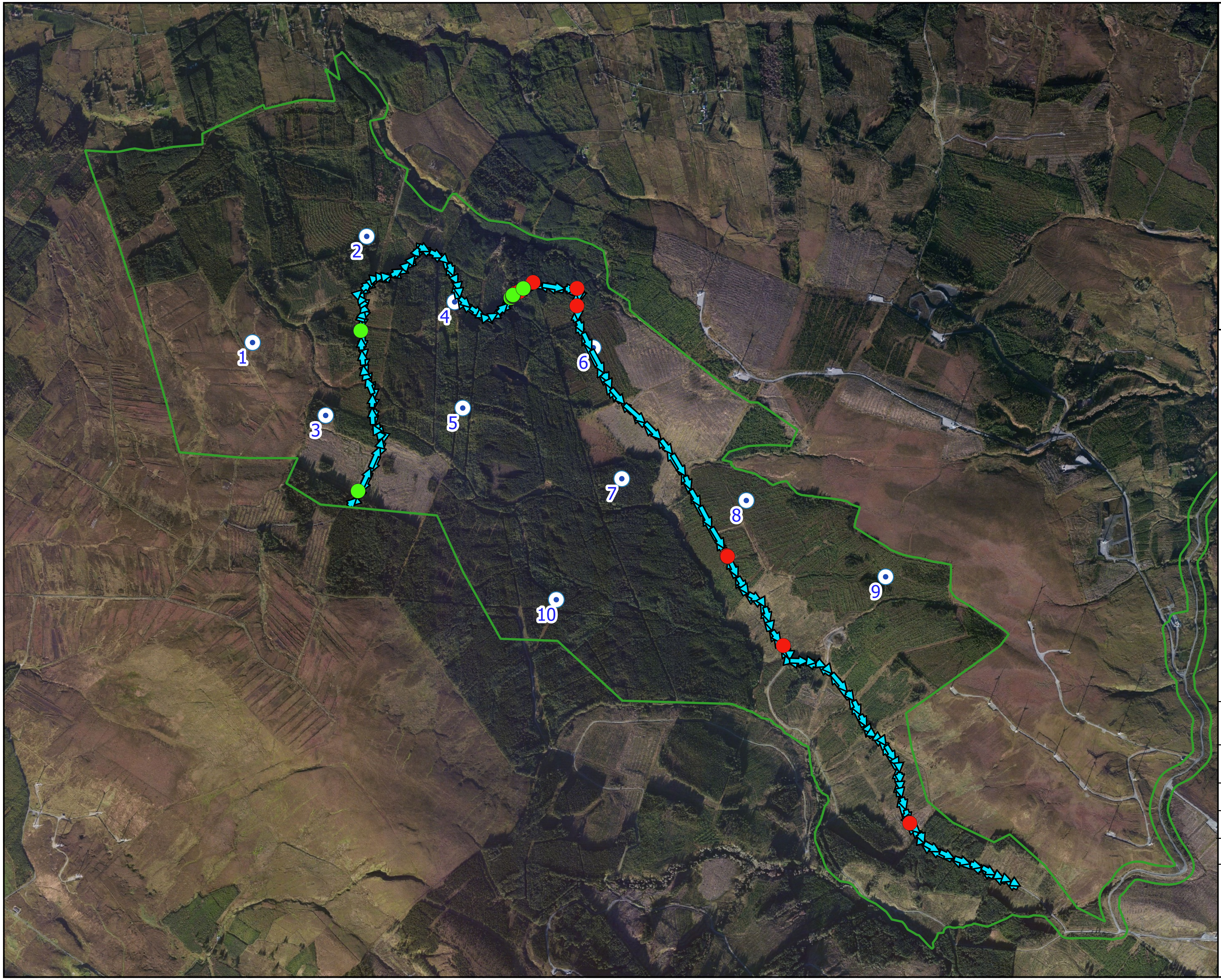

Map Legend

- Site Boundary
- Proposed Turbine Locations
- Autumn Walked Transects
- Common pipistrelle
- Soprano pipistrelle

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Drawing Title: Autumn Manual Transect Results

Project Title: Croagh Windfarm

Drawn By	Checked By
LD	JH
Project No. 180511	Drawing No. Figure 4.3
Scale 1:22000	Date 08.07.2020

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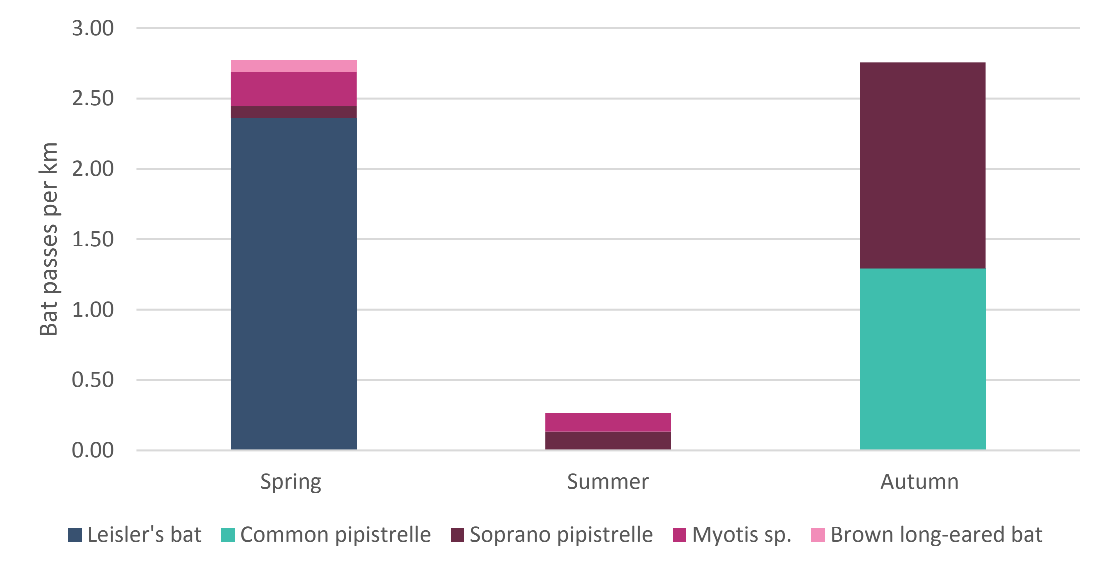

Figure 4.4 Walked & driven transects 2019 – Species composition per survey period.

4.6 Ground-level Static Surveys

In total, 21,214 bat passes were recorded across all deployments. In general, Leisler's bat (n= 7,699), common pipistrelle (n=6,384) and soprano pipistrelle (n=6,628) occurred most frequently, while instances of *Myotis* sp. (n=456) and brown long-eared bat (n=47) were significantly less. Figure 4.5 presents relative species composition across all ground-level static detector surveys.

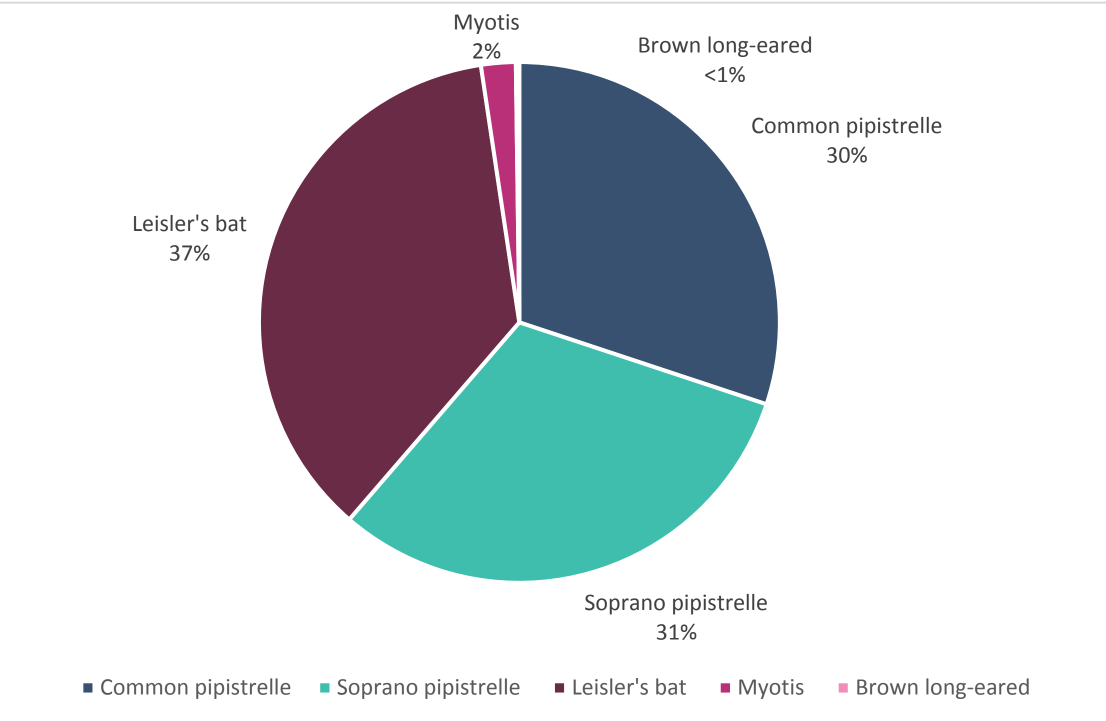

Figure 4.5 Static detector surveys: Species composition across all deployments (total bat passes)

Bat activity was calculated as total bat passes per hour (bpph) per season to account for any bias in survey effort, resulting from varying night lengths between seasons. Figure 4.6 and Table 4.4 presents these results for each species. Bat activity was dominated by Leisler's bat in spring. Common and soprano pipistrelle were more frequently occurring in summer and autumn. Instances of *Myotis* sp. and brown long-eared bat were relatively rare.

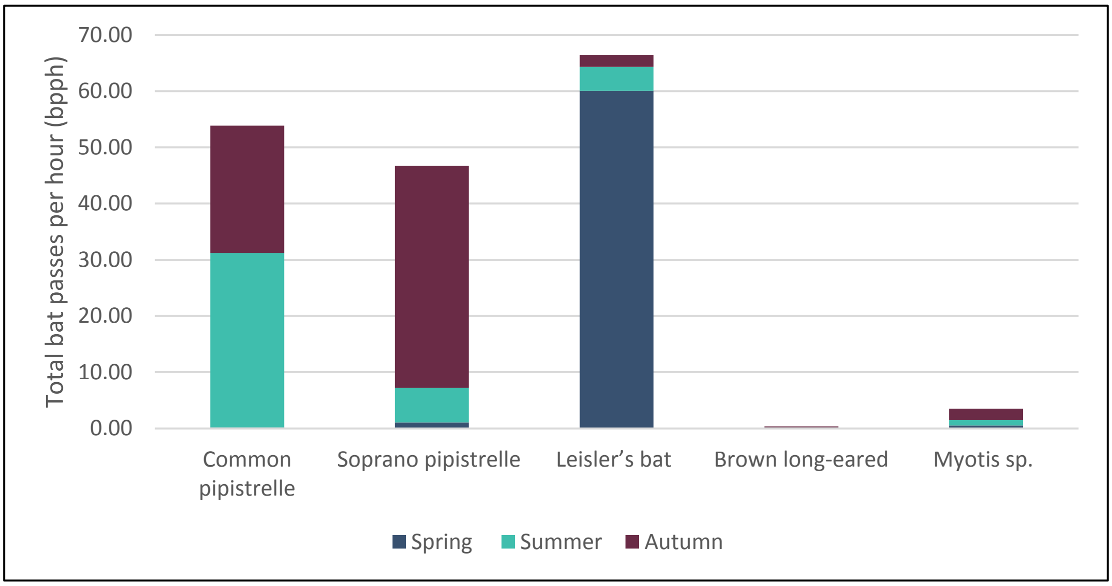

Figure 4.6 Static detector surveys: Species composition across all deployments (total bat passes per hour, all nights)

Table 4.4 Static detector surveys: Species composition across all deployments (total bat passes per hour, all nights).

	Spring	Summer	Autumn
Total survey hours	*116.1*	*95.7*	*149.8*
Common pipistrelle	0.16	31.04	22.66
Soprano pipistrelle	1.06	6.15	39.49
Leisler's bat	60.05	4.27	2.12
Brown long-eared	0.09	0.05	0.21
Myotis sp.	0.52	0.95	2.04

The Nightly Pass Rate (i.e. total bat passes per hour, per night) was used to determine typical bat activity at the proposed site. Activity was variable between survey nights. Therefore, the median Nightly Pass Rate was used as the most appropriate measure of bat activity (Linott & Mathews, 2018). Figure 4.7 illustrates the median Nightly Pass Rate per species per deployment. Zero data, when a species was not detected on a night, was also included.

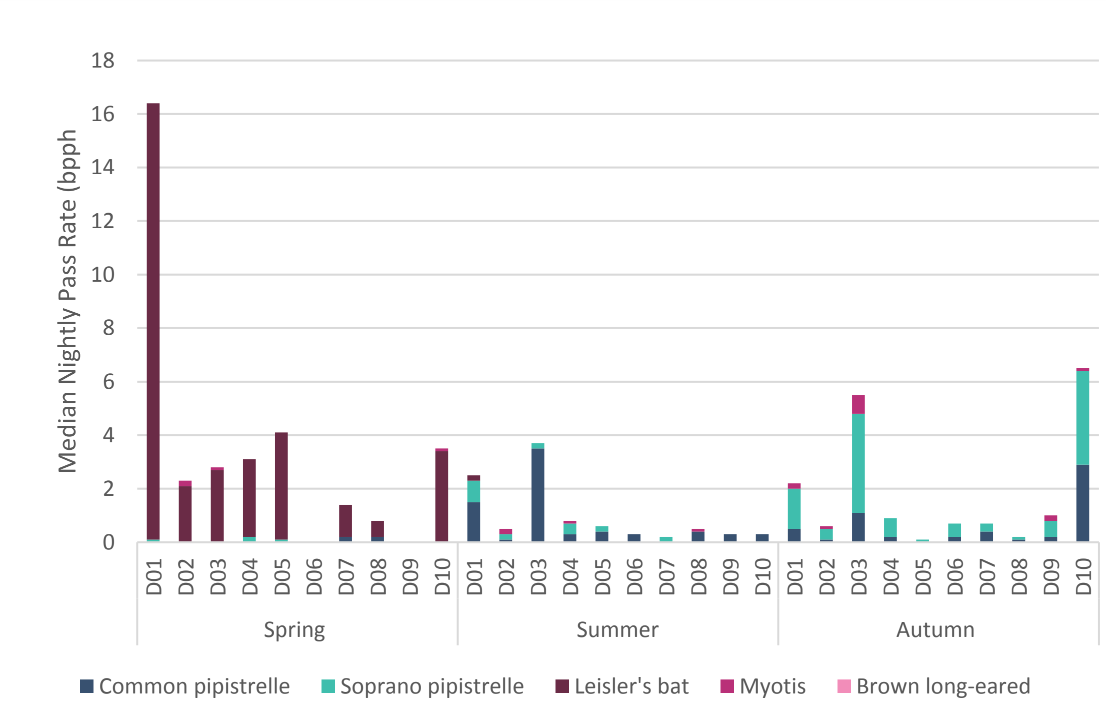

Figure 4.7 Static detector surveys: Median Nightly Pass Rate (bat passes per hour) including absences, per location per survey period.

Leisler's bat was predominant at all other detectors during the spring particularly at detector 1 where Leislers activity was significantly higher than all other species (Figure 4.7). During the summer and autumn seasons, Leisler's activity dropped off and common and soprano pipistrelles were more prevalent during the summer and autumn seasons.

Bat activity levels were objectively assessed against a reference dataset using Ecobat. Table 4.5 presents the results of Ecobat analysis for each species per season on a site-level. **Appendix 3** provides these results per detector. All species showed at least *Moderate* median bat activity during at least one season. Activity peaked with *Moderate* activity for brown long-eared bat and *High* activity for all other species.

Table 4.5 Static detector surveys: Site-level Ecobat Analysis

Survey Period	Median Percentile	Median Bat Activity	Max Percentile	Max Bat Activity	Nights Recorded	Ref Range
Common pipistrelle						
Spring	6	Low	45	Moderate	11	1087
Summer	47	Moderate	100	High	81	2203
Autumn	58	Moderate	99	High	96	1996
Soprano pipistrelle						
Spring	23	Low-Moderate	85	High	26	1104
Summer	24	Low-Moderate	96	High	63	2074
Autumn	64	Moderate-High	100	High	100	1923
Leisler's bat						
Spring	76	Moderate-High	100	High	98	954
Summer	47	Moderate	89	High	35	1698

Survey Period	Median Percentile	Median Bat Activity	Max Percentile	Max Bat Activity	Nights Recorded	Ref Range
Autumn	54	Moderate	86	High	37	1217
Myotis sp.						
Spring	6	Low	57	Moderate	28	762
Summer	5	Low	68	Moderate-High	46	1217
Autumn	41	Moderate	81	High	72	1365
Brown long-eared bat						
Spring	6	Low	40	Moderate	5	305
Summer	5	Low	5	Low	5	481
Autumn	31	Low-Moderate	54	Moderate	13	831

4.7 Surveys at Height

Two microphones, one at the top of the met mast (High) and one at the bottom (Low) attached to a Static detector recorded simultaneously. Bat activity was extremely low with just 38 bat passes recorded over 69 nights of monitoring. Overall, bat activity was higher at height than at ground level (Figure 4.8). However, the majority of this activity (n = 20 bat passes) was attributed to Leisler's bat on a single night in June (Mast-2). The bat species recorded at the met mast were also recorded during the ground level static detector surveys else where on site. The bat activity levels recorded at height are extremely low when compared ground level static bat detector levels i.e.Leisler's bat (n= 7,699) were recorded across all ground level static detectors across all seasons.

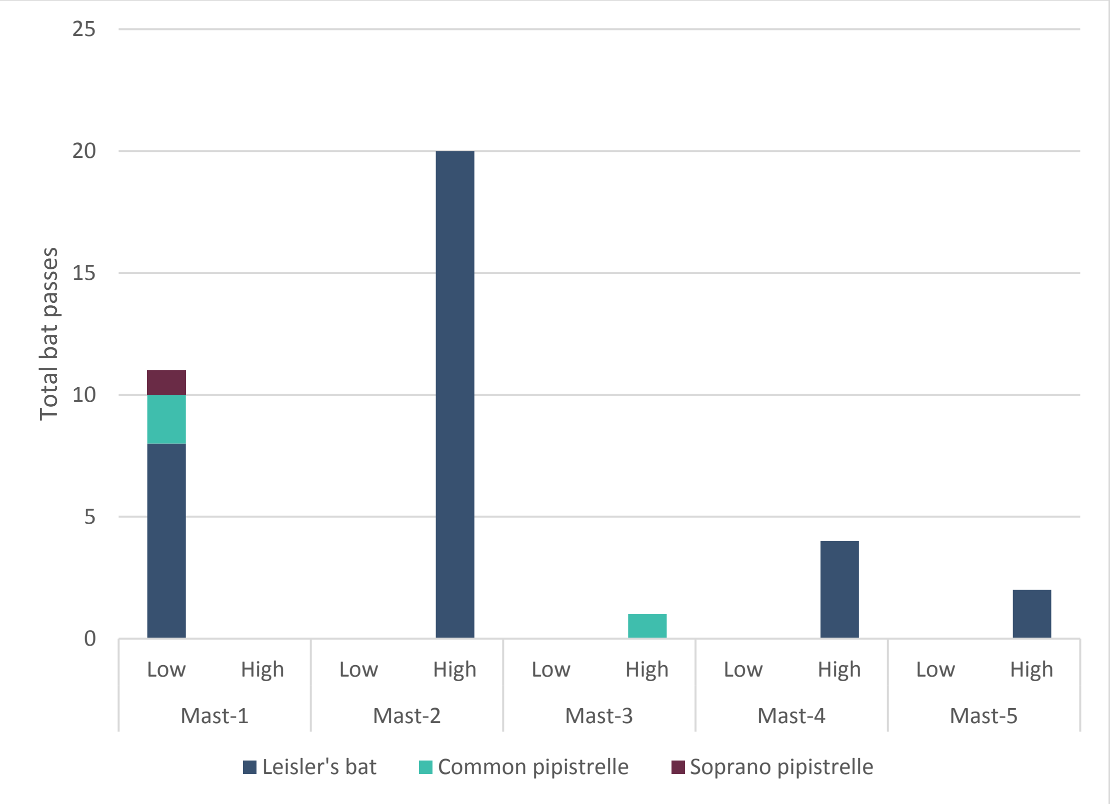

Figure 4.8 Surveys at height - species composition per microphone per deployment.

4.8 Significance of Bat population recorded at the site

Ecological evaluation and within this Section follows a methodology that is set out in Chapter three of the '*Guidelines for Assessment of Ecological Impacts of National Roads Schemes'* (NRA, 2009).

All bat species in Ireland are protected under the Bonn Convention (1992), Bern Convention (1982) and the EU Habitats Directive (92/43/EEC). Additionally, in Ireland bat species are afforded further protection under the Birds and Natural Habitats Regulations (2011) and the Wildlife Acts 1976-2019. No bat roosts were identified within the footprint of the proposed development. Bats as an Ecological Receptor have been assigned ***Local Importance (Higher value***) on the basis that the habitats within the study area are utilised by a regularly occurring bat population of Local Importance.

The development site does not support a roosting site of ecological significance. Risk & Impact Assessment

As per SNH Guidance, wind farms present four potential risks to bats:

- Collision mortality, barotrauma and other injuries
- Loss or damage to commuting and foraging habitat
- Loss of, or damage to, roosts
- Displacement of individuals or populations

For each of these four risks, the detailed knowledge of bat distribution and activity within the study area has been utilised to predict the potential effects of the wind farm on bats.

4.9 Collision Mortality

4.9.1 Assessment of Site-Risk

The likely impact of a proposed development on bats is related to site-based risk factors, including habitat and development features. The site risk assessment, as per Table 3a of the SNH guidance, is provided in Table 4.6 below.

Table 4.6 Site Risk Assessment

Criteria	Site-specific Evaluation	Individual Risk	Site Assessment
Habitat Risk	No potential roost features identified within the site.	Low	Low
	Upland peatland & conifer forestry habitats within the site (Low foraging/commuting suitability)	Low	
	Connected to wider landscape by forestry habitats.	Moderate	
Project Size	Small scale development (10 no. turbines)	Small	Large
	Other wind energy developments within 5km (see Table 4.3)	Large	
	Comprising turbines>100 m in height	Large	
Site Risk Assessment (from criteria in plate 3.3)			**Medium Site Risk (3)**

The site of the proposed development is located in conifer plantation with small areas of upland peatland. As per table 3a of the SNH Guidance (2019), it has a low habitat risk score. The proposed development includes 10 turbines of over 100m in height. As per Table 3a, it is a small project (10 turbines) but the turbines are greater than 100m in height and thus for the purposes of the assessment, it is considered to be a large project. It is also noted that it is in close proximity to other wind farm developments.

The cross tabulation of a large project on a low risk site results in an overall risk score of **Medium** (SNH Table 3a)(Appendix 1).

4.9.2 Assessment of Collision Risk

The following high-risk species were recorded during the dedicated surveys:

- Leisler's Bat,
- Common Pipistrelle
- Soprano pipistrelle

The Overall Risk Assessment for high collision risk species is provided in the sections below. Overall Risk was determined, in accordance with Table 3b of SNH guidance (**Appendix** 4), by a cross-tablature of the site risk level (i.e. Medium) and Ecobat bat activity outputs for each species. The assessment was carried out for both median and maximum Ecobat activity categories in order to provide insight into typical bat activity (i.e. median values) and activity peaks (i.e. maximum values). SNH recommends that that most appropriate activity level (i.e. median or maximum) be utilised to determine the overall risk assessment for a species.

As per SNH guidance there is no requirement to complete an Overall Risk Assessment for low risk species. During the extensive suite of surveys undertaken that following low risk species were recorded:

- Myotis spp.
- Brown Long-eared Bat

Overall activity levels were low for the above species no significant collision related effects are anticipated.

4.9.2.1 Leisler's bat

This site is within the current range of the Leisler's bat (NPWS, 2019). Leisler's bats are classed as a rarer species of a high population risk which have a high collision risk (Plate 3.2). Leisler's bats were recorded during activity surveys across the proposed site. When assessed in the context of the identified site risk and in line with Table 3b (SNH 2019) overall activity risk for Leisler's bat was found to be ***Medium*** at typical activity levels and ***High*** at peak activity levels across all three seasons (See Table 4.7).

Based on site visit and survey data, including walked and driven transects, it is determined that the Typical Activity (i.e. Median) is reflective of the nature of the site, which is an upland conifer plantation with low levels of bat activity recorded during the walked and driven transects undertaken

Thus, there is **Medium** collision risk level assigned to the local population of Leisler's Bat.

Table 4.7 Leisler's bat - Overall risk assessment

Survey Period	Site Risk	Typical Activity (Median)	Typical Risk Assessment (as per Table 3b SNH 2019)	Activity Peaks (Maximum)	Peak Risk Assessment (as per Table 3b SNH 2019)
Spring	Medium (3)	Moderate to High (4)	Typical Risk is Medium (12)	High (5)	Peak Risk is High (15)

Survey Period	Site Risk	Typical Activity (Median)	Typical Risk Assessment (as per Table 3b SNH 2019)	Activity Peaks (Maximum)	Peak Risk Assessment (as per Table 3b SNH 2019)
Summer		Moderate (3)	Typical Risk is Medium (9)	High (5)	Peak Risk is High (15)
Autumn		Moderate (3)	Typical Risk is Medium (9)	High (5)	Peak Risk is High (15)

4.9.2.2 Soprano pipistrelle

This site is within the current range of the Soprano pipistrelle bat (NPWS, 2019). Soprano pipistrelle are classed as a common species of a medium population risk which have a high potential collision risk (Plate 3.2). Soprano pipistrelle were recorded during activity surveys across the proposed site. When assessed in the context of the identified site risk and in line with Table 3b (SNH 2019) overall activity risk for Soprano pipistrelle was found to be ***Medium*** at typical activity levels and ***High*** at peak activity levels across all three seasons (See Table 4.8 below).

Based on site visit and survey data, including walked and driven transects, it is determined that the Typical Activity (i.e. Median) is reflective of the nature of the site, which is an upland conifer plantation with low levels of bat activity recorded during the walked and driven transects undertaken

Thus, there is **Medium** collision risk level assigned to the local population of Soprano Pipistrelle.

Table 4.8 Soprano pipistrelle – Overall risk assessment

Survey Period	Site Risk	Typical Activity (Median)	Typical Risk Assessment (as per Table 3b SNH 2019)	Activity Peaks (Maximum)	Peak Risk Assessment (as per Table 3b SNH 2019)
Spring	Medium (3)	Low to Moderate (2)	Typical Risk is Medium (6)	High (5)	Peak Risk is High (15)
Summer		Low to Moderate (2)	Typical Risk is Medium (6)	High (5)	Peak Risk is High (15)
Autumn		Moderate to High (4)	Typical Risk is Medium (12)	High (5)	Peak Risk is High (15)

4.9.2.3 Common pipistrelle

This site is within the current range of the Common pipistrelle bat (NPWS, 2019). Common pipistrelle are classed as a common species of a medium population risk which have a high collision risk (Plate 3.2). Common pipistrelle were recorded during activity surveys across the proposed site. When assessed in the context of the identified site risk and in line with Table 3b (SNH 2019); overall activity risk for Common pipistrelle at typical activity levels was found to be ***Low*** in Spring and ***Medium*** in Summer & Autumn. Peak risk levels for Common pipistrelle were ***Medium*** in Spring and ***High*** in Summer & Autumn.(See Table 4.9)

Based on site visit and survey data, including walked and driven transects, it is determined that the Typical Activity (i.e. Median) is reflective of the nature of the site, which is a upland conifer plantation with low levels of bat activity recorded during the walked and driven transects undertaken

Thus, there is **Moderate** collision risk level assigned to the local population of Common Pipistrelle.

Table 4.9 Common pipistrelle – Overall risk assessment

Survey Period	Site Risk	Typical Activity (Median)	Typical Risk Assessment (as per Table 3b SNH 2019)	Activity Peaks (Maximum)	Peak Risk Assessment (as per Table 3b SNH 2019)
Spring	Medium (3)	Low (1)	Typical Risk is Low (3)	Moderate (3)	Peak Risk is Medium (9)
Summer		Moderate (3)	Typical Risk is Medium (9)	High (5)	Peak Risk is High (15)
Autumn		Moderate (3)	Typical Risk is Medium (9)	High (5)	Peak Risk is High (15)

4.10 Loss or damage to commuting and foraging habitat

In absence of appropriate design, the loss or degradation of commuting/foraging habitat has potential to reduce feeding opportunities and/or displace bat populations. However, the development is predominantly located within an existing commercial forestry plantation and there will be no net loss of bat foraging/commuting habitat associated with the proposed wind farm development.

The development, including the creation of new road infrastructure and grid connection route, has the potential to open up the commercial forestry and thereby increase the amount and availability of linear landscape features that may be utilised by bats for commuting or foraging.

No significant effects with regard to loss of commuting and foraging habitat are anticipated.

4.11 Loss of, or damage to, roosts

The development is predominantly located within a commercial forestry plantation. The trees in the plantation do not provide potential roosting habitat of significance for bats. One derelict structure was identified within the proposed site. Although the structure will be retained it was subject a roost inspection and emergence survey, but no evidence of bats was recorded.

Overall no roosting sites suitable for maternity colonies, swarming or hibernation were identified and none will be impacted by the proposed development.

There will be no loss of tree roosting habitat of linear landscape connectivity associated with these works.

Any culverts located along the grid connectiuon route were assessmend as having neglidable roosting potential for bats.

The habitats present along the grid connection route consist mostly of coniferous plantation, previously exiting forestry tracks and regional roads. The coniferous plantations along the grid connection route were assessed as low suitability for roosting bats, and there will be no loss of any roosting site of ecological significance.

No significant effects with regard to loss of, or damage to, roosts anticipated.

4.12 Displacement of individuals or populations

The development is predominantly located within a commercial forestry plantation. There will be no net loss of linear landscape features for commuting and foraging bats and there will be no loss of any roosting site of ecological significance. The habitats on the site will remain suitable for bats and no significant displacement of individuals or populations is anticipated.

5. BEST PRACTICE & MITIGATION MEASURES

This section describes the best practice and site-specific mitigation measures that are in place to avoid and reduce the potential for significant effects on local bat populations.

5.1 Standard Best Practice Measures

5.1.1 Noise Restrictions

During the construction phase, plant machinery will be turned off when not in use and all plant and equipment for use will comply with the Construction Plant and Equipment Permissible Noise Levels Regulations (SI 359/1996).

5.1.2 Lighting Restrictions

Where lighting is required, directional lighting will be used to prevent overspill on to woodland/forestry edges. This will be achieved using lighting accessories, such as hoods, cowls, louvers and shields, to direct the light to the intended area only.

5.1.3 Buffering

A 50m buffer from the blade tip to the nearest woodland, as recommended by the Natural England (2014) and SNH (2019) guidelines, shall be implemented. These vegetation-free areas will be maintained during the operational life of the development.

The correct buffer distance must be measured from the blade tip sweep to the canopy of the nearest habitat feature. Measuring 50m for the base of the turbine to the habitat feature is inadequate as tall tree canopies may put bat populations at risk. It is necessary to calculate the distance between the edge of the habitat feature and the centre of the tower (b). Using the formula:

$$b = \sqrt{(50 + bl)^2 - (hh - fh)^2}$$

Where, bl =Blade length, hh = hub height, fh = feature height all in metres. i.e (above) b = 69.3m (Plate 5.1)

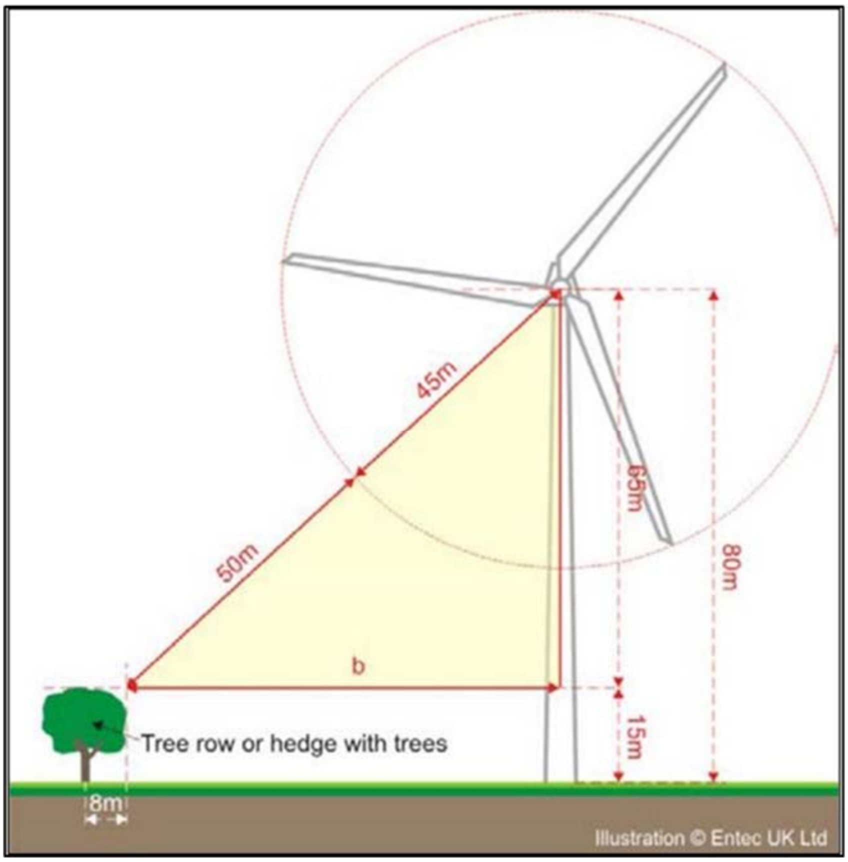

Plate 5.1 Calculate buffer distances (Natural England, 2014).

5.2 Site Specific Mitigation and Monitoring Programme

Overall risk levels for high collision risk bat species was typically ***Medium***. This risk level is reflective of the nature of the site, which is an upland conifer plantation with low levels of bat activity recorded during the walked and driven transects undertaken.

However, taking precautionary approach and given that high collision risk was recorded at peak activity levels, an adaptive monitoring and mitigation strategy has been devised for the proposed development in line with the case study example provided in Appendix 5 of the SNH Guidance.

5.2.1 Post Construction Monitoring & Assessment of Adaptive Mitigation Requirement

As per SNH Guidance at least 3 years of post-construction monitoring is required to assess the effects of construction related habitat modification on bat activity. For example, it may be that the construction of wind turbines significantly reduces bat activity at the site relative to that recorded pre-construction and to a level at which there is no longer potential for significant effects on bats (SNH 2019). Therefore, the results of post construction monitoring shall be utilised to assess changes in bat activity patterns and to inform the design of any advanced site specified mitigation requirements, including curtailment, to ensure that there are no significant residual effects on bat species.

5.2.1.1 Operational Year 1

Static monitoring at turbine bases and nacelle level shall take place at each turbine during the bat activity season (between April and October). Full spectrum recording detectors shall be utilised for the same duration as during pre-application surveys and at the same density (SNH, 2019).

Key weather parameters and other factors that are known to influence collision risk will be monitored and shall include:

- Windspeed in m/s (measured at nacelle height)
- Temperature (ºC)
- Precipitation (mm/hr)

Carcass searches, to monitor and record bat fatalities, shall be conducted at each turbine in accordance with SNH Guidance. This shall include searcher efficiency trials and an assessment of scavenger removal rates to determine the appropriate correction factor to be applied in relation to determining an accurate estimate of collision mortality. Calculating casualty rates across the site shall be done in accordance with the methods and formulas provided in Appendix 4 of the SNH Guidance.

At the end of Year 1, and if a curtailment requirement is identified (i.e. significant bat fatalities encountered), a curtailment programme shall be devised around key activity periods and weather parameters.

Curtailment involves raising the cut-in speed with associated loss of power generation in combination with reducing the blade rotation (blade feathering) below the cut-in speed. The most basic and least sophisticated form of curtailment “blanket” curtailment -involves feathering the blades between dusk and dawn over the entire bat active period (April to October). A more sophisticated and efficient solution is to focus on certain times and dates, corresponding with those periods when the highest level of bat activity is expected to occur. Further savings can be achieved by programming the SCADA operating system to only pause/feather the blades below a specified wind speed and above a specified temperature within specified time periods.

In order to minimise down time, the threshold values at which turbines are feathered should be site specific and informed by bat activity peaks at that location, but as an indication, they are likely to be in the range of wind speeds between 5.0 and 6.5m/s and at temperatures above approximately 10 or 11ºC measured at the nacelle. Significant savings can be achieved by so-called “smart “curtailment over the other less sophisticated alternatives.

The effectiveness of curtailment needs to be monitored in order to determine (a) whether it is working effectively (i.e. the level of bat mortality is incidental), and (b) whether the curtailment regime can be refined such that turbine down-time can be minimised whilst ensuring that it remains effective at preventing casualties.

5.2.1.2 Operational Years 2 & 3

Where a curtailment requirement is identified, monitoring surveys shall continue in Year 2 and 3 and the success of the curtailment strategy shall be assessed in line with the baseline data collected in the subsequent year/years.

The performance of the curtailment programme in terms of its ability to respond to the changes in bat abundance based on temperature and wind speed shall be analysed to confirm it is neither significantly over- nor under- curtailing during different periods of bat activity.

At the end of each year, the efficacy of the curtailment programme shall be reviewed, and any identified efficiencies incorporated into the curtailment programme.

5.3 Residual Impacts

Taking into consideration the proposed best practice and adaptive mitigation measures; significant residual effects on bats with regard to 1) Collision mortality, barotrauma and other injuries, 2) Loss or damage to commuting and foraging habitat, 3) Loss of, or damage to, roosts and 4) Displacement of individuals or populations are not anticipated.

6. CONCLUSION

This report provides a full and comprehensive assessment of the potential for impact on bat populations at the proposed development site. The surveys and assessment provided in this report are in accordance with SNH guidance. Following consideration of the residual effects (post mitigation) it is noted that the proposed development will not result in any significant effects on bats

Provided that the proposed wind farm development is constructed and operated in accordance with the design, best practice and mitigation that is described within this report, significant effects on bats are not anticipated at any geographic scale.

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APPENDIX 1

HABITAT SUITABILITY ASSESSMENT

Guidelines for assessing the potential suitability of a site for bats, based on the presence of habitat features (taken from Collins, 2016).

Suitability	Roosting Habitats	Commuting and Foraging Habitats
Negligible	Negligible habitat features on site likely to be used by roosting bats.	Negligible habitat features on site likely to be used by commuting or foraging bats.
Low	A structure with one or more potential roost sites that could be used by individual bats opportunistically. However, these potential roost sites do not provide enough space, shelter, protection, appropriate conditions[1] and/or suitable surrounding habitat to be used on a regular basis or by larger numbers of bats, i.e. unlikely to be suitable for maternity or hibernation[2]. A tree of sufficient size and age to contain potential roost features but with none seen from the ground or features seen with only very limited roosting potential[3].	Habitat that could be used by small numbers of commuting bats such as a gappy hedgerow or unvegetated stream, but isolated, i.e. not very well connected to the surrounding landscape by other habitat. Suitable, but isolated habitat that could be used by small numbers of foraging bats such as a lone tree (not in a parkland situation) or a patch of scrub.
Moderate	A structure or tree with one or more potential roost sites that could be used by bats due to their size, shelter, protection, conditions and surrounding habitat but unlikely to support a roost of high conservation status (with respect to roost type only - the assessments in this table are made irrespective of species conservation status, which is established after presence is confirmed).	Continuous habitat connected to the wider landscape that could be used by bats for commuting such as lines of trees and scrub or linked back gardens. Habitat that is connected to the wider landscape that could be used by bats for foraging such as trees, scrub, grassland or water.
High	A structure or tree with one or potential roost sites that are obviously suitable for use by larger numbers of bats on a more regular basis and potentially for longer periods of time due to their size, shelter, protection, conditions and surrounding habitat.	Continuous, high-quality habitat that is well connected to the wider landscape that is likely to be used regularly by commuting bats such as river valleys, streams, hedgerows, lines of trees and woodland edge. High-quality habitat that is well connected to the wider landscape that is likely to be used regularly by foraging bats such as broadleaved woodland, tree-lined watercourses and grazed parkland. Site is close to and connected to known roosts.

1 For example, in terms of temperature, humidity, height above ground, light levels or levels of disturbance.
2 Larger numbers of Common pipistrelle may be present during autumn and winter in large buildings in highly urbanised areas, based on evidence from the Netherlands (Korsten et al. 2015).

3 Categorisation aligns with BS 8596:2015 Surveying for bats in trees and woodland (BSI, 2015).

APPENDIX 2

SITE RISK ASSESSMENT

Table 3a: *Stage 1 - Initial site risk assessment*

Site Risk Level (1-5)*	**Project Size**			
		Small	**Medium**	**Large**
Habitat Risk	**Low**	1	2	3
	Moderate	2	3	4
	High	3	4	5

Key: Green (1-2) - low/lowest site risk; Amber (3) - medium site risk; Red (4-5) - high/highest site risk.

* Some sites could conceivably be assessed as being of no (0) risk to bats. This assessment is only likely to be valid in more extreme environments, such as above the known altitudinal range of bats, or outside the known geographical distribution of any resident British species.

Habitat Risk	**Description**
Low	Small number of potential roost features, of low quality. Low quality foraging habitat that could be used by small numbers of foraging bats. Isolated site not connected to the wider landscape by prominent linear features.
Moderate	Buildings, trees or other structures with moderate-high potential as roost sites on or near the site. Habitat could be used extensively by foraging bats. Site is connected to the wider landscape by linear features such as scrub, tree lines and streams.
High	Numerous suitable buildings, trees (particularly mature ancient woodland) or other structures with moderate-high potential as roost sites on or near the site, and/or confirmed roosts present close to or on the site. Extensive and diverse habitat mosaic of high quality for foraging bats. Site is connected to the wider landscape by a network of strong linear features such as rivers, blocks of woodland and mature hedgerows. At/near edge of range and/or on an important flyway. Close to key roost and/or swarming site.

Project Size	**Description**
Small	Small scale development (≤10 turbines). No other wind energy developments within 10km. Comprising turbines <50m in height.
Medium	Larger developments (between 10 and 40 turbines). May have some other wind developments within 5km. Comprising turbines 50-100m in height.
Large	Largest developments (>40 turbines) with other wind energy developments within 5km. Comprising turbines >100m in height.

APPENDIX 3

ECOBAT PER DETECTOR ANALYSIS

ECOBAT ANALYSIS – PER DETECTOR RESULTS

Summary tables are provided for each species recorded showing key metrics per detector per survey period.

LEISLER'S BAT

Survey Period	Nights Recorded	Ref Range	Detector ID	Median Bat Activity Level	Median Bat Activity	Max Bat Activity Level	Max Bat Activity Level
Spring	11	449	D01	94	High	100	High
Spring	8	449	D02	72	Moderate/High	86	High
Spring	8	449	D03	78	Moderate/High	94	High
Spring	12	449	D04	76	Moderate/High	96	High
Spring	10	449	D05	80	High	94	High
Spring	-	-	D06	-	-	-	-
Spring	12	449	D07	64	Moderate/High	82	High
Spring	10	449	D08	48	Moderate	84	High
Spring	0	449	D09	0	Nil	0	Nil
Spring	9	449	D10	78	Moderate/High	97	High
Summer	5	616	D01	51	Moderate	78	Moderate/High
Summer	3	616	D02	43	Moderate	43	Moderate
Summer	4	616	D03	58	Moderate	81	High
Summer	4	616	D04	54	Moderate	78	Moderate/High
Summer	3	616	D05	41	Moderate	71	Moderate/High
Summer	5	616	D06	51	Moderate	85	High
Summer	0	616	D07	0	Nil	0	Nil
Summer	2	616	D08	28	Low/Moderate	38	Low/Moderate
Summer	2	616	D09	74	Moderate/High	83	High
Summer	3	616	D10	43	Moderate	72	Moderate/High
Autumn	4	840	D01	71	Moderate/High	77	Moderate/High
Autumn	4	840	D02	53	Moderate	84	Moderate/High
Autumn	7	840	D03	48	Moderate	79	Moderate/High
Autumn	4	840	D04	32	Low/Moderate	53	Moderate
Autumn	0	840	D05	0	Nil	0	Nil
Autumn	3	840	D06	57	Moderate	78	Moderate/High
Autumn	4	840	D07	77	Moderate/High	86	High
Autumn	2	840	D08	48	Moderate	53	Moderate
Autumn	3	840	D09	74	Moderate/High	78	Moderate/High
Autumn	3	840	D10	70	Moderate/High	72	Moderate/High

SOPRANO PIPISTRELLE							
Survey Period	Nights Recorded	Ref Range	Detector ID	Median Bat Activity Level	Median Bat Activity	Max Bat Activity Level	Max Bat Activity Level
Spring	4	370	D01	30	Low/Moderate	85	High
Spring	2	370	D02	37	Low/Moderate	43	Moderate
Spring	3	370	D03	30	Low/Moderate	43	Moderate
Spring	4	370	D04	30	Low/Moderate	53	Moderate
Spring	13	370	D05	30	Low/Moderate	30	Low/Moderate
Spring	-	-	D06	-	-	-	-
Spring	0	370	D07	0	Nil	0	Nil
Spring	0	370	D08	0	Nil	0	Nil
Spring	0	0	D09	0	Nil	0	Nil
Spring	1	370	D10	19	Low	19	Low
Summer	9	614	D01	54	Moderate	94	High
Summer	6	614	D02	18	Low	61	Moderate/High
Summer	8	614	D03	54	Moderate	82	High
Summer	10	614	D04	38	Low/Moderate	57	Moderate
Summer	6	614	D05	18	Low	60	Moderate
Summer	4	614	D06	31	Low/Moderate	43	Moderate
Summer	1	0	D07	18	Low	18	Low
Summer	0	614	D08	0	Nil	0	Nil
Summer	2	614	D09	18	Low	31	Low/Moderate
Summer	3	614	D10	25	Low/Moderate	63	Moderate/High
Autumn	14	961	D01	76	Moderate/High	100	High
Autumn	11	961	D02	53	Moderate	84	High
Autumn	13	961	D03	86	High	97	High
Autumn	10	961	D04	66	Moderate/High	87	High
Autumn	4	961	D05	24	Low/Moderate	92	High
Autumn	12	961	D06	63	Moderate/High	87	High
Autumn	9	961	D07	53	Moderate	84	High
Autumn	7	961	D08	24	Low/Moderate	66	Moderate/High
Autumn	6	961	D09	76	Moderate/High	81	High
Autumn	11	961	D10	86	High	99	High

COMMON PIPISTRELLE

Survey Period	Nights Recorded	Ref Range	Detector ID	Median Bat Activity Level	Median Bat Activity	Max Bat Activity Level	Max Bat Activity Level
Spring	2	358	D01	19	Low	19	Low
Spring	1	358	D02	19	Low	19	Low
Spring	0	358	D03	0	Nil	0	Nil
Spring	4	358	D04	25	Low/Moderate	48	Moderate
Spring	0	358	D05	0	Nil	0	Nil
Spring	-	-	D06	-	-	-	-
Spring	2	358	D07	25	Low/Moderate	30	Low/Moderate
Spring	1	358	D08	30	Low/Moderate	30	Low/Moderate
Spring	0	358	D09	0	Nil	0	Nil
Spring	1	358	D10	30	Low/Moderate	30	Low/Moderate
Summer	11	666	D01	61	Moderate/High	96	High
Summer	5	666	D02	31	Low/Moderate	61	Moderate/High
Summer	10	666	D03	74	Moderate/High	100	High
Summer	6	666	D04	41	Moderate	65	Moderate/High
Summer	6	666	D05	18	Moderate	60	Moderate/High
Summer	7	666	D06	46	Moderate	74	Moderate/High
Summer	0	666	D07	0	Nil	0	Nil
Summer	3	666	D08	43	Moderate	71	Moderate/High
Summer	7	666	D09	35	Low/Moderate	75	Moderate/High
Summer	6	666	D10	38	Low/Moderate	60	Moderate
Autumn	11	1119	D01	87	High	99	High
Autumn	6	1119	D02	41	Moderate	72	Moderate/High
Autumn	12	1119	D03	72	Moderate/High	100	High
Autumn	9	1119	D04	48	Moderate	77	Moderate/High
Autumn	1	1119	D05	48	Moderate	48	Moderate
Autumn	13	1119	D06	40	Low/Moderate	76	Moderate/High
Autumn	8	1119	D07	63	Moderate/High	92	High
Autumn	5	1119	D08	24	Low/Moderate	63	Moderate/High
Autumn	7	1119	D09	52	Moderate	78	Moderate/High
Autumn	9	1119	D10	84	High	93	High

MYOTIS SP.

Survey Period	Nights Recorded	Ref Range	Detector ID	Median Bat Activity Level	Median Bat Activity	Max Bat Activity Level	Max Bat Activity Level
Spring	3	256	D01	19	Low	60	Moderate
Spring	4	256	D02	35	Low/ Moderate	53	Moderate
Spring	4	256	D03	19	Low	30	Low/Moderate
Spring	4	256	D04	29	Low/ Moderate	57	Moderate
Spring	13	256	D05	19	Low	30	Low/ Moderate
Spring	-	-	D06	-	-	-	-
Spring	0	256	D07	0	Nil	0	Nil
Spring	3	256	D08	19	Low	19	Low
Spring	0	256	D09	0	Nil	0	Nil
Spring	5	256	D10	19	Low	19	Low
Summer	5	367	D01	38	Low/ Moderate	67	Moderate/High
Summer	5	367	D02	18	Low	18	Low
Summer	6	367	D03	25	Low/ Moderate	38	Low/ Moderate
Summer	7	367	D04	38	Low/ Moderate	51	Moderate
Summer	2	367	D05	18	Low	18	Low
Summer	5	367	D06	18	Low	31	Low/ Moderate
Summer	0	367	D07	0	Nil	0	Nil
Summer	3	367	D08	18	Low	31	Low/ Moderate
Summer	4	367	D09	18	Low	31	Low/ Moderate
Summer	5	367	D10	18	Low	31	Low/ Moderate
Autumn	6	796	D01	51	Moderate	76	Moderate/High
Autumn	6	796	D02	24	Low/ Moderate	70	Moderate/High
Autumn	12	796	D03	63	Moderate/High	81	High
Autumn	6	796	D04	24	Low/ Moderate	53	Moderate
Autumn	1	796	D05	24	Low/ Moderate	24	Low/ Moderate
Autumn	6	796	D06	48	Moderate	57	Moderate
Autumn	4	796	D07	40	Low/ Moderate	40	Low/ Moderate
Autumn	2	796	D08	24	Low/ Moderate	24	Low/ Moderate
Autumn	8	796	D09	53	Moderate	66	Moderate/High
Autumn	7	796	D10	48	Moderate	66	Moderate/High

BROWN LONG-EARED BAT

Survey Period	Nights Recorded	Ref Range	Detector ID	Median Bat Activity level	Median Bat Activity	Max Bat Activity Level	Max Bat Activity Level
Spring	3	174	D01	31	Low/Moderate	43	Moderate
Spring	1	174	D02	19	Low	19	Low
Spring	0	174	D03	0	Nil	0	Nil
Spring	0	174	D04	0	Nil	0	Nil
Spring	0	174	D05	0	Nil	0	Nil
Spring	-	-	D06	-	-	-	-
Spring	0	174	D07	0	Nil	0	Nil
Spring	0	174	D08	0	Nil	0	Nil
Spring	0	174	D09	0	Nil	0	Nil
Spring	0	174	D10	0	Nil	0	Nil
Summer	2	186	D01	18	Low	18	Low
Summer	0	186	D02	0	Nil	0	Nil
Summer	0	186	D03	0	Nil	0	Nil
Summer	1	186	D04	18	Low	18	Low
Summer	0	186	D05	0	Nil	0	Nil
Summer	0	186	D06	0	Nil	0	Nil
Summer	0	186	D07	0	Nil	0	Nil
Summer	0	186	D08	0	Nil	0	Nil
Summer	2	186	D09	18	Low	18	Low
Summer	0	186	D10	0	Nil	0	Nil
Autumn	3	517	D01	40	Low/Moderate	40	Moderate
Autumn	1	517	D02	53	Moderate	53	Moderate
Autumn	1	517	D03	57	Moderate	57	Moderate
Autumn	4	517	D04	40	Low/Moderate	53	Moderate
Autumn	0	517	D05	0	Nil	0	Nil
Autumn	0	517	D06	0	Nil	0	Nil
Autumn	0	517	D07	0	Nil	0	Nil
Autumn	0	517	D08	0	Nil	0	Nil
Autumn	2	517	D09	40	Low/Moderate	48	Moderate
Autumn	0	517	D10	0	Nil	0	Nil

APPENDIX 4

OVERALL RISK ASSESSMENT

Table 3b: *Stage 2 - Overall risk assessment*

Site risk level (from Table 3a)	Ecobat activity category (or equivalent justified categorisation)					
	Nil (0)	Low (1)	Low-moderate (2)	Moderate (3)	Moderate-high (4)	High (5)
Lowest (1)	0	1	2	3	4	5
Low (2)	0	2	4	6	8	10
Med (3)	0	3	6	9	12	15
High (4)	0	4	8	12	15	18
Highest (5)	0	5	10	15	20	25

The scores in the table are a product of multiplying site risk level and the Ecobat activity category (or equivalent). The activity categories equate to those given in Table 1 for high collision risk species. Nil (0) means no bat activity was recorded across the whole site, but caution is needed here, because although the values given in this column are "0", at sites where pre-construction surveys found no bat activity, there remains the possibility that new turbines could attract some bat species, thereby altering the level of risk that applies in reality.

Overall assessment:

Low (green)	0-4
Medium (amber)	5-12
High (red)	15-25

It is important to have an understanding of both "typical" and unusually high levels of bat activity at a site so that potentially important peaks in activity are not overlooked. It is therefore recommended that both the highest Ecobat activity category and the most frequent activity category (i.e. the median) are assessed separately in Table 3b and presented in the overall risk assessment. A judgement can then be made on which is the most relevant. It should be noted that presenting mean activity levels can be highly misleading where the data are highly skewed, as is frequently the case with bat activity at wind turbines (Lintott & Mathews, 2018).

APPENDIX 6-3

FISHERIES AND AQUATIC REPORT