



Swansea University
Prifysgol Abertawe

Modelling the Current and Future Distribution of Hyperoceanic Bryophytes in the UK

Oliver Benton Morgan, BSc (Hons).

Submitted to Swansea University in fulfilment of the requirements for the Degree of MRes Biosciences.

Swansea University

September 2023

Abstract

Hyperoceanic bryophytes in the UK have expanded their spatial distribution since the 1970s due to air quality improvements, habitat modification and altering climatic conditions. They are predominantly located in areas of high humidity which is common across west of the UK. Changes in environmental conditions have resulted in hyperoceanic bryophytes colonising new habitats including scrub associated forest edges of temperate rainforest plantations within South Wales. These plantations face anthropogenic disturbance as a result of heavy machinery traffic which results in damage to scrub along forest tracks. This results in damage to willows that are often inhabited by epiphytic hyperoceanic bryophytes. The current extent of location suitability for hyperoceanic bryophytes and how they may respond to climate change within the UK is unknown. This study shows a correlation between nine hyperoceanic bryophyte presence and humidity suggesting humidity to be a driver of hyperoceanic bryophyte presence. This study also shows that areas of higher relative humidity (RH) are more likely to have hyperoceanic bryophytes present and that the current extent of location suitability for these species is larger than previously understood. Current estimates that keeping the global surface temperature under 1.5 °C is becoming more unlikely. As a result we used shared socio-economic pathway 3 as outlined by the Intergovernmental Panel on Climate Change (IPCC), in which average global surface temperature is predicted to be 2.8 °C. We predicted that the area of location suitability of hyperoceanic bryophytes is increased primarily in northern regions of the UK and a decrease in southern regions of the UK. This study highlights the importance of understanding the distribution of a species as it can be used to predict the reaction of the species to climate change and how lack of action may result in decreased spatial distribution for hyperoceanic bryophytes vulnerable to climate change.

Declarations

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed: 

Date: 27/09/2023

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed: 

Date: 27/09/2023 ✓

STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for electronic sharing.

Signed: 

Date: 27/09/2023

STATEMENT 3

The University's ethical procedures have been followed and, where appropriate, that ethical approval has been granted.

Signed: 

Date: 27/09/2023

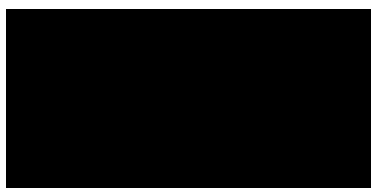
MRes Biosciences - Statement of Expenditure

Student Name: Oliver Benton Morgan

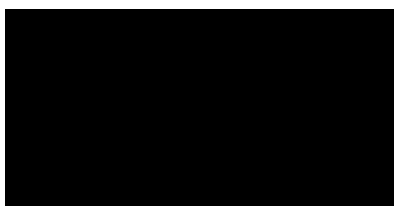
| Category | Item | Quantity | Total Cost* (£) |
|----------------------------|---|----------|-----------------------|
| Book | Mosses and Liverworts of Britain and Ireland A Field Guide | 1 | £41.99 |
| Book | Willows and Poplars of Great Britain and Ireland Volume 4 | 1 | £15.50 |
| Book | Joint Species Distribution Modelling With Applications in R | 1 | £34.99 |
| Book | Statistics for Ecologists Using R and Excel Data Collection, Exploration, Analysis and Presentation | 1 | £34.99 |
| Book | Field Handbook to British and Irish Dandelions | 1 | £19.50 |
| Book | The Lost Rainforests of Britain Hardback | 1 | £19.99 |
| Field Equipment | Triplet Loupe Hand Lens, 21mm, 20x magnification | 1 | £40.00 |
| Field Equipment | TGP-4500 - Tinytag Plus 2 Datalogger | 2 | £420.00 (£210.00 * 2) |
| Field Equipment | ACS-6000 Gemini Trigger Start Magnet | 1 | £12.00 |
| Field Equipment / Software | TGP-4500 - Tinytag Plus 2 Datalogger (Starter Kit) | 1 | £259.00 |
| Delivery Cost A | Delivery Cost A | 1 | £8 |
| Delivery Cost B | Delivery Cost B | 1 | £8 |
| Total: | | | £913.96 |

*Including VAT and delivery where applicable.

I hereby certify that the above information is true and correct to the best of my knowledge.



Signature (Supervisor)



Signature (Student)

Statement of Contributions

| Contributor Role | Persons involved |
|--------------------------------------|-------------------------|
| Conceptualization | PN, JP |
| Data Curation | OBM, PN, JP, CH |
| Formal Analysis | OBM |
| Funding Acquisition | n/a |
| Investigation | OBM, PN |
| Methodology | OBM, PN, MLR |
| Field Work | OBM, PN, JP, CH |
| Project Administration | PN |
| Resources | PN |
| Software | OBM |
| Supervision | PN, MLR |
| Validation | N/a |
| Visualisation | OBM |
| Writing – Original Draft Preparation | OBM |
| Writing – Review & Editing | OBM, PN, MLR |

PN – Dr Penny Neyland (Supervisor & Data collection)

MLR – Dr Miguel Lurgi Rivera (Supervisor)

OBM – Oliver Benton Morgan (MRes Student)

JP – Joey Pickard (Data collection & Access to sites)

CH – Charles Hipkin (Data collection)

Ethics Approval



Swansea University
Prifysgol Abertawe

Approval Date: 25/03/2023

Research Ethics Approval Number: 1 2023 6343 5437

Thank you for completing a research ethics application for ethical approval and submitting the required documentation via the online platform.

Project Title Modelling the Distribution of Hyperoceanic Bryophytes in Wales
Applicant name MR OLIVER BENTON MORGAN
Submitted by MR OLIVER BENTON MORGAN / DR PENELOPE NEYLAND
Full application form link <https://swansea.forms.ethicalreviewmanager.com/Project/Index/8042>

The Science and Engineering ethics committee has approved the ethics application, subject to the conditions outlined below:

Approval conditions

1. The approval is based on the information given within the application and the work will be conducted in line with this. It is the responsibility of the applicant to ensure all relevant external and internal regulations, policies and legislations are met.
2. This project may be subject to periodic review by the committee. The approval may be suspended or revoked at any time if there has been a breach of conditions.
3. Any substantial amendments to the approved proposal will be submitted to the ethics committee prior to implementing any such changes.

Specific conditions in respect of this application:

The application has been classified as Low risk to the University.

No additional conditions.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees. It complies with [the guidelines of UKRI](#) and the concordat to support [Research Integrity](#).

Science and Engineering Research and Ethics Chair

Swansea University.

If you have any query regarding this notification, then please contact your research ethics administrator for the faculty.

- For Science and Engineering contact FSE-Ethics@swansea.ac.uk
- For Medicine, Health and Life Science contact FMHLS-Ethics@swansea.ac.uk
- For Humanities and Social Sciences contact FHSS-Ethics@swansea.ac.uk

Table of Contents

| | |
|---|-------------------------------------|
| Summary | Error! Bookmark not defined. |
| Declarations | 3 |
| MRes Biosciences - Statement of Expenditure | 4 |
| Statement of Contributions | 5 |
| Ethics Approval | 6 |
| Acknowledgements | 9 |
| List of Tables and Figures | 10 |
| Definitions or Abbreviations | 11 |
| 1 Introduction | 12 |
| 1.1 Hyperoceanic Bryophytes | 12 |
| 1.2 Drivers of Current Bryophyte Distribution | 13 |
| 2 Methodology | 16 |
| 2.1 Study Area | 16 |
| 2.2 Epiphyte Surface and Environmental Data | 19 |
| 2.2.1 Environmental Data..... | 19 |
| 2.2.2 Tree Vegetation Data..... | 20 |
| 2.3 Field Sampling | 20 |
| 2.3.1 Proxy Measures of Environmental Variables..... | 20 |
| 2.4 Statistical Analysis | 20 |
| 2.4.1 Analysis of Environmental Conditions at the Study Sites | 21 |
| 2.4.2 Species Distribution Modelling..... | 22 |
| 3 Results | 25 |
| 3.1 Field Observations | 25 |
| 3.2 Environmental Conditions | 25 |
| 3.2.1 Drivers of Bryophyte Richness | 25 |
| 3.2.2 Ellenberg Environmental Values..... | 26 |
| 3.2.3 Associations with Environmental Variables | 28 |
| 3.3 Model Predictions | 31 |
| 3.3.1 Predicted Current Distributions within the UK..... | 31 |
| 3.3.2 Predicted Future Distributions within the UK..... | 33 |
| 4 Discussion | 35 |
| 4.2 Field Observations | 35 |
| 4.3 Environmental Conditions | 35 |
| 4.4 Hyperoceanic Bryophyte Distribution | 36 |
| 4.4.1 Proxy Measures of Environmental Conditions | 37 |

| | |
|--|-----|
| 4.5 Species Distribution Models | 38 |
| 4.5.1 Current Distribution of Hyperoceanic Bryophytes | 38 |
| 4.5.2 Future Distribution of Hyperoceanic Bryophytes | 39 |
| 4.5.3 Biodiversity Implications | 40 |
| 4.6 Future Studies | 40 |
| 4.7 Limitations | 41 |
| 5 Conclusion | 42 |
| References | 44 |
| Appendix | 54 |
| Appendix 1: Current Distribution SDM R Code | 54 |
| Appendix 2: Future Distribution SDM R Code | 71 |
| Appendix 3: Swansea University Science Fieldwork Risk Assessment | 85 |
| Appendix 4: Lost Peatlands Risk Assessments | 92 |
| Appendix 5: Project Background | 160 |
| Appendix 6: Model Mean Performance | 161 |
| Appendix 7: Significant differences between sites | 162 |
| Appendix 8: Environmental Variables | 163 |
| Appendix 9: Field Observations | 166 |

Acknowledgements

To the supervisors of this project Dr Penny Neyland & Dr Miguel Lurgi Rivera for their supervision and assistance throughout the project.

To Joey Pickard and members at Natural Resources Wales (NRW) for assistance during the initial site visits, providing access to land and assistance in identifying species.

To Sam Bosanquet and Des Callaghan for providing help with understanding the niche of hyperoceanic bryophytes and for providing access to full journal articles and privately held records of hyperoceanic bryophytes within Wales.

To Catrin Thorne for her continued support throughout this project.

Special thanks is given to both Charles Hipkin and Hilary Hipkin for their invaluable assistance with hyperoceanic bryophyte identification and providing a vast collection of previous records of hyperoceanic bryophytes that proved to be indispensable to this study.

List of Tables and Figures

| | |
|---|----|
| <i>Figure 1: Study site locations in South Wales relative to the United Kingdom.</i> | 16 |
| <i>Figure 2: Relationship between bryophyte species richness and humidity.</i> | 24 |
| <i>Figure 3: PCA biplot of 52 samples using proxy environmental data (Ellenberg indicator values)</i> | 26 |
| <i>Figure 4: CCA biplot of 13 species in relation to environmental variables.</i> | 27 |
| <i>Figure 5: CCA biplot of 52 samples in relation to environmental variables.</i> | 28 |
| <i>Figure 6: Current distribution of nine hyperoceanic bryophytes within the UK.</i> | 30 |
| <i>Figure 7: Future distribution of nine hyperoceanic bryophytes within the UK.</i> | 32 |

Definitions or Abbreviations

AUC – Area Under the Curve

BRT – Boosted Regression Tree

CCA - Canonical Correspondence Analysis

GHG- Greenhouse Gases

GLM – Generalized Linear Model

GPS – Global Positioning System

IPCC – Intergovernmental Panel on Climate Change

IUCN – International Union for Conservation of Nature

MARS – Multivariate Adaptive Regression Spline

NBN – National Biodiversity Network

ONS – Office of National Statistics

PCA – Principal Component Analysis

RCP – Representative Concentration Pathway

RF – Random Forest

RH – Relative Humidity

SDM – Species Distribution Model

SSP3 – Shared Socio-Economic Pathway 3

SVM – Support Vector Machine

1 Introduction

Globally, species are undergoing significant shifts in distribution due to climate change and anthropogenic pressure resulting from land use change, habitat alteration or overexploitation (Perry *et al.*, 2005; Gillings, Balmer & Fuller, 2014). As the climate warms, species tend to move poleward or to higher altitudes to remain within their specific temperature tolerances (Chen *et al.*, 2011; VanDerWal *et al.*, 2013). Some species that may not have the plasticity required to adapt to a changing climate at pace with other species may not be able to track climate change adequately and as such are at risk of climate change induced extinction (Wieczynski *et al.*, 2018; Qian *et al.*, 2022).

One group of species that are undergoing significant distribution shifts and in some cases may not be able to keep up with current environmental change are bryophytes including those found within oceanic and hyperoceanic mountainous regions (Hodd, Bourke & Skeffington, 2014; Zanatta *et al.*, 2020). This is despite that the current bryophyte abundance and distribution pattern is largely due to their capacity to disperse rapidly and over large geographical distances (Laaka-Lindberg, Korpelainen & Pohjamo, 2003; Patiño & Vanderpoorten, 2018). This may be due in part to the projected fast rate of climate change and the rate at which colonisation of new habitats occur with only 30% of bryophyte species predicted to successfully colonise new suitable environments by 2050 (Zanatta *et al.*, 2020).

Bryophytes are an often overlooked yet key component of many biological systems from ancient woodlands to grasslands and often provide ecosystem services including carbon sequestration, nutrient cycling and as bioindicators of air quality and climatic conditions (Turetsky, 2003; Benitez, Armijos & Calva, 2021; Ruklani, Rubasinghe & Jayasuriya, 2021; Corinna *et al.*, 2022; Lyons, Turner & Ashton, 2022). In many of these habitats they are usually a pioneer species that colonises soils or rocky substrate. This allows other plant species to establish over time (Duncan & Dalton, 2013).

1.1 Hyperoceanic Bryophytes

One area in which bryophytes are rarely considered are non-native conifer forest plantations, such as Sitka spruce (*Picea sitchensis*) plantations, which can provide a highly biodiverse ecosystem of sometimes endemic bryophytes prior to harvesting (Köster *et al.*, 2012; Tullus *et al.*, 2012). Within the UK, forest plantations make up 6.6% of the total land cover and (51%) of the UK woodland area in 2019 (ONS, 2023) and within these areas bryophytes with specific niche requirements may inhabit rocky and dry surfaces. Conversely some species occur epiphytically on biotic surfaces such as the bark of trees or other plant surfaces and can be distributed under a range of variables such as pH tree bark, nutrient content, and moisture of the tree bark, humidity in the local climate and exposure to sunlight (Spicer & Woods, 2022).

Hyperoceanic climates correlate with areas of high humidity and as a result, hyperoceanic bryophytes are generally restricted in their distribution by climate to regions of high moisture (Hill & Preston, 1998; Hill & Preston, 2013; Pescott & Preston, 2014). On average relative humidity is highest along the western coastline of the UK during Autumn and Winter with 82-85% RH and 85-88% RH respectively. During warmer months, the trend continues with the West UK seeing higher relative humidity at approximately 79-82% RH during both Summer and Spring (Jenkins, Perry & Prior, 2009).

1.2 Drivers of Current Bryophyte Distribution

Across UK, hyperoceanic bryophytes are more abundant in Western regions including South and West Wales, West Ireland, North West and South West England and West Scotland where they are predominantly located (Blockeel *et al.*, 2014; Bosanquet, 2015; Callaghan, 2020).

In order to protect species that are at risk from climate change and anthropogenic disturbance an understanding of drivers of their distribution patterns is required (Thuiller *et al.*, 2008; Ehrlén & Morris, 2015). Desiccation due to a lack of rainfall may also be a driver of hyperoceanic bryophyte distribution within the UK as areas of highest bryophyte distribution such as in west Scotland that encounter the highest mean annual rainfall across the UK at 2200-4700 mm on average per year compared to approximately 400-1300 mm on average per year in Eastern Scotland. (Met Office, 2013; Pescott & Preston, 2014). These areas can be defined having an oceanic climate as per Amann's index of hygromy (Smith, 1950; Ellis, 2016).

Air pollution has significantly reduced since the late 20th century especially in locations with known records of hyperoceanic bryophytes and may have resulted in an increased distribution of hyperoceanic bryophytes (Gilbert, 1968; Larsen *et al.*, 2007; Carnell *et al.*, 2019; Vohra *et al.*, 2021; Amy & Prescott, 2023). It has been widely shown that polluting compounds that are commonly formed as a byproduct of combustion vehicles such as sulphur dioxide (SO₂) or nitrogen oxides (NO_x) can result in a reduction in bryophyte presence (LeBlanc & Rao, 1973; Bell, Ashenden & Rafarel, 1992). It is suggested that this is due to a phytotoxic effect of the concentration of pollutants (Davies *et al.*, 2007). Given that hyperoceanic bryophytes are highly sensitive to air pollutants, an increase in air quality through a reduction in polluting compounds has resulted in an increase in the distribution and abundance of hyperoceanic bryophytes within the UK (Pescott *et al.*, 2015).

As non-vascular plants, bryophytes derive water intake from humid air, therefore humidity is a driver of their distribution (Wood, 2007; Batke *et al.*, 2015). Due to their reliance on humidity, bryophytes can be used as a proxy indicator for humidity within forests by using epiphytic bryophyte cover (Karger *et al.*, 2012; Batke *et al.*, 2015). Some species may not recover from desiccation that occurs during dry seasons, further showing the importance of humidity as a potential driver of current bryophyte distribution within

wetter regions of the UK (García *et al.*, 2016). Hyperoceanic bryophytes are highly sensitive to desiccation due to decreasing humidity and as a result are restricted to high humidity zones within the UK (Ratcliffe, 1968; Pardow & Lakatos, 2012).

Hyperoceanic bryophytes are currently distributed within forests and along substrates such as rocky surfaces or as tree epiphytes. They are often located under canopy cover or under cover from other vegetation which leads to frost resilience during winter giving rise to their current distribution patterns primarily within covered forests and plantations but can also be located along forest track edges (Ratcliffe, 1968; Bosanquet, 2004; Averis, 2009; Coote *et al.*, 2009; Hill & Preston, 2013; Hassel *et al.*, 2014; Bosanquet, Genny & Cox, 2018; Vitt, Finnegan & House, 2019).

Hyperoceanic bryophytes may respond better to climate change than bryophytes despite limited dispersal capacity since they are already distributed in wetter and cooler microclimates of the UK and thus changes in humidity, temperature and annual rainfall at a regional level may not significantly impact hyperoceanic species assemblages (Preston, Harrower & Hill, 2013; Hodd, Bourke & Skeffington, 2014; Hill & Preston, 2015).

Understanding the current and future distributions of species, may allow for species to be translocated to other areas with a similar set of environmental parameters (Barlow *et al.*, 2021). This can be particularly useful for species in threatened areas that undergo significant disturbance such as forestry plantations in which hyperoceanic bryophytes that are epiphytic on willows (*Salix* sp.) and Sitka spruce (*Picea sitchensis*) are often overlooked as the host tree is either harvested as a crop (Sitka spruce) or damaged by regular vehicle movement along forestry tracks (*Salix* sp.) (Hipkin pers.comm.).

Given that a large number of hyperoceanic bryophytes are epiphytic to Sitka spruce (*P. sitchensis*), loss of biodiversity via habitat alteration may be prevalent (Acton & Rothero, 2010). In addition to this, new roads / forestry tracks are often created within these habitats in order to provide access for industrial vehicles used during the removal of felled trees. During this process, trees are cleared along the roadways posing further risk as large vehicles often displace trees when turning and causing disturbance for any epiphytic hyperoceanic bryophytes.

The aim of this study was to understand the current and future distribution of selected hyperoceanic bryophytes within Wales and the drivers behind these distributional patterns. These selected species will be those identified within Sitka spruce (*Picea sitchensis*) plantations in South Wales including Irish daltonia (*Daltonia splachnoides*), Fingered cowwort (*Colura calyptrifolia*) and Pearl pouncewort (*Lejeunea patens*).

We hypothesize that in areas of high humidity, a higher proportion of hyperoceanic bryophytes may be present within non-native conifer plantations in south Wales.. We also hypothesize that by utilising predictive species distribution modelling methods and UK wide climate data, current distributions of hyperoceanic bryophytes will correlate with areas of high humidity within the UK and that under future climate change scenarios the distribution of bryophytes will see a Northern movement in order to remain within their preferred climatic niche range, including factors such as humidity, temperature and rainfall.

To test these hypotheses we sampled the community composition of epiphytic bryophytes in three temperate forest plantations in South Wales known to be inhabited by hyperoceanic bryophytes. We also sampled the local climatic conditions at each sample. We also utilise a series species distribution models utilising current bioclimatic data to predict the current potential distribution of nine hyperoceanic bryophytes across the UK. These include six currently threatened species, under the IUCN Red List and three priority hyperoceanic bryophyte species (González, 2019; Hodgetts *et al.*, 2019; Sabovljevic *et al.*, 2019; Sim-Sim *et al.*, 2019). These currently threatened species include, Wilson's pouchwort (*Acrobolbus wilsonii*), Atlantic pouncewort (*Lejeunea mandonii*), Hooked veilwort (*Metzgeria leptoneura*), Carrington's scalewort (*Radula carringtonii*), Holt's scalewort (*R. holtii*) and Pale scalewort (*R. voluta*). The priority species include aforementioned *D. splachnoides*, *C. calyptrifolia* and *L. patens*.

We also utilised projected climatic data in which average surface temperature is approximately 2.8 °C to predict the distribution of these nine hyperoceanic bryophytes across the UK between 2081 and 2100. This timeframe was chosen as previous studies have investigated the short term impacts of climate change on hyperoceanic bryophytes, whereas few studies have been conducted which look at the long term outcomes of climatic alterations on the distribution of hyperoceanic bryophytes within the UK.

2 Methodology

2.1 Study Area

The study areas were located around South Wales at three separate locations. Rheola forest, Glynorrwg forest / the Afan Valley Forest and Pen y Cymoedd wind farm and are located at 51.733441, -3.663236, 51.661306, -3.670111 and 51.710870, -3.562223, respectively (Figure 1). Field data was collected between the 21st of February and the 7th of August 2023.

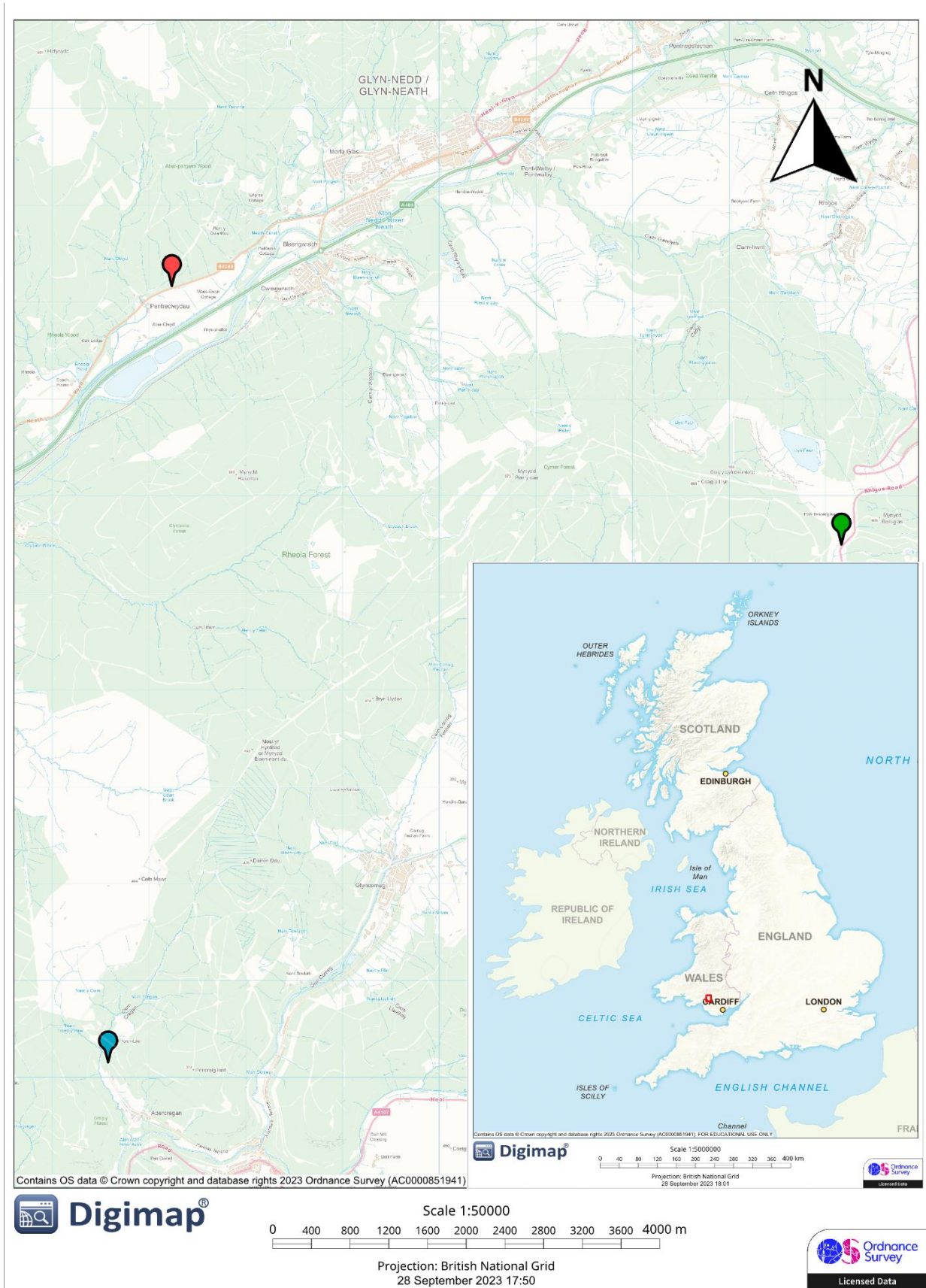


Figure 1: Locations of the study sites within South Wales relative to the United Kingdom. Blue marker – Glyncoed forest; Red marker – Rheola Forest; Green marker – Pen-y-Cymoedd wind farm.

The areas were chosen based on previous reports of hyperoceanic bryophytes being identified in the areas. These comprised of reports that had been sent to local authorities and from publicly available databases of identified species through British Bryological Society's records within NBN atlas (Bosanquet, 2004; Bosanquet, 2015). In addition to this, all of these sites fell within the defined range of a hyperoceanic climate based on Amann's hygothermy index value of 150 to 200+ (Ellis, 2016). Amann's hygothermy index is a measure of how oceanic a climate is and is based on the mean annual precipitation, temperature, and the mean temperature of both the warmest and coldest month (Amann, 1929). This was found by utilising a map created as part of the Lost Rainforests of Britain project (Lost Rainforests of Britain, 2021).

The annual climate between each of the three study sites is similar with each of the sites having the maximum mean annual temperature of 17.5 °C in July and a minimum mean annual temperature of approximately 1.5 °C during February. Wind speed ranges from 4.69 ms⁻¹ to 6.69 ms⁻¹. Furthermore all three areas experience the highest level of precipitation in November with an approximate average rainfall of 94 mm with April having the lowest precipitation at an approximate average rainfall of 46 mm. Climatic conditions at the sites was sourced from the Weather Spark data service (<https://weatherspark.com/compare/y/37815~37814~37826/Comparison-of-the-Average-Weather-in-Glyncorwg-Glyn-neath-and-Crynant>).

All of the study sites are areas of large conifer plantations at various growth stages with Sitka spruce (*Picea sitchensis*) being the primary planted tree and the most dominant species in each area. However, willows (*Salix* spp.) appear at the edge of the forest and along the border of tracks that run through the forest.

Pen-y-Cymoedd and Glyncorwg forest are part of the Lost Peatlands project which is aimed at the restoration of 250 hectares (ha) of peatlands in Neath Port Talbot which have been drained and afforested to be used as plantations, significantly altering the community assemblages (<https://www.npt.gov.uk/lostpeatlands>). Once restored, these peatlands should consist of *Sphagnum* sp., round leaved sundew (*Drosera rotundifolia*) and hare's-tail cottongrass (*Eriophorum cespitosum*) (Littlewood *et al.*, 2010).

However, the afforestation activities that are common in these sites have led to habitat disturbance and destruction within the forest, particularly along tracks often used by large transport vehicles resulting in anthropogenic disturbance to the trees that line the track edges through damaged and fallen trees.

2.2 Epiphyte Surface and Environmental Data

After identifying the three study sites, trees at each site were randomly selected along transects of the plantation forest tracks and up to approximately 3 m inside of the canopy from the track. Each tree was treated as a separate sample and was identified down to species level where possible. Additionally, to test the hypothesis that hyperoceanic presence is predicted by humidity, samples that did not support hyperoceanic epiphytes were also recorded to be used as a control. At each sample, local climatic variables were recorded.

2.2.1 Environmental Data

For the local climatic variables, four variables were considered including: temperature (°C), relative humidity (% RH), wind speed (ms^{-1}) and Zeta (the ratio of red light to far red light). These variables were recorded once per sample at the time of sampling and species identification. This sampling period was conducted between February to August 2023. Red to far red light was recorded to determine the impact that shade had on the distribution of hyperoceanic bryophytes in high light exposed areas and lower light covered areas under the canopy. Temperature and humidity were both recorded at each sample using a handheld Hygro-Thermo – Pen-shaped pocket hygrometer (ETI Ltd). However, this only provided a point in time and does not provide long term data which may vary temporally.

Therefore, to avoid this issue, this data was then supplemented by placing three TinyTag2 dataloggers to record minimum, maximum and actual relative humidity (% RH) and minimum, maximum and actual temperature (°C). One datalogger was placed at each of the three sites to collect data over a longer period of time for later analysis upon retrieval. Each TinyTag2 datalogger was placed for a minimum of 2 weeks up to a maximum of 1.5 months. The dataloggers were set up on the 20th of May (Rheola Forest), 16th of July (Glyncoirwg forest) and 18th of July (Pen-y-Cymoedd wind farm). These recorded the temperature and relative humidity every 12 hours until the device was either stopped or was at full memory capacity. To quantify shade, the ratio of red to far red light was measured, using Red (660 nm) / Far-Red (730 nm) Sensor (Skye Instruments) with the range set to 0-2.000 $\mu \text{mol s}^{-1} \text{m}^{-2}$. Finally, to gather wind speed *in situ* a ClimeMET Handheld Wind Meter (Model CM2030) was utilised.

Field data on climatic variables was then supplemented with additional climatic data that had been gathered from public sources for use with developing and testing the SDM including annual temperature (°C * 10), precipitation (mm) or diurnal range (°C * 10) which are included along with other variables as part of the WorldClim data set (Hijmans *et al.*, 2005; Fick & Hijmans, 2017).

2.2.2 Tree Vegetation Data

Variables regarding tree attributes were also collected and included the diameter at breast height (cm) and the height of the tree (m). The diameter was measured at approximately 1.37 m from the base of the tree. If the tree had forked into two or more trunks below this height then each trunk was measured and combined for a total diameter but still remained as one individual sample.

2.3 Field Sampling

Prior to species identification, a master species list was created to act as a reference guide for any species located in each of the three study sites. The species within this list were not just hyperoceanic epiphytes but also associates that grow in similar conditions to hyperoceanic bryophytes such as *Lejeunea patens* being a close associate of *Daltonia splachnoides* (Blockeel *et al.*, 2014). This was used as some hyperoceanic associated species were more easily identifiable and thus may provide aid in identification of hyperoceanic epiphytes on the same sample. Additionally, records of hyperoceanic bryophyte presence within South Wales forestry plantations were also retrieved from public databases and privately held sources from Charles & Hilary Hipkin (Hipkin, pers. com) and Sam Bosanquet (Bosanquet pers.comm; GBIF.org, 2023).

Field sampling was conducted between February and August of 2023 for a total of 52 samples across each of the three sites with subsequent visits occurring post June 2023 to access and collect the dataloggers for use with the analysis. Both hyperoceanic bryophytes and non-hyperoceanic bryophytes present on each tree sample were identified to species level using a hand lens (x20) (Atherton *et al.* 2010).

2.3.1 Proxy Measures of Environmental Variables

Ellenberg Indicator Values specifically for bryophytes, were obtained from BRYOATT provided a proxy measure of the environmental conditions at each sample (Hill *et al.*, 2007). These variables included, light (L), moisture (F), salt tolerance (S), heavy-metal tolerance (HM), reaction (R; representing pH tolerances) and nitrogen (N).

2.4 Statistical Analysis

2.4.1 Data Exploration

Each site was plotted using DIGIMAP (Edina.ac.uk) online geographical plotting software to visualise the distribution of the three sites (Figure 1). Furthermore species occurrence data gathered from public databases and private records required sorting and removal of duplicates as not all datasets followed a standardised format resulting in overlapped in some areas. This was done to ensure no formatting or

analytical issues when conducting any part of the analysis including pseudo-replication. In addition any datapoints that fell outside of the defined geographical range for the project or that were errors were removed.

2.4.2 Analysis of Environmental Conditions at the Study Sites

Environmental variables of each site were analysed to determine microclimatic differences in addition to relationships between the presence of hyperoceanic bryophytes and bioclimatic variables such as humidity. Species richness of bryophytes was also plotted to determine basic relationships between species richness and environmental variables, the presence of hyperoceanic bryophytes or biotic factors. Ellenberg indicator values were also analysed to visualise the environmental conditions of the sample sites.

Differences in environmental conditions, bryophyte species richness and biotic variables between the three sample sites were assessed using one-way analysis of variance (ANOVA) tests as it would allow for testing of significant differences between the three sites. The model assumption is that the data is normally distributed, however is fairly robust if the data is not normally distributed. Differences in climatic conditions derived from the dataloggers between the three sample sites was then assessed, similarly using ANOVA.

Bryophyte species richness was quantified to determine if any environmental variables were drivers of bryophyte species richness. To achieve this, the number of bryophyte species per sample (individual tree) were analysed against the recorded environmental variables. This was analysed using a generalized linear model using Poisson regression. Hyperoceanic bryophyte presence was also tested to determine if any of the environmental variables had a significant effect on driving hyperoceanic bryophyte presence. Both of these tests used a generalized linear model using a binomial family. To implement the binomial model for analysing the hyperoceanic bryophyte presence, the presence or absence of any hyperoceanic bryophyte species for a given sample was coded as a 1 or 0 respectively. Differences in mean environmental conditions across the three sites, using Ellenberg indicator values was assessed using ANOVA. Principal component analysis was used to reduce the dimensionality of variability of the mean Ellenberg indicator values for each sample using the ggcorrplot package version 0.1.4, the FactoMineR package version 2.8 and the factoextra package version 1.0.7 (Sebastien, Julie & Francois, 2008; Kassambara & Mundt, 2020; Kassambara, 2022). The results from this were then plotted to determine the distribution of samples in relation Ellenberg indicator values to gain an understanding of the environmental conditions of the sites. All previous analysis was conducted within R studio, utilising R version 4.2.2 (Posit team, 2023).

Bryophytes identified during the study were then assessed on their relation to proxy measures of environmental variables using Canonical correspondence analysis (CCA). This provided an overview of the pattern of distribution of species in relation to environmental variables to explain any relation between

species and environmental variables. Similar analysis was conducted to analyse the distribution of samples in relation to environmental conditions using direct ordination to show the environmental conditions at each sample and how they may relate to each other (Cajo, 1986). These methods were conducted within ECOM version 2.1, 2007, Pisces Conservation Ltd. Lymington, UK (www.pisces-conservation.com).

2.4.3 Species Distribution Modelling

The Global Biodiversity Information Facility (GBIF) was used to gather public records of presence only data of each of the nine species. Using species occurrence data gathered from GBIF, we created a series of SDMs. The model that was fitted, used species occurrence data in downloaded from public database GBIF, in addition to climatic data whereby presence and absence data for the target hyperoceanic bryophyte species were included. This differs from other models which may only use species presence data and by including absence data allow for the removal of any bias of presence only data (Brotons *et al.*, 2004; Kent & Carmel, 2011).

Different SDMs were fit to each species dataset for the species recorded during field sampling species which included *Daltonia splachnoides*, *Colura calyptrifolia* and *Lejeunea* with the addition of six species categorised as vulnerable to near threatened according to the IUCN Red List including Wilson’s pouchwort (*Acrobolbus wilsonii*), Atlantic pouncewort (*Lejeunea mandonii*), Hooked veilwort (*Metzgeria leptoneura*), Carrington’s scalewort (*Radula carringtonii*), Holt’s scalewort (*R. holtii*) and Pale scalewort (*R. voluta*) (Table 1).

Table 2: Revised list of currently vulnerable and near threatened hyperoceanic bryophytes according to the IUCN Red List (González, 2019; Hodgetts *et al.*, 2019; Sabovljevic *et al.*, 2019; Sim-Sim *et al.*, 2019).

| Species Name | IUCN Red List Category |
|-----------------------------|------------------------|
| <i>Acrobolbus wilsonii</i> | VULNERABLE |
| <i>Lejeunea mandonii</i> | VULNERABLE |
| <i>Metzgeria leptoneura</i> | VULNERABLE |
| <i>Radula carringtonii</i> | NEAR THREATENED |
| <i>Radula holtii</i> | NEAR THREATENED |
| <i>Radula voluta</i> | NEAR THREATENED |

The species occurrence data from GBIF was downloaded through the dismo package version 1.3-9 within R. A total of 22,452 records of global presence data across all nine species were thus obtained (Hijmans *et al.*, 2022). Any records within these that did not contain spatial data (longitude and latitude) were

removed as they were not able to be plotted, reducing the total number of occurrence records to 19,543 across all nine species.

Worldclim data which consists of global weather and climate data was overlaid over the public presence records for each of the hyperoceanic bryophyte species to determine their current potential location suitability. Using the raster package within R, worldclim data at a 2.5-minute spatial resolution was imported (Hijmans *et al.*, 2005; Hijmans, 2022). This provided global data with historical global average climatic data for a total of 19 bioclimatic variables derived from data taken between 1970-2000 (Fick & Hijmans, 2017). The global data was then cropped to only include values correlating with coordinates in the UK. By doing this, we could reduce the size of the data being modelled, which results in significantly optimised output time. The values of temperature variables is stored as °C * 10 to allow for smaller file sizes and thus, temperature values were returned to °C. Additionally, we also tested the worldclim dataset for multicollinearity and removed any variables that are highly correlated. The occurrence records of each species were then plotted against the worldclim data of the remaining current bioclimatic variables. These cropped climatic variables used in the SDM include, mean diurnal range, isothermality, temperature seasonality, mean temperature of the wettest quarter, mean temperature of the driest quarter, mean temperature of the warmest quarter, precipitation of the wettest and driest month, precipitation seasonality and the precipitation of the warmest and coldest quarter.

We fit SDMs relating species occurrences to environmental variables. We used the SDM function from the package SDM version 1.1-8 in R and fit five different models including: generalized linear model (GLM), support vector machine (SVM), random forests (RF), boosted regression trees (BRT) and multivariate adaptive regression spline (MARS). Each model 10 replications using bootstrapping methods. The results were then combined using the ensemble function which combined the results of the weighted average AUC (area under the curve) scores. AUC is a method in which the overall accuracy of a model is summarized based on a scale of 0 to 1 in which values closer to 1 indicate better model performance and values closer to 0 worse model performance. AUC Scores of >0.8 can be interpreted as very good model performance (Bradley, 1997; Mandrekar, 2010). This allowed us to obtain location suitability maps of the hyperoceanic bryophytes studies based on current climatic conditions (Guisan, Weiss & Weiss, 1999; Guisan & Thuiller, 2005). This procedure was repeated independently for each of the hyperoceanic bryophyte studied.

To investigate the potential effects of future climate change on the distribution of these species, we used future predicted climatic for the years 2081-2100 and used the fitted SDMs to predict potential future distributions based on this data. This was done using shared socioeconomic pathway 370 (SSP3) also known as regional rivalry. Under this scenario, national policies become focussed on national security rather than international cooperation. Environmental issues are not addressed resulting in a severe decline

in biodiversity and environmental security and little climate change mitigation policies (van Vuuren *et al.*, 2014; Riahi *et al.*, 2017). This scenario also correlates to the 2100 radiative forcing level (watts per m²) of 7 W / m² which is the measure of the difference in energy flux derived from the difference in energy entering the atmosphere versus energy leaving the atmosphere (Forster, 2003; Enting, 2018). This scenario was utilised as it would allow for the prediction of hyperoceanic bryophyte distribution under the near highest level of abiotic stress as a result of high greenhouse gas (GHG) emissions (IPCC, 2023). The target of keeping global average temperatures under 1.5 °C compared to preindustrial temperature remains achievable if adequate climate mitigation takes place, however it is becoming more likely that global average temperatures will pass this goal and thus higher temperature scenarios should be considered (Marcucci *et al.*, 2019; Cointe & Guillemot, 2023; Gambhir *et al.*, 2023). It has been predicted that under SSP3 the global surface temperature is likely to be approximately 2.8 °C between 2081 and 2100 (IPCC, 2021). This data was downloaded into R studio, using the geodata package version 0.5-8 (Hijmans *et al.*, 2023). The same methodology to predict possible current locations was used to predict possible future location of the nine species under SSP3 including the download of species presence records for the nine species from the GBIF public database and the use of the worldclim data within R.

3 Results

3.1 Field Observations

A total of 13 epiphytic bryophytes were identified from 52 individual trees across the three study sites. Of these, 37 individual trees (71%) were native willow (*Salix* sp.) trees, 12 (23%) were the plantation crop, Sitka Spruce (*Picea sitchensis*), with the remaining three samples (6%), other native broad-leaved trees. Of the 13 species identified, a total of 109 individuals were recorded. Of these individual records, the majority were identified in Rheola Forest with a total of 64 individuals (59%) being recorded. This was followed by Pen-y-Cymoedd wind farm with 31 individuals (28%) and Glyncorrwg forest with 14 individuals (13%).

The most abundant bryophyte species sampled was *Daltonia splachnoides* which was identified on 22 (39%) of the 52 individual trees and was most abundant in Rheola Forest with 77% of the individual trees, hosted *D. splachnoides*. In addition to *D. splachnoides*, a further two hyperoceanic bryophytes were identified across the three areas which included *Colura calyptrifolia* and *Lejeunea patens*.

Hyperoceanic bryophytes were most abundant within Rheola Forest with 77% of total samples from Rheola Forest (N = 22) containing at least one species of hyperoceanic bryophyte whereas Glyncorrwg forest had the lowest proportion of hyperoceanic bryophytes present with 40% of the total samples containing at least one hyperoceanic bryophyte.

Of the three hyperoceanic bryophytes identified during the field sampling portion of this study, two were exclusive to certain tree species. These include *D. splachnoides* which was exclusively identified on native Willow (*Salix* sp.) and *Lejeunea patens* which was exclusively identified as an epiphyte on Sitka spruce (*Picea sitchensis*). The third hyperoceanic bryophyte, *Colura calyptrifolia* was not exclusive to any tree species. Additionally, three species were exclusively sampled within Pen-y-Cymoedd wind farm. These include *Aulacomnium palustre* (N = 1), *Lejeunea patens* (N = 2) and *Racomitrium lanuginosum* (N = 1).

3.2 Environmental Conditions

3.2.1 Drivers of Bryophyte Richness

Results indicate that relative humidity is the main driver of bryophyte species richness out of all of the recorded environmental variables ($F_{39} = 6.712$, $p < 0.05$). Further to this there is evidence that points a significant positive relationship occurring between relative humidity recorded with a hygrometer and epiphytic bryophyte species richness ($R^2 = 0.28$, $F = 18.74$, $df = 48$, $p < 0.001$) (Figure 2). There is also an observed significant negative relationship between epiphytic hyperoceanic bryophyte presence and

wind speed ($z = -2.86, p < 0.01$) and a significant positive relationship between epiphytic hyperoceanic bryophyte presence and relative humidity ($z = 2.67, p < 0.01$). Additionally, results also indicate that the presence of hyperoceanic bryophytes is driven by both relative humidity ($z = 3.09, p < 0.05$) and temperature ($z = 2.63, p < 0.01$) (refer to appendix 8, figure 2).

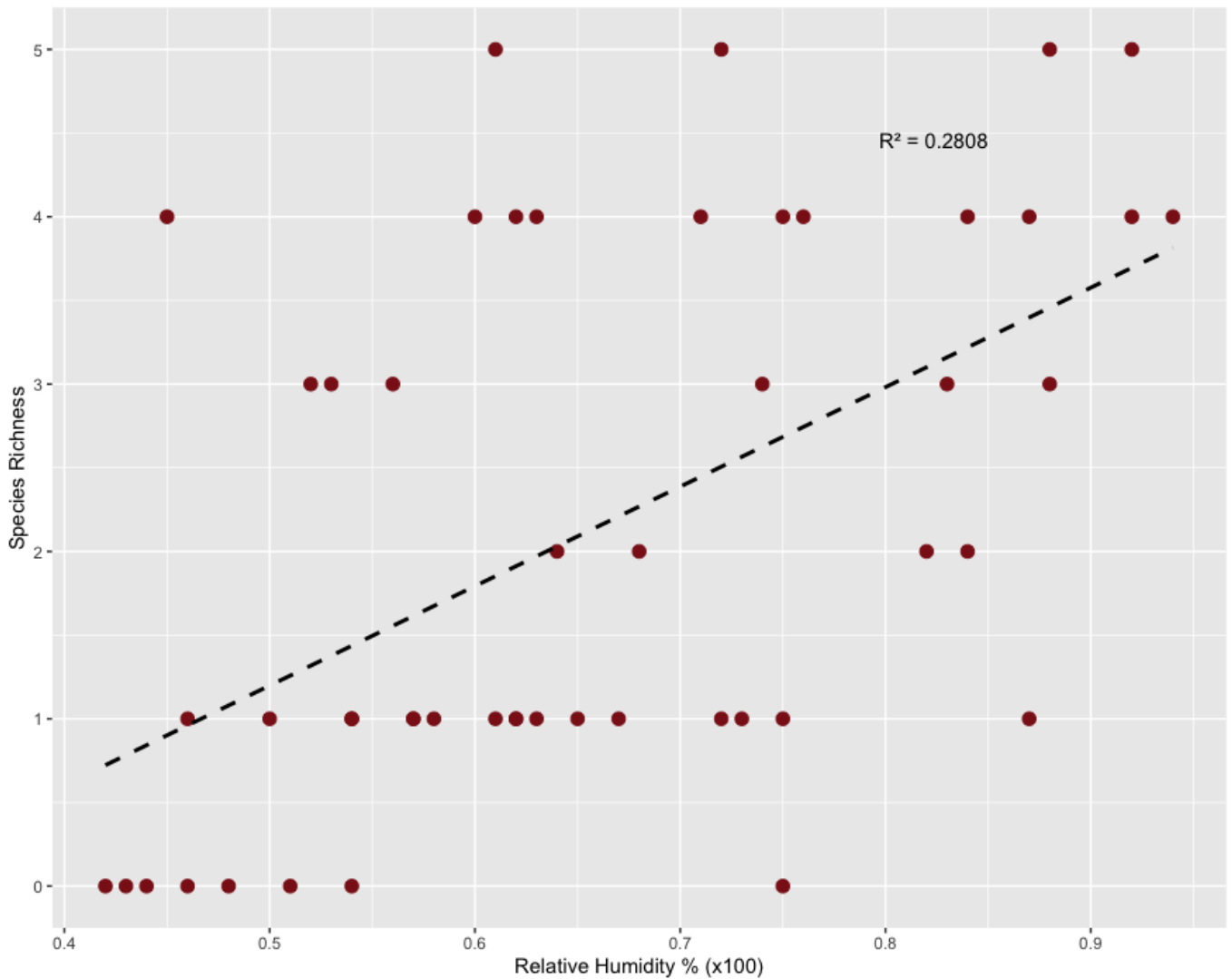


Figure 2: The relationship between relative humidity (RH %) and bryophyte species richness within sitka spruce plantations in South Wales. Relative humidity (RH %) was recorded at each sample along with species richness of epiphytic bryophytes present. Dashed black line represents results derived from a linear model. The dashed black line is significant at $P < 0.001$. $R^2 = 0.28$

3.2.2 Ellenberg Environmental Values

Ellenberg Reaction (R) was statistically significantly different between sites ($F_{(2,41)} = 10.45, p < 0.001$). Pen-y-Cymoedd wind farm was significantly lower (i.e. more acidic) in mean reaction value to both Glyncorrwg forest ($p < 0.001$) and Rheola Forest (< 0.001).

Reaction, nitrogen and heavy metal tolerance Ellenberg indicator values of the epiphytic bryophytes were positively correlated with light requirements. Salt tolerance and nitrogen requirements were also highly positively correlated. Moisture was negatively correlated with all other Ellenberg indicator values. Moisture and nitrogen specifically were highly negatively correlated. Heavy metal tolerance and reaction are also negatively correlated.

Results from the PCA suggest that moisture was positively associated with principal component 1 and 2 whereas all other Ellenberg indicator values are negatively associated with principal component 1 and thus PC1 can be defined by moisture (Figure 3). Principal component 2 may be explained by reaction and light, both of which are positively associated with PC2 with the remaining Ellenberg indicator value of nitrogen being negatively associated with both PC1 and PC2. Glyncorwg forest samples were not highly influenced by environmental conditions as seen due to the central clustering. However, samples from Rheola Forest were mainly determined through moisture and nitrogen along PC1. Samples from Pen-y-Cymoedd wind farm were influenced mainly by light and moisture, however most samples from Pen-y-Cymoedd were not influenced by Ellenberg indicator values of environmental conditions (Figure 3).

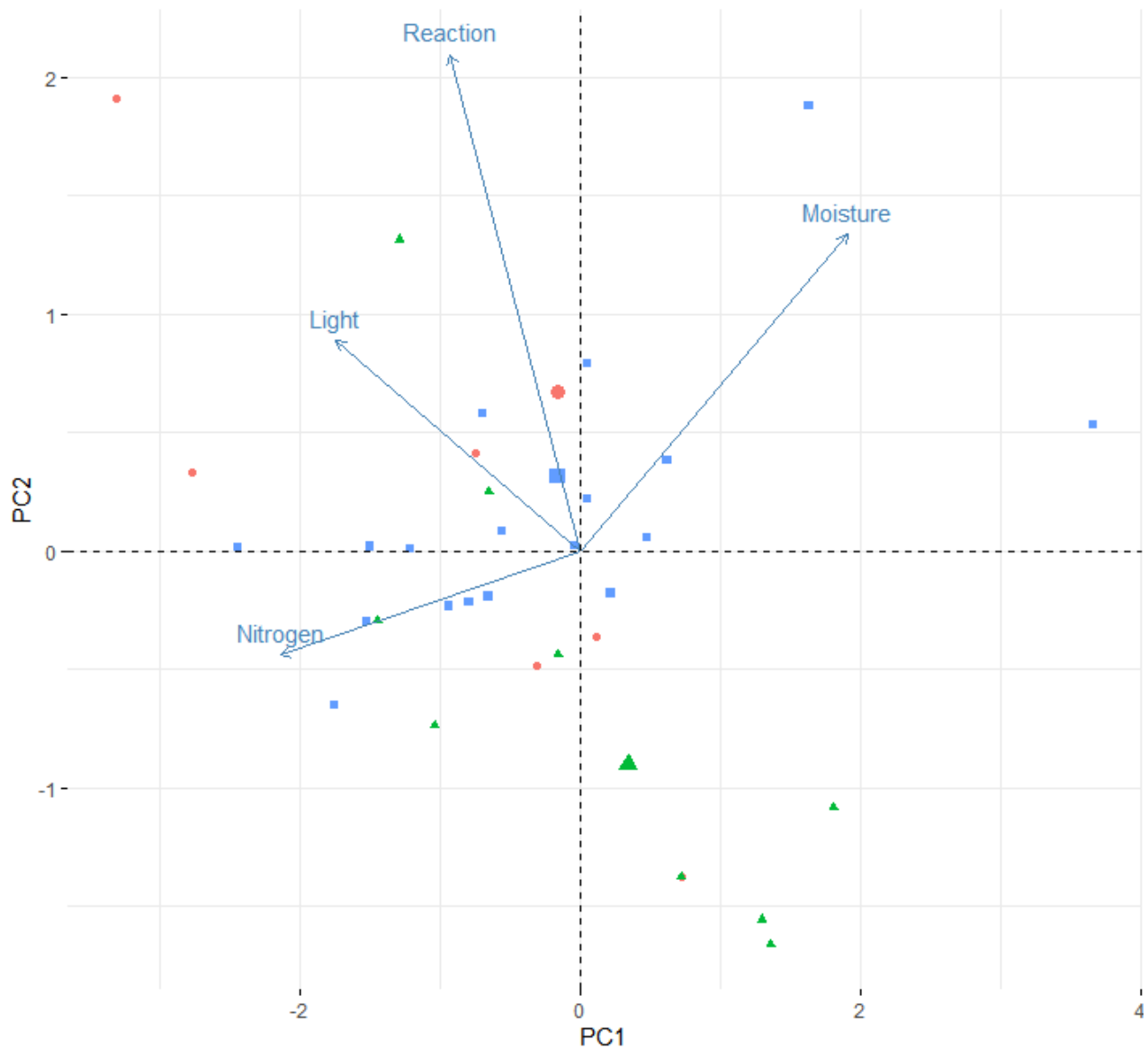


Figure 3: Principal Component Analysis (PCA) biplot of 52 individual tree samples collected at three different Sitka Spruce (*P. sitchensis*) plantations, using Ellenberg Indicator Values of Nitrogen, Light, Reaction & Moisture. Pen-y-Cymoedd wind farm – green triangles; Rheola Forest – blue squares; Glyncorrwg forest – red circles.

3.2.3 Associations with Environmental Variables

Canonical correspondence analysis (CCA) results indicate that *D. splachnoides* and *Lejeunea patens* are positively associated with moisture but negatively associated with relative humidity. *Colura calyptrifolia* is positively associated with light and moisture. *Lejeunea patens* and *D. splachnoides* are both negatively associated with nitrogen. *Ulota crispa* is positively associated with nitrogen (Figure 4).

D. splachnoides, *Metzgeria furcata* and *C. calyptrifolia* are associated with Rheola Forest whereas *L. patens* is more associated with Glyncorrwg forest. Environmental conditions at Glyncorrwg forest are similar whereas Rheola Forest had a higher association with moisture (Figure 5).

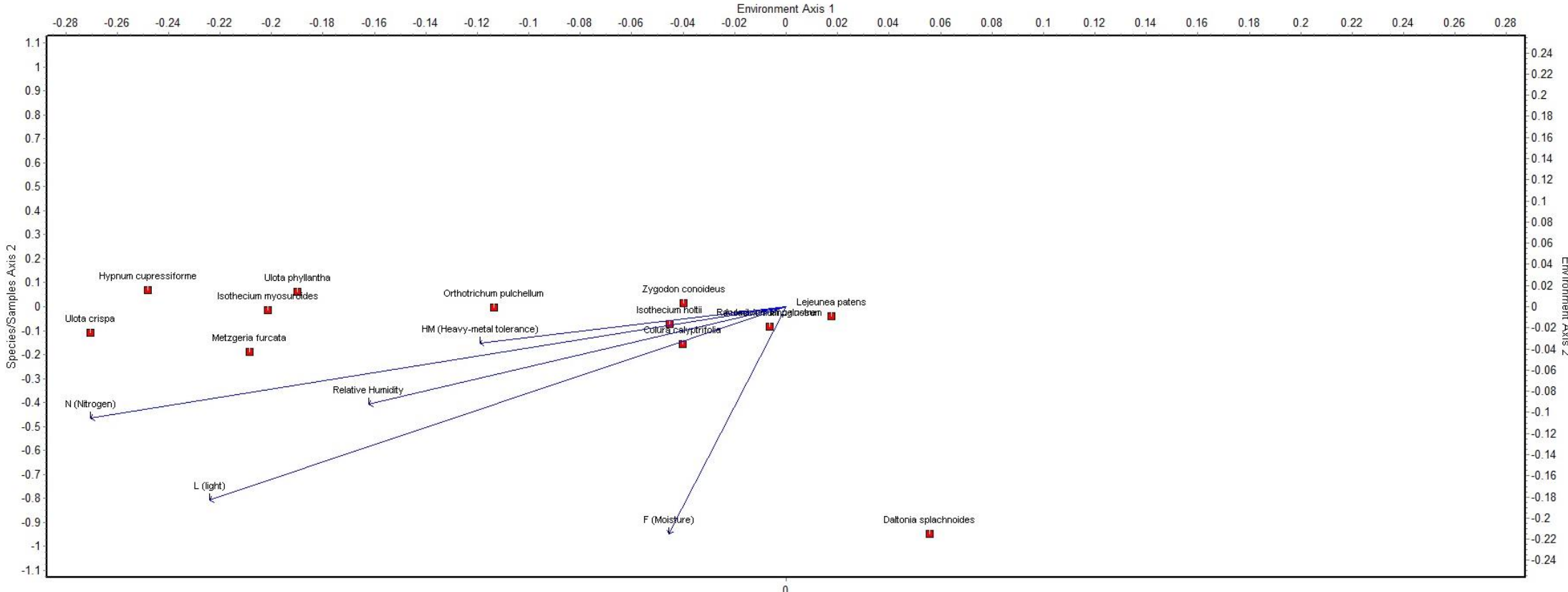


Figure 4: Canonical correspondence analysis biplot of 13 species identified during field sampling of trees across three sitka spruce (*Picea sitchensis*) plantations in South Wales sites using mean relative humidity and mean bryophyte Ellenberg values of (HM) heavy metal tolerance, (N) nitrogen concentration, (L) light availability, (F) moisture content. Mean Ellenberg values for (S) salt tolerance were removed due to high multicollinearity score.

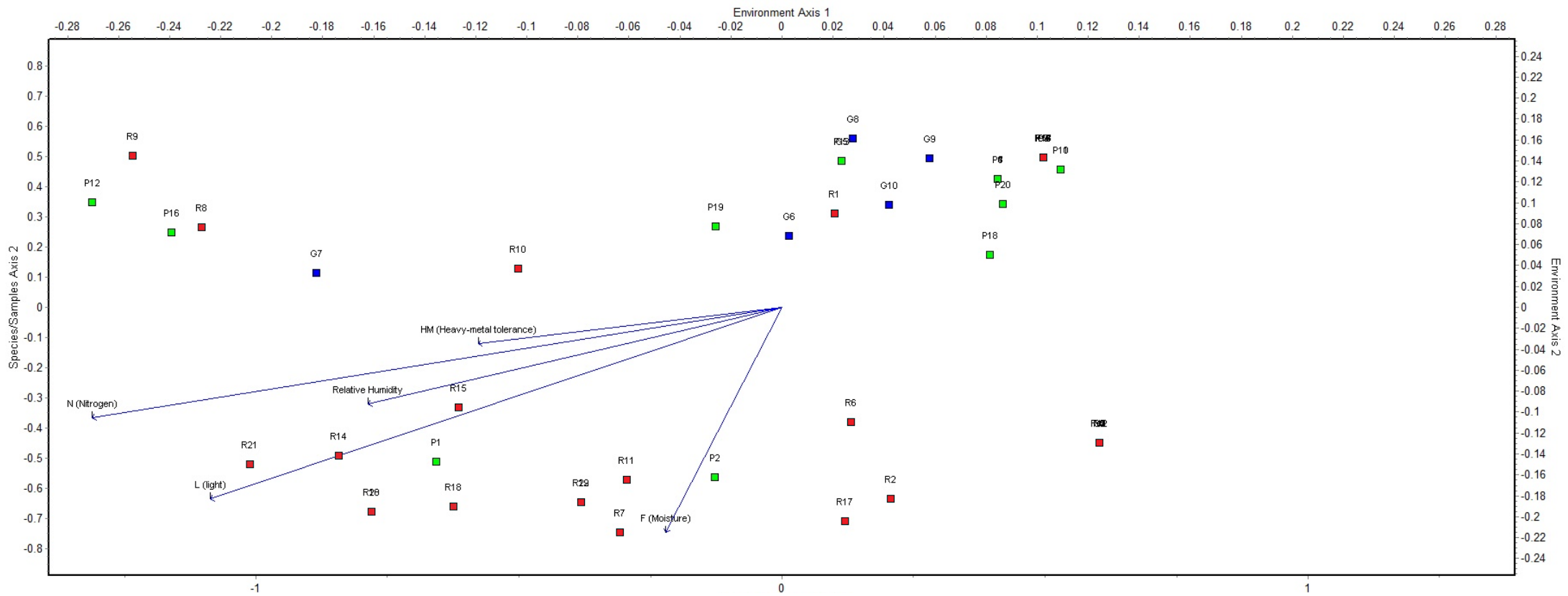


Figure 5: Canonical correspondence analysis biplot of 52 samples across three study sites and their distribution in relation to environmental conditions derived from mean Ellenberg indicator values of (HM) heavy metal tolerance, (N) nitrogen concentration, (L) light availability, (F) moisture content. Mean Ellenberg values for (S) salt tolerance were removed due to high multicollinearity score. Correlated variables are indicated by the closeness of arrows. R – Rheola (Red squares); G – Glyn-corrwg (Dark blue squares); P – Pen-y-Cymoedd (Green squares).

3.3 Model Predictions

3.3.1 Predicted Current Distributions within the UK

Of the three hyperoceanic bryophytes identified during field sampling the predicted habitat suitability model indicates that *D. splachnoides* currently has the most limited distribution followed by *Colura calyptrifolia* and then *Lejeunea patens*. For all three species, the majority of the Eastern coastline and inland regions of the United Kingdom is unsuitable given current climatic conditions. Additionally central East Ireland may be another area that is unsuitable for these species (Figure 6). Given current climatic conditions and model predictions *Radula holtii* is the most limited in current possible location suitability given that the current potentially suitable locations are restricted to South West Ireland and some areas of Scotland. Of the currently threatened species, *Metzgeria leptoneura* had the largest extent by area of potentially suitable locations which occur across most of Wales, West Scotland and coastal regions of South West Ireland with some smaller potential suitable locations being projected to be in West England (Figure 6). (Refer to Appendix 6, table 1 for AUC scores of the current distribution).

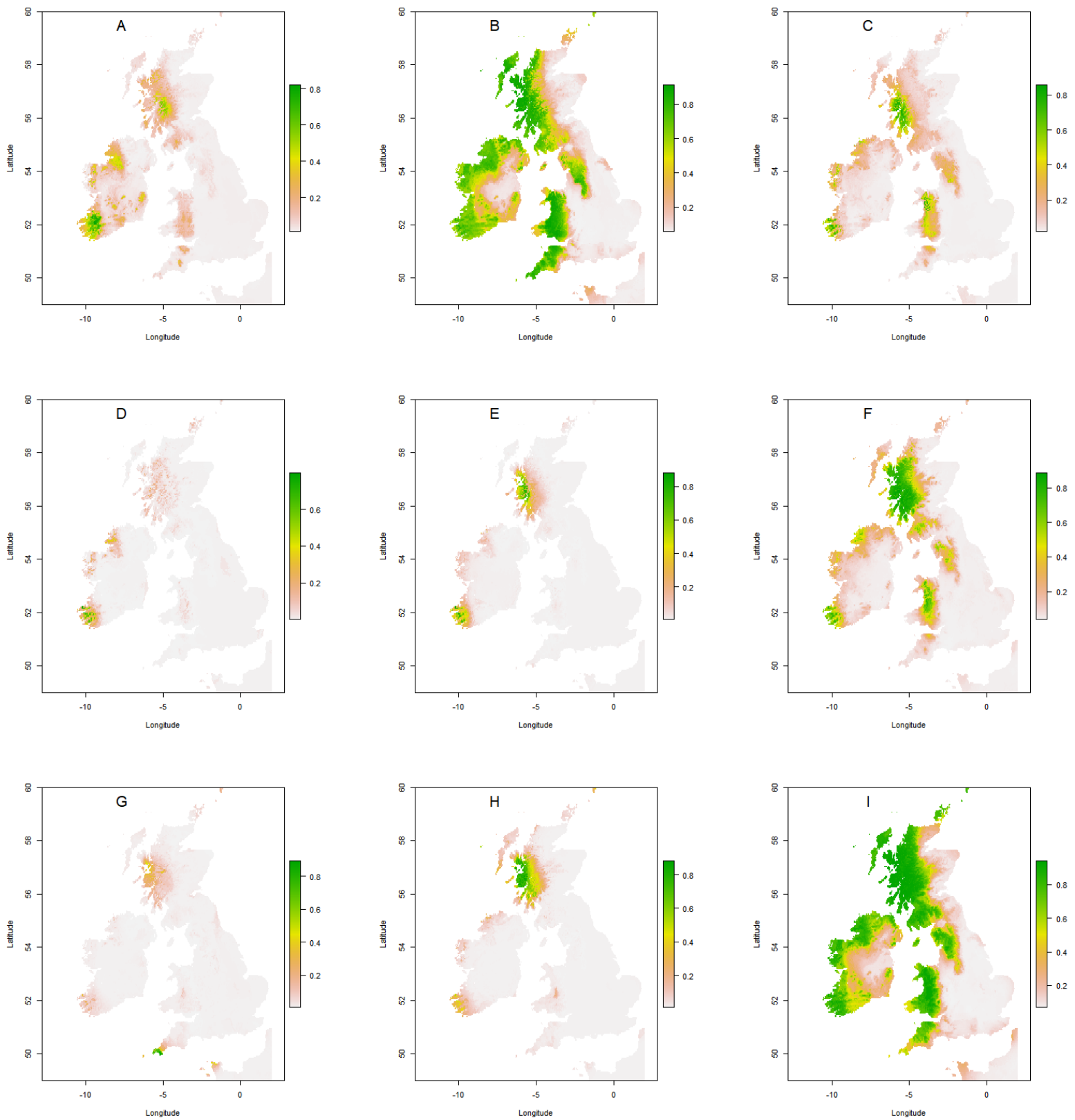


Figure 6: Species Distribution Model of potential predicted locations of occurrence within the UK given current climatic conditions: A - *Daltonia splachnoides*; B - *Colura calyptriifolia*; C - *Radula voluta*; D - *Radula holtii*; E - *Radula carringtonii*; F - *Metzgeria leptoneura*; G - *Lejeunea mandonii*; H - *Acrobolbus wilsonii*; I - *Lejeunea patens*. Location suitability based on mean AUC scores from five model methods (GLM, SVM, RF, BRT, MARS). Locations of higher suitability are shown in green (AUC score closer to 1), and locations of lower suitability are shown in white / light orange (AUC scores closer to 0).

3.3.2 Predicted Future Distributions within the UK

Comparing current predicted locations of suitability to projected future locations of suitability between 2081 and 2100 show a visual increase in distribution across all species. *Lejeunea patens* which had the largest potential distribution within the UK given current climatic conditions, extends this distribution to be potentially located across the majority of the UK. *Radula voluta* increases in distribution and is predicted to be located across the majority of Ireland and across the Western coast of the UK. *Radula carringtonii* is predicted to have the most limited distribution in 2081-2100 given projected climatic conditions (Figure 7) (Refer to appendix 6, table 2 for AUC scores of the future distribution).

Comparing current predicted locations of suitability to projected future locations of suitability between 2081 and 2100 show an increase in distribution across most all species with some seeing regional reductions in habitat suitability such as *Daltonia splachnoides* (Figure 7). *Lejeunea patens* which had the largest distribution within the UK given current climatic conditions will have a reduced possible location suitability in South Wales, South England and South Ireland whilst extending its possible distribution further into North Scotland. *Lejeunea mandonii* is predicted to have the most limited distribution between 2081 and 2100 with only small possible locations predicted to be in South West England and North West Scotland (Figure 7). The area of location suitability of *Radula holtii*, which had the most limited distribution given current climatic conditions is predicted to increase by 2081-2100 with an increase in area of possible location suitability in North West Scotland.

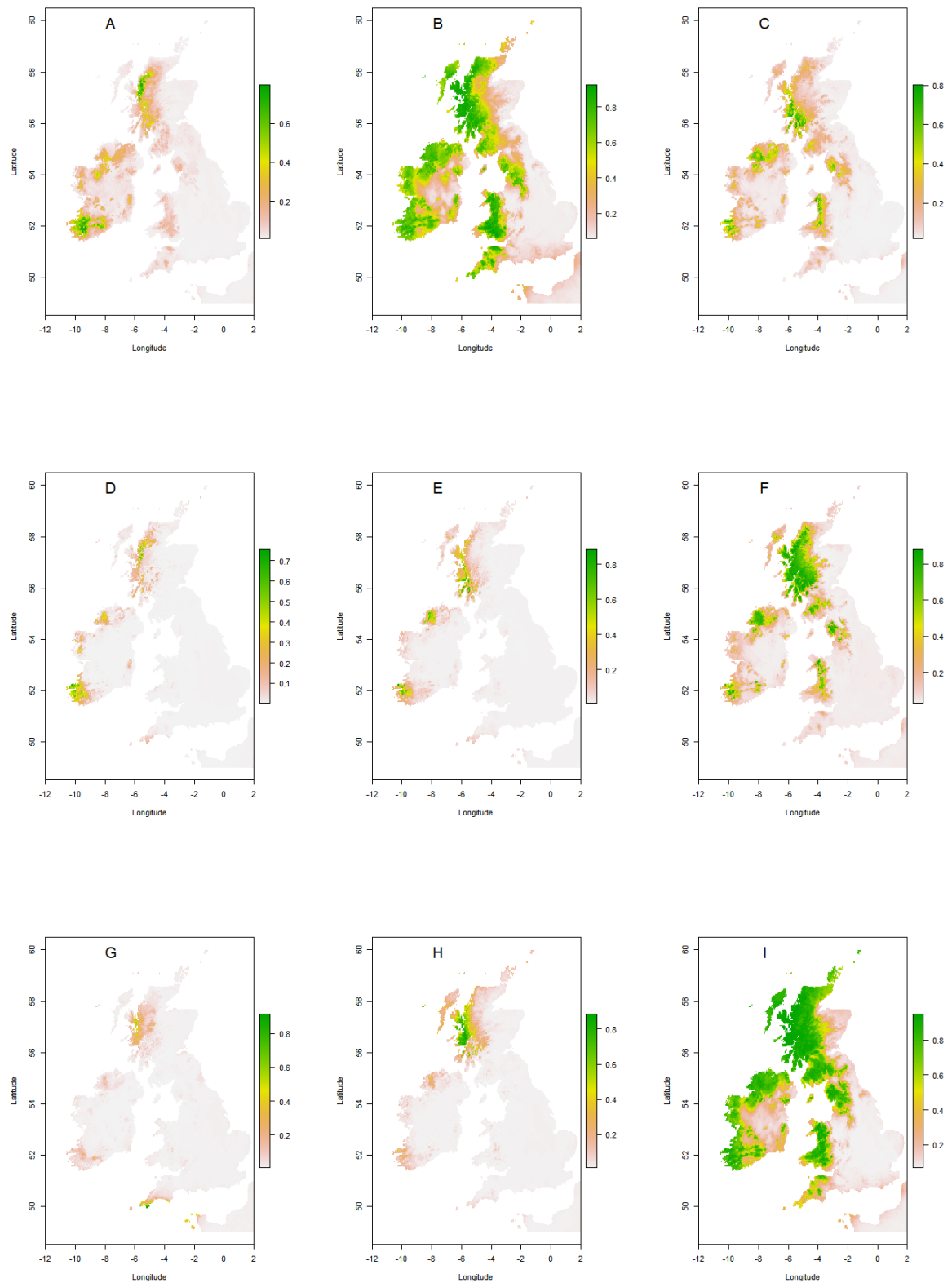


Figure 7: Species Distribution Model of potential predicted locations of occurrence within the UK between 2081-2100 under Shared Socio-economic Pathway 3: A -*Daltonia splachnoides*; B -*Colura calyptrifolia*; C -*Radula voluta*; D -*Radula holtii*; E -*Radula carringtonii*; F -*Metzgeria leptoneura*; G -*Lejeunea mandonii*; H -*Acrobolbus wilsonii*; I -*Lejeunea patens*. Location suitability based on mean AUC scores from five model methods (GLM, SVM, RF, BRT, MARS). Locations of higher suitability are shown in green (AUC score closer to 1), and locations of lower suitability are shown in white / light orange (AUC scores closer to 0).

4 Discussion

This study shows that humidity is a driver of hyperoceanic bryophyte presence within temperate forest plantations. The results also indicate that hyperoceanic bryophytes may thrive in habitats that consist of high humidity and high temperature, similar to climatic conditions observed at Rheola Forest. Further, species distribution models (SDMs) reveal that hyperoceanic bryophytes may be much more widespread than previously thought based on current potential location suitability, however this needs to be confirmed through field surveys which will determine model accuracy in predicting the potential suitable locations for hyperoceanic bryophytes in the UK. SDMs of future predicted climate change under shared socioeconomic pathway 3 (SSP3) indicate an increased area of high habitat overall when compared to models of current climatic conditions which may be due in part to increased precipitation in the UK or poleward movement due to increased temperatures when compared to current records.

4.2 Field Observations

The majority of identified species were epiphytic on willows (*Salix* sp). which in itself was the most abundant epiphyte host species along the plantation forest tracks. The high frequency of *Salix* sp. along the forest plantation tracks may be explained due to the species' resilience in highly moist conditions such as in bogs and near rivers or ditches that may be prone to streams forming during colder months (Cremer, 2003; Henderson, 2010). Ditches were common along the Sitka spruce plantation tracks across the three study sites and in some instances showed signs of a regular flow of water through moist soils and nearby water bodies. These ditches may contribute to the microclimate with increased humidity over areas further into the plantation coupe.

Given that Rheola Forest had the highest epiphytic bryophyte species richness and highest proportion of hyperoceanic bryophytes present it may indicate that the climatic conditions observed at Rheola Forest are essential to bryophyte presence. Some epiphytic bryophyte species may be used as proxy bioindicators of hyperoceanic bryophytes such as *Lejeunea patens*, *Hypnum cupressiforme* and *Isothecium myosuroides* all of which are common associates of the hyperoceanic species, *Daltonia splachnoides* (Blockeel *et al.*, 2014).

4.3 Environmental Conditions

Humidity is a driver of bryophyte species richness, and areas of high humidity may contain more bryophyte species (Wolf, 1993) . This aligns with the results of the mean humidity recorded *in situ* in which Rheola Forest had the highest mean humidity in addition to the highest mean species richness. Areas of high humidity often host diverse bryophyte assemblages particularly when the focal species is epiphytic

(Kessler, 2001; Geffert, 2013; Doležal, *et al.*, 2023; Økland *et al.*, 2023). Previous studies have shown that regions of higher humidity such as temperate or tropical rainforests and floodplains may lead to diverse coexisting bryophyte communities (Benavides, *et al.*, 2006; Tng, Dalton & Jordan, 2009).

4.4 Hyperoceanic Bryophyte Distribution

Throughout the duration of the study, the hyperoceanic bryophytes identified are of particular note. *Daltonia splachnoides* is of particular interest as it is a Section 7 species under the Environment (Wales) Act 2016 and is classified as a species of principal importance due to its role in enhancing biodiversity relation to Wales. Further to this, under the same act, areas in which *D. splachnoides* had been identified tend to be classed as an Oceanic Ravine Assemblage (Environment (Wales) Act 2016). Additional species identified at the three sites may support the study sites being defined by an Oceanic Ravine Assemblage due to the presence of *Colura calyptrifolia* and *Isothecium holtii*. *D. splachnoides* had previously been classified as nationally rare, thus indicating the importance of conservation of the species. *C. calyptrifolia* and *L. patens* were classified as being endemic to western Europe but not nationally rare (Bosanquet, Genney & Cox, 2018).

During the course of this study, *D. splachnoides* was reclassified from vulnerable to least concern due to significant expansion its range and having colonised scrub associated with plantation edges. Both *C. calyptrifolia* and *L. patens* were classified as least concern due to high abundance (Callaghan, 2022). The expansion in range may be due to the continuous modification of native habitats into constructed habitats used for agriculture or forestry known as recombinant ecology (Rotheram, 2017). As these habitats are modified and non-native species are introduced, novel associations will form that create new opportunities for species to exploit the new niche (Shea & Chesson, 2002). Alterations in biotic conditions induced by climate change may exacerbate this and may lead to further colonisation of newly created novel ecosystems (Hobbs, Higgs, Harris, 2009; Starzomski, 2013). This has been seen at the study locations presented here, as environmental conditions within the study sites has changed substantially over the last 40 years through afforestation of peat bogs, air quality changes and alterations in forest vegetation dynamics (Hipkin pers. Comm.). Additional expansion in ranges have been seen in bryophytes across the UK but still remain vulnerable to alterations in climatic conditions due to climate change (Hayhow *et al.*, 2019).

The climate change induced alterations in abiotic conditions such as increased rainfall resulting in increased water availability and increased humidity, may help to benefit hyperoceanic bryophytes. Bryophytes are haploid-dominant organisms meaning that the majority of their life cycle is spent as a haploid gametophyte that then produce diploid sporophytes (Shaw, Szövényi & Shaw, 2011). Water is

heavily relied upon by bryophytes as it allows for the movement of sperm between the antheridium to the archegonium and thus a lack of water is a significant barrier to sexual reproduction in bryophytes (Wyatt, 1982; Longton, 2019).

A higher proportion of hyperoceanic bryophytes were identified at Rheola Forest when compared to the other study sites. In addition to humidity, temperature was also shown to be a significant driver of the presence or absence of hyperoceanic bryophytes across all three study sites in which higher temperature (°C) results in a higher likelihood of a hyperoceanic bryophyte being identified. Results may aid in this explanation as it was found dimension 1 was mostly explained by moisture (Figure 3). This indicates that moisture is the best explanatory variable to describe what drives bryophyte species distribution and diversity at Rheola Forest (Yoshikawa, Overduin & Harden, 2004; Rixen & Mulder, 2005; Jang & Viles, 2021). Given this it may further suggest that Rheola may provide the climatic conditions required for the presence of hyperoceanic bryophytes due to the association with proxy measures of moisture. Hyperoceanics do associate with areas of high humidity such as water bodies in which species may undergo submersion or the substrate is moist similar to the plantation edges in which trackside ditches can provide additional sources of humidity through flowing water (Averis, 2011; Hill & Preston, 2013). Additionally, higher temperatures within these sites over time has led to increased rate of evaporation resulting in increased humidity creating the environmental conditions required by hyperoceanic bryophytes (Ratcliffe, 1968; Sillett & Antoine, 2004).

4.4.1 Proxy Measures of Environmental Conditions

Bryophyte based Ellenberg Indicator values provide a useful proxy measurement for abiotic conditions. However they should be used with caution, particularly when only a subset of species are sampled in which proxy measures for moisture for a given species can range from a moist site with average dampness to a near wet-land site that is highly saturated with water depending on the species (Hill *et al.*, 1999; Hill *et al.*, 2004). Reaction (proxy for pH) was significantly higher at Glyncorrwg forest when compared to the other study Rheola Forest and Pen-y-Cymoedd wind farm. Conversely, Pen-y-Cymoedd seems to have a mix of environmental variables with select locations being similar to the niche required for hyperoceanic bryophyte presence. Additionally, Pen-y-Cymoedd and Glyncorrwg appear to have similar environmental conditions, further explained through the lack of significant difference in Ellenberg indicator values (Refer to Appendix 8, figure 1).

Community composition of sampled species appears to be highly similar within Glyncorrwg as the majority of samples are clustered in the same location. However the samples from Glyncorrwg are not associated with the majority of Ellenberg indicator values which may suggest a lack of species data and thus introduced biases (Schaffers & Sýkora, 2000). Samples from Rheola Forest were primarily associated

with moisture and may indicate that Rheola is a moister site and thus may contain the environmental conditions commonly associated with hyperoceanic bryophyte presence over the study sites (Figures 4 and 5).

Interestingly *D. splachnoides* was positively associated with a moist environment but was negatively associated to relative humidity suggesting possible sampling errors as Ellenberg values do correspond well to field measurements and hyperoceanic bryophytes are associated with areas of high humidity (Schaffers & Sýkora, 2000). The three main hyperoceanic bryophytes identified during this study (*Colura calyptrifolia*, *Daltonia splachnoides* and *Lejeunea patens*) all associate with low proxy measures of light suggesting a tolerance for shade (Hill *et al.*, 2007). These species also associate with moisture, similar to results indicating the hyperoceanic presence and moisture relationships (Averis, 2007; Majestyk, 2011).

Zygodon conoideus, *Isothecium holtii* and *Colura calyptrifolia* correlate with areas of low light, low nitrogen content, no heavy metal content and low relative humidity given their position along the environmental axis and their respective Ellenberg indicator values (Hill *et al.*, 2007). Further to this, the clustering of *Ulota crispa*, *Hypnum cupressiforme*, *Ulota phyllantha*, *Isothecium myosuroides* and *Metzgeria furcata* indicate similar ecological responses to the presented environmental conditions (Hill *et al.*, 2007).

4.5 Species Distribution Models

4.5.1 Current Distribution of Hyperoceanic Bryophytes

The results from the current distribution of the hyperoceanic bryophytes may be of substantial use in conservation ecology (Rathore & Sharma, 2023). Through the identification of potential locations that provide suitable climatic conditions for the species in question, it provides new areas in which translocation may be conducted. The three study sites were all *P. sitchensis* plantations and thus are at risk of regular anthropogenic disturbance, not just through logging, but also collateral damage of scrub along tracksides from heavy plant machinery and the installation of new wind turbines. In the case of epiphytic hyperoceanic bryophytes discussed here, the risk increases and thus translocation of rare species identified within these high-risk locations may be required as is the case for *R. voluta* which has the most limited distribution within the UK. If the SDMs of the current possible locations for each hyperoceanic bryophyte is correct then it would suggest that scarce hyperoceanic bryophytes are much more abundant than previously understood, with possible distribution of scarce species such as *Daltonia splachnoides* being possibly located across most of the Western United Kingdom, however field surveys should be carried out to confirm this (GBIF.org, 2023).

4.5.2 Future Distribution of Hyperoceanic Bryophytes

Species Distribution Models under future climate scenarios indicate that current distribution of the presented hyperoceanic bryophyte species may increase in Northern regions and decrease in Southern regions over the next 60-80 years if world governments follow shared socio-economic pathway 3 (SSP3). Under this scenario, little climate mitigation actions are undertaken, and consumption of fossil fuels continues to increase up to 2100 resulting in increased carbon dioxide (CO₂) emissions up to 86.1 gigatonnes per year and a global mean temperature of 4.07 °C by 2100 (Fujimori *et al.*, 2017; Riahi *et al.*, 2017; IPCC, 2022). Within the UK, the spatial extent of protected areas would decline due to an increased use of natural resources. Increased focus on agriculture and reduced environmental protection policies would result in an increased use of chemicals on the now agriculture dominated land further leading to increased habitat degradation up until 2040 at which point the use of pesticides becomes unprofitable (Brown *et al.*, 2022; Harmáčková *et al.*, 2022; Merkle *et al.*, 2022; Merkle *et al.*, 2023).

This continuous use of fossil fuels and increased CO₂ emissions may result in an increase in the abundance of hyperoceanic bryophytes (Sérgio, Figueira & Menezes, 2011). Elevated CO₂ concentrations drive an increase in the rate of photosynthetic activity and total biomass in species that utilise C₃ carbon fixation (Policy *et al.*, 1993; Stephanie *et al.*, 1999; Proctor, 2000; Keenan *et al.*, 2021). However, other variables must be included to form valuable conclusions regarding the physiological response of C₃ bryophytes to elevated levels of CO₂ such as water and nutrient availability as both of these can play a role in the response of biomass accumulation under elevated CO₂ levels in C₃ plants (Toet *et al.*, 2006; Serk *et al.*, 2021; Terrer *et al.*, 2021).

When comparing climatic variables between current and predicted future values (2081-2100 under SSP3), the variable that changes the most in value the most in the UK is annual precipitation (mm). Precipitation in the UK at current values has a maximum value of approximately 2000 mm observed in West Scotland, whereas annual precipitation in the UK between 2081-2100 and under SSP3 is approximately 3000 mm predicted to be observed in West Scotland (Fick & Hijmans, 2017). This may indicate further that humidity and moisture are drivers of hyperoceanic bryophyte distribution (Hill & Preston, 1998). Predicted frequency of extreme precipitation events between 2045 to 2065 is predicted to be highest under the scenario used in this study (SSP3) when compared to the other scenarios (SSP1 to 5) (Liu *et al.*, 2020). This increase in frequency and amount of precipitation and the that may be driving a possible increase in hyperoceanic bryophyte distribution is due to increased evaporation of oceans due to increased ocean temperatures (Dore, 2005; Tabari, 2020).

Hyperoceanic bryophytes are currently generally restricted to more humid Western climates (Hill & Preston, 1998; Preston & Hill, 1999). Under future climate scenarios, projected possible distribution are

predominantly along the West coast of the UK in areas of relative humidity (approximately 85% RH on average) with some expansion into North Scotland such as *Lejeunea patens*. The expansion in area of possible suitable locations for *L. patens* may be due to the current distribution through confirmed presence records being highest out of the discussed hyperoceanic species and being located across most of Wales, Ireland and Scotland (GBIF.org, 2023). Additionally, the expansion into regions in the North of the UK may be due to species tracking climate change in which species disperse poleward into order to remain within their cooler niche habitats (Groom, 2013; Wen *et al.*, 2018).

Using predicted data under the Relative Concentration Pathway (RCP) 8.5 scenario predicted that in Wales, hyperoceanic bryophytes will undergo substantial reductions in distribution due to a reduction in habitat suitability (Spill, 2021). Under the RCP 8.5 scenario, the mean global warming temperature increase is projected to be 2 °C whereas the mean global warming increased projections under the scenario utilised within this study, SSP3, was projected to be between 2.8 °C and 4.6 °C by 2081-2100 (IPCC, 2013; IPCC, 2022). Given this, the results from the study presented may still offer key insights as the two scenarios do differ in all climatic conditions and variables used in the model (Kim *et al.*, 2015).

4.5.3 Biodiversity Implications

Within the UK approximately 30% of bryophytes are at least medium risk from climate change (Hayhow *et al.*, 2019). UK bryophytes and lichens have shown an increase in mean distribution since the 1970s primarily due to an improvement in air quality (Pescott *et al.*, 2015). However, currently 19% of the taxa or 191 species are at risk of extinction according to the IUCN Red List (Hayhow *et al.*, 2019; Callaghan, 2019). Bryophytes also face the largest risk from climate change with approximately 30% of total bryophytes being at risk, more than any other taxonomic group, with the exception of vascular plants who face similar risk (Pearce-Higgins, 2017). Within Wales, six bryophyte species have been classed as extinct with a further 18% or 146 species of the total 850 assessed bryophyte species being defined as threatened with risk of extinction in Wales (Callaghan, 2019). The increase in bryophyte distribution observed since 1970 has also carried over to hyperoceanics (Callaghan, 2019). Given that hyperoceanic bryophyte distribution has increased in part due to air quality improvements, a continuation of the reduction in air pollution may be vital to solving the biodiversity crisis faced by bryophytes and many other taxa.

4.6 Future Studies

Future studies may wish to investigate the areas identified within the SDMs to confirm or deny the model accuracy. This may also aid in the collection of new identification records of hyperoceanic bryophytes within the UK. Additionally this may also lead to the identification of new areas of hyperoceanic bryophyte

occurrence outside of the model outputs that may lead to improving future model accuracy. Further to this, by confirming future distribution we may be able to understand whether we are on track for the observed distribution to occur by 2081-2100.

Future studies may also wish to model species that are lacking in records as by utilising different modelling methods as to what was used in this study, the results are not as sensitive to small sample sizes and thus can be applied for rare endemic species (Pearson *et al.*, 2006; Wisz *et al.*, 2008).

4.7 Limitations

This study does have some limitations. Epiphytic bryophytes only represent a small subsection of the community composition and therefore environmental conditions at the sites may not be well represented. Additionally, other ecological variables may influence the overall community composition which may not be understood when only sampling a small proportion of present species (Zelený & Schaffers, 2012; Szymura, Szymura & Macioł, 2014). This would also reduce bias from other climatic variables not measured during the study (Schaffers & Sýkora, 2000) Future studies may wish to take this into account and sample a broad list of non-epiphytic species to fully represent the environmental conditions of the study site whilst using proxy measures.

The sampling strategy utilised in this study may not best reflect the community composition at the three study sites. By restricting sampling to transects along forest track edges and up to 3 m into the forest on each side, some epiphytic bryophyte and hyperoceanic bryophyte species may not be sampled and thus are underrepresented. Future studies may wish to carry out sampling further into the forest canopy to sample areas of lower light availability to gain a representative understanding of the community composition.

This field sampling portion of this study was conducted in areas of known higher humidity. As a result, the results may not be representative of areas of lower relative humidity. This was accounted for with the species distribution models which took into account varying levels of humidity across the UK. Despite this, future studies may wish to take this into account and sample from known areas of both high and low relative humidity to provide a broad understanding of the local distribution patterns of hyperoceanic bryophytes.

Handheld recording devices may not represent temporal variations in climatic conditions. By using recording devices at each sample site an understanding of the spatial variation of climatic conditions, is provided but does not represent the annual temporal fluctuations of the same site. Field sampling was also

collected during warmer months and thus does not consider periods in time in which precipitation is highest. Additionally, by only using a single long-term datalogger per site it did not allow for spatial data to be collected over a prolonged period of time. Future studies may wish to use multiple long-term dataloggers per site rather than the single to provide spatio-temporal data to best understand the conditions at a site to ensure all seasonality bias are considered.

The models used within this study did not consider the alterations in hyperoceanic bryophyte habitats which may habitat loss and alterations under SSP3. Within this scenario, deforestation will continue due to increased urban sprawl for use within agriculture and thus causing significant decline in temperature coniferous forest cover at approximately 2120 km² of habitat loss between 2015-2100 (Li *et al.*, 2022).

The locations within the UK that have a high location suitability for a given species do not indicate the likelihood that the species will be found there as the models used in this study are only the possible suitable locations that a species may be found in rather than the likelihood of a given species to be found in the same location (Sinclair, White & Newell, 2010).

5 Conclusion

The distribution shift observed on a number of hyperoceanic bryophytes within the last 40 years, including *Colura calyptrifolia*, *Daltonia splachnoides*, and *Lejeunea patens* may be due in part to improved air quality, climate change induced alterations to environmental conditions such as rainfall and habitat modification within Rheola Forest, Glyncoerrwg and Pen-y-Cymoedd, all of which are now temperate rainforests plantations populated with Sitka spruce with willow dominated scrub along forest tracks (Hipkin pers.comm.; Pescott *et al.*, 2015; Rotheram, 2017). These alterations and changes in climatic conditions have resulted in the environmental conditions associated with hyperoceanic bryophytes resulting in an increase in distribution due their reliance on moisture and may lead to further colonisation of newly created novel ecosystems within constructed habitats (Wyatt, 1982; Hill & Preston, 1998; Hobbs, Higgs, Harris, 2009; Starzomski, 2013; Longton, 2019; Callaghan, 2020). High humidity and high temperature are drivers of hyperoceanic bryophyte presence with humidity being a driver of bryophyte species richness within temperate rainforest plantations. The hypothesis that the current distribution of hyperoceanic bryophytes is restricted to regions of high humidity in the UK was correct in which nine hyperoceanic bryophytes were primarily located across the West of the UK (Bainbridge *et al.*, 1989; Hill & Preston, 1998). Additionally, the hypothesis that the potential distribution of hyperoceanic bryophytes under future climate change would undergo a Northern movement was correct as an overall increase in the possible location suitability in Northern regions for the nine hyperoceanic bryophytes was observed

with decreased area of location suitability in Southern regions suggesting a northward movement, provided that hyperoceanic bryophytes are able to track climate change at an adequate pace.

References

- Abd Latif, Z. & Blackburn, G.A. (2010) The effects of gap size on some microclimate variables during late summer and autumn in a temperate broadleaved deciduous forest. *International Journal of Biometeorology*, **54**, 119-129.
- Acton, A. & Rothero, G. (2010) Lichens and bryophytes of Atlantic woodland in Scotland: an introduction to their ecology and management. *Back from the Brink Management Series*. Plantlife Sailsbury.
- Agehara, S. & Warncke, D. (2005) Soil Moisture and Temperature Effects on Nitrogen Release from Organic Nitrogen Sources. *Soil Science Society of America Journal - SSSAJ*, **69** 1844-1855.
- Amann, J. (1929) L'hygrothermie du climat, facteur déterminant la répartition des espèces atlantiques. *Bulletin de la Murithienne*, 39-46.
- Amy, S. & Pescott, O. (2023) Bryophyte distribution data in iRecord: an introduction to the resource. *Field Bryology*, **129**, 36-46.
- Averis, A. (2007) Habitats of *Colura calyptrifolia* in North-western Britain. *Field Bryology*, **91**, 17-21.
- Bainbridge, I., Brown, A., Burnett, N., Corbett, P., Cork, C., Ferris, R., Howe, M., Maddock, A., Mountford, E. & Pritchard, S. (2013) Guidelines for the selection of biological SSSIs..
- Barlow, M.M., Johnson, C.N., McDowell, M.C., Fielding, M.W., Amin, R.J. & Brewster, R. (2021) Species distribution models for conservation: Identifying translocation sites for eastern quolls under climate change. *Global Ecology and Conservation*, **29**, e01735.
- Bates, J.W., Thompson, K. & Grime, J.P. (2005) Effects of simulated long-term climatic change on the bryophytes of a limestone grassland community. *Global Change Biology*, **11**, 757-769.
- Batke, S.P., Murphy, B.R., Hill, N. & Kelly, D.L. (2015) Can air humidity and temperature regimes within cloud forest canopies be predicted from bryophyte and lichen cover? *Ecological Indicators*, **56**, 1-5.
- Bell, S., Ashenden, T.W. & Rafarel, C.R. (1992) Effects of rural roadside levels of nitrogen dioxide on *Polytrichum formosum* Hedw. *Environmental Pollution*, **76**, 11-14.
- Benavides, J.C., Duque M, A.J., Duivenvoorden, J.F. & Cleef, A.M. (2006) Species richness and distribution of understorey bryophytes in different forest types in Colombian Amazonia. *Journal of Bryology*, **28**, 182-189.
- Benítez, Á., Armijos, L. & Calva, J. (2021) Monitoring Air Quality with Transplanted Bryophytes in a Neotropical Andean City. *Life*, **11**, 821.
- Blockeel, T.L., Bosanquet, S.D., Hill, M. & Preston, C.D. (2014) *Atlas of British & Irish Bryophytes: The Distribution and Habitat of Mosses and Liverworts in Britain and Ireland*. Newbury Berkshire: Pisces publications on behalf of the British Bryological Society.
- Bosanquet, S. (2004) *Colura calyptrifolia* in Wales. *Field Bryology*, **82**, 3-5.
- Bosanquet SDS (2015). The effects of topography and rainfall on the distribution of Oceanic/Atlantic bryophytes in Wales. NRW Evidence Report No: 146, 22 pp, Natural Resources Wales, Bangor.
- Bosanquet, S.D.S., Genney, D.R. & Cox, J.H.S. 2018. Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 12 Bryophytes. JNCC, Peterborough.
- Bradley, A.P. (1997) The use of the area under the ROC curve in the evaluation of machine learning algorithms. *Pattern Recognition*, **30**, 1145-1159.

- Brotons, L., Thuiller, W., Araújo, M.B. & Hirzel, A.H. (2004) Presence-absence versus presence-only modelling methods for predicting bird habitat suitability. *Ecography*, **27**, 437-448.
- Brown, C., Seo, B., Alexander, P., Burton, V., Chacón-Montalván, E.A., Dunford, R., Merkle, M., Harrison, P.A., Prestele, R., Robinson, E.L. & Rounsevell, M. (2022) Agent-Based Modeling of Alternative Futures in the British Land Use System. *Earth's Future*, **10**, e2022EF002905.
- Callaghan, D.A. (2020) Ecology of the hyperoceanic liverwort *Leptoscyphus cuneifolius* (Hook.) Mitt. at a key site in the British Isles. *Journal of Bryology*, **42**, 133-142.
- Callaghan, D.A. (2022) A new IUCN Red List of the bryophytes of Britain, 2023. *Journal of Bryology*, **44**, 271-389.
- Callaghan, D.A., Bosanquet, S.D.S. & Bissell, R. (2019) Population change in hyper-oceanic liverworts before and after hydroelectric power development: a preliminary study. *Journal of Bryology*, **41**, 1-11.
- Carnell, E., Vieno, M., Vardoulakis, S., Beck, R., Heaviside, C., Tomlinson, S., Dragosits, U., Heal, M.R. & Reis, S. (2019) Modelling public health improvements as a result of air pollution control policies in the UK over four decades—1970 to 2010. *Environmental Research Letters*, **14**, 074001.
- Chamberlain S, Barve V, Mcglinn D, Oldoni D, Desmet P, Geffert L, Ram K (2023). Rgbif-package: Interface to the Global Biodiversity Information Facility API_. R package version 3.7.7. Available at: <https://CRAN.R-project.org/package=rgbif>
- Chen, I.-C., Hill, J.K., Ohlemüller, R., Roy, D.B. & Thomas, C.D. (2011) Rapid Range Shifts of Species Associated with High Levels of Climate Warming. *Science*, **333**, 1024-1026.
- Cointe, B. & Guillemot, H. (2023) A history of the 1.5°C target. *WIREs Climate Change*, **14**, e824.
- Coote, L., Smith, G.F., Kelly, D.L., O'Donoghue, S., Dowding, P., Iremonger, S. & Mitchell, F.J. (2009) Epiphytes of Sitka spruce (*Picea sitchensis*) plantations in Ireland and the effects of open spaces. *Plantation Forests and Biodiversity: Oxymoron or Opportunity?*, 29-44.
- Cremer, K.W. (2003) Introduced willows can become invasive pests in Australia. *Biodiversity*, **4**, 17-24.
- Davies, L., Bates, J.W., Bell, J.N.B., James, P.W. & Purvis, O.W. (2007) Diversity and sensitivity of epiphytes to oxides of nitrogen in London. *Environmental Pollution*, **146**, 299-310.
- Doležal, J., Korznikov, K., Altman, J., Fibich, P., Řeháková, K., Lltonga, E.N., Majeský, L. & Dančák, M. (2023) Ecological niches of epiphyllous bryophytes along Afrotropical elevation gradient. *Oikos*, **2023**, e09772.
- Dore, M.H.I. (2005) Climate change and changes in global precipitation patterns: What do we know? *Environment International*, **31**, 1167-1181.
- Duncan, D. & Dalton, P.L. (1982) Recolonisation by bryophytes following fire. *Journal of Bryology*, **12**, 53-63.
- Ehrlén, J. & Morris, W.F. (2015) Predicting changes in the distribution and abundance of species under environmental change. *Ecology Letters*, **18**, 303-314.
- Ellis, C.J. (2016) Oceanic and temperate rainforest climates and their epiphyte indicators in Britain. *Ecological Indicators*, **70**, 125-133.
- Enting, I.G. (2018) Metrics for Greenhouse Gas Equivalence. *Encyclopedia of the Anthropocene* (eds D.A. Dellasala & M.I. Goldstein), pp. 467-471. Elsevier, Oxford.
- Environmental Community Analysis Version 2.1, 2007, Pisces Conservation Ltd. Lymington, UK (www.pisces-conservation.com)

- Environment (Wales) Act 2016. Available at: <https://www.legislation.gov.uk/anaw/2016/3/contents/enacted> (Accessed 9 September 2023).
- Fick, S.E. & Hijmans, R.J. (2017) WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology*, **37**, 4302-4315.
- Forster, P. (2003) OZONE | Role in Climate. *Encyclopedia of Atmospheric Sciences* (ed. J.R. Holton), pp. 1649-1655. Academic Press, Oxford.
- Fujimori, S., Hasegawa, T., Masui, T., Takahashi, K., Herran, D.S., Dai, H., Hijioka, Y. & Kainuma, M. (2017) SSP3: AIM implementation of Shared Socioeconomic Pathways. *Global Environmental Change*, **42**, 268-283.
- Gambhir, A., Mittal, S., Lamboll, R.D., Grant, N., Bernie, D., Gohar, L., Hawkes, A., Köberle, A., Rogelj, J. & Lowe, J.A. (2023) Adjusting 1.5 degree C climate change mitigation pathways in light of adverse new information. *Nature Communications*, **14**, 5117.
- García, E.L., Rosenstiel, T.N., Graves, C., Shortlidge, E.E. & Eppley, S.M. (2016) Distribution drivers and physiological responses in geothermal bryophyte communities. *American Journal of Botany*, **103**, 625-634.
- GBIF.org (2023) *GBIF Home Page*. Available at: <https://www.gbif.org/>
- Geffert, J.L., Frahm, J.-P., Barthlott, W. & Mutke, J. (2013) Global moss diversity: spatial and taxonomic patterns of species richness. *Journal of Bryology*, **35**, 1-11.
- GILBERT, O.L. (1968) BRYOPHYTES AS INDICATORS OF AIR POLLUTION IN THE TYNE VALLEY. *New Phytologist*, **67**, 15-30.
- González Mancebo, J. 2019. *Lejeunea mandonii*. *The IUCN Red List of Threatened Species 2019*: e.T87543416A87714324. <https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T87543416A87714324.en>. Accessed on 22 September 2023.
- Gillings, S., Balmer, D.E. & Fuller, R.J. (2015) Directionality of recent bird distribution shifts and climate change in Great Britain. *Global Change Biology*, **21**, 2155-2168.
- Greig-Smith, P. (1950) Evidence from Hepatics on the History of the British Flora. *Journal of Ecology*, **38**, 320-344.
- Groom, Q.J. (2013) Some poleward movement of British native vascular plants is occurring, but the fingerprint of climate change is not evident. *PeerJ*, **1**, e77.
- Guisan, A. & Thuiller, W. (2005) Predicting species distribution: offering more than simple habitat models. *Ecology Letters*, **8**, 993-1009.
- Guisan, A., Weiss, S.B. & Weiss, A.D. (1999) GLM versus CCA spatial modeling of plant species distribution. *Plant Ecology*, **143**, 107-122.
- Harmáčková, Z.V., Pedde, S., Bullock, J.M., Dellaccio, O., Dicks, J., Linney, G., Merkle, M., Rounsevell, M.D.A., Stenning, J. & Harrison, P.A. (2022) Improving regional applicability of the UK shared socioeconomic Pathways through iterative participatory co-design. *Climate Risk Management*, **37**, 100452.
- Hassel, K., Appelgren, L., Blom, H.H., Flynn, K.M., Gaarder, G., Heegaard, E., Høitomt, T., Jordal, J.B., Lima, M., Söderström, L. & Wangen, K. (2014) *Colura calyptrifolia* a new oceanic liverwort to Norway and Scandinavia. *Lindbergia*, **37**, 1-5, 5.
- Hayhow, D.B., Eaton, M.A., Stanbury, A.J., Burns, F., Kirby, W., Bailey, N., Beckmann, B., Bedford, J., Boersch-Supan, P. & Coomber, F. (2019) State of nature 2019.

- Henderson, L. (1991) Alien Invasive *Salix* spp. (Willows) in the Grassland Biome of South Africa. *South African Forestry Journal*, **157**, 91-95.
- Heritage, S.N. (2011) Assessing the impacts of small scale hydroelectric schemes on rare bryophytes and lichens.
- Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G. & Jarvis, A. (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, **25**, 1965-1978.
- Hijmans R (2022). Raster: Geographic Data Analysis and Modeling. R package version 3.6-11. Available at: <https://CRAN.R-project.org/package=raster>
- Hijmans RJ, Phillips S, Leathwick J, Elith J (2022). dismo: Species Distribution Modeling. R package version 1.3-9. Available at: <https://CRAN.R-project.org/package=dismo>
- Hijmans RJ, Barbosa M, Ghosh A, Mandel A (2023). geodata: Download Geographic Data. R package version 0.5-8. Available at: <https://CRAN.R-project.org/package=geodata>
- Hill, M.O., Mountford, J.O., Roy, D.B. & Bunce, R.G.H. (1999) *Ellenberg's indicator values for British plants. ECOFACT Volume 2 Technical Annex*. Institute of Terrestrial Ecology.
- Hill, M.O. & Preston, C.D. (1998) The geographical relationships of British and Irish bryophytes. *Journal of Bryology*, **20**, 127-226.
- Hill, M.O. & Preston, C.D. (2015) Disappearance of boreal plants in southern Britain: habitat loss or climate change? *Biological Journal of the Linnean Society*, **115**, 598-610.
- Hobbs, R.J., Higgs, E. & Harris, J.A. (2009) Novel ecosystems: implications for conservation and restoration. *Trends in Ecology & Evolution*, **24**, 599-605.
- Hodd, R.L., Bourke, D. & Skeffington, M.S. (2014) Projected Range Contractions of European Protected Oceanic Montane Plant Communities: Focus on Climate Change Impacts Is Essential for Their Future Conservation. *PloS one*, **9**, e95147.
- Hodgetts, N., Calix, M., Englefield, E., Fettes, N., García Criado, M., Patin, L., Nieto, A., Bergamini, A., Bisang, I., Baisheva, E.v., Campisi, P., Cogoni, A., Hallingbäck, T., Konstantinova, N., Lockhart, N., Sabovljevic, M., Schnyder, N., Schröck, C., Sérgio, C. & Zarnowiec, J. (2019) *A miniature world in decline European Red List of Mosses, Liverworts and Hornworts*.
- Hodgetts, N., Lockhart, N., Rothero, G., Sergio, C. & Vanderpoorten, A. 2019. *Acrobolbus wilsonii*. *The IUCN Red List of Threatened Species* 2019: e.T78591292A87791487. <https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T78591292A87791487.en>. Accessed on 22 September 2023.
- Hodgetts, N., Lockhart, N., Rothero, G. & Vanderpoorten, A. 2019. *Radula voluta* (Europe assessment). *The IUCN Red List of Threatened Species* 2019: e.T87544389A87824676. Accessed on 22 September 2023.
- Hollis, D., McCarthy, M., Kendon, M., Legg, T. & Simpson, I. (2018) HadUK-Grid gridded and regional average climate observations for the UK. *Centre for Environmental Data Analysis*.
- Hutsemékers, V., Mouton, L., Westenbohm, H., Collart, F. & Vanderpoorten, A. (2023) Disentangling climate change from air pollution effects on epiphytic bryophytes. *Global Change Biology*, **29**, 3990-4000.
- IPCC, 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A.

Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

- Jang, K. & Viles, H. (2022) Moisture Interactions Between Mosses and Their Underlying Stone Substrates. *Studies in Conservation*, **67**, 532-544.
- Jenkins, G.J., Perry, M.C., and Prior, M.J. (2008). The climate of the United Kingdom and recent trends. Met Office Hadley Centre, Exeter, UK.
- Karger, D.N., Kluge, J., Abrahamczyk, S., Salazar, L., Homeier, J., Lehnert, M., Amoroso, V.B. & Kessler, M. (2012) Bryophyte cover on trees as proxy for air humidity in the tropics. *Ecological Indicators*, **20**, 277-281.
- Kassambara A, Mundt F (2020). *factoextra: Extract and Visualize the Results of Multivariate Data Analyses*. R package version 1.0.7. Available at: <https://CRAN.R-project.org/package=factoextra>
- Kassambara A (2022). *ggcorrplot: Visualization of a Correlation Matrix using 'ggplot2'*. R package version 0.1.4. Available at: <https://CRAN.R-project.org/package=ggcorrplot>
- Kaufmann, S. & Berg, C. (2014) Bryophyte Ecology and Conservation in the Troodos Mountains, Cyprus. *Herzogia*, **27**, 165-187, 123.
- Keenan, T.F., Luo, X., De Kauwe, M.G., Medlyn, B.E., Prentice, I.C., Stocker, B.D., Smith, N.G., Terrer, C., Wang, H., Zhang, Y. & Zhou, S. (2021) RETRACTED ARTICLE: A constraint on historic growth in global photosynthesis due to increasing CO₂. *Nature*, **600**, 253-258.
- Kent, R. & Carmel, Y. (2011) Presence-only versus presence-absence data in species composition determinant analyses. *Diversity and Distributions*, **17**, 474-479.
- Kessler, M. (2001) Pteridophyte species richness in Andean forests in Bolivia. *Biodiversity & Conservation*, **10**, 1473-1495.
- Kim, K.-H., Cho, J., Lee, Y.H. & Lee, W.-S. (2015) Predicting potential epidemics of rice leaf blast and sheath blight in South Korea under the RCP 4.5 and RCP 8.5 climate change scenarios using a rice disease epidemiology model, EPIRICE. *Agricultural and Forest Meteorology*, **203**, 191-207.
- Köster, N., Kreft, H., Nieder, J. & Barthlott, W. (2013) Range size and climatic niche correlate with the vulnerability of epiphytes to human land use in the tropics. *Journal of Biogeography*, **40**, 963-976.
- Laaka-Lindberg, S., Korpelainen, H. & Pohjamo, M. (2003) DISPERSAL OF ASEXUAL PROPAGULES IN BRYOPHYTES. *The Journal of the Hattori Botanical Laboratory*, **93**, 319-330.
- Larsen, R.S., Bell, J.N.B., James, P.W., Chimonides, P.J., Rumsey, F.J., Tremper, A. & Purvis, O.W. (2007) Lichen and bryophyte distribution on oak in London in relation to air pollution and bark acidity. *Environmental Pollution*, **146**, 332-340.
- LeBlanc, F. & Rao, D.N. (1973) Effects of Sulphur Dioxide on Lichen and Moss Transplants. *Ecology*, **54**, 612-617.
- Lee, H., Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P., Trisos, C., Romero, J., Aldunce, P. & Barrett, K. (2023) Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.
- Li, G., Fang, C., Li, Y., Wang, Z., Sun, S., He, S., Qi, W., Bao, C., Ma, H., Fan, Y., Feng, Y. & Liu, X. (2022) Global impacts of future urban expansion on terrestrial vertebrate diversity. *Nature Communications*, **13**, 1628.

- Littlewood, N., Anderson, P., Artz, R., Bragg, O., Lunt, P. & Marrs, R. (2010) Peatland biodiversity. *IUCN UK Peatland Programme, Edinburgh*.
- Liu, Y., Chen, J., Pan, T., Liu, Y., Zhang, Y., Ge, Q., Ciais, P. & Penuelas, J. (2020) Global Socioeconomic Risk of Precipitation Extremes Under Climate Change. *Earth's Future*, **8**, e2019EF001331.
- Longton, R. (2019) Sexual reproduction in bryophytes in relation to physical factors of the environment. *Bryophyte development*, pp. 139-166. CRC Press.
- Majestyk, P. (2011) A TAXONOMIC TREATMENT OF DALTONIA (MUSCI: DALTONIACEAE) IN THE AMERICAS. *Journal of the Botanical Research Institute of Texas*, **5**, 553-575.
- Mandrekar, J.N. (2010) Receiver Operating Characteristic Curve in Diagnostic Test Assessment. *Journal of Thoracic Oncology*, **5**, 1315-1316.
- Marcucci, A., Panos, E., Kypreos, S. & Fragkos, P. (2019) Probabilistic assessment of realizing the 1.5 °C climate target. *Applied Energy*, **239**, 239-251.
- Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L. & Gomis, M. (2021) Climate change 2021: the physical science basis. *Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change*, **2**.
- Merkle, M., Alexander, P., Brown, C., Seo, B., Harrison, P.A., Harmáčková, Z.V., Pedde, S. & Rounsevell, M. (2022) Downscaling population and urban land use for socio-economic scenarios in the UK. *Regional Environmental Change*, **22**, 106.
- Merkle, M., Dellaccio, O., Dunford, R., Harmáčková, Z.V., Harrison, P.A., Mercure, J.F., Pedde, S., Seo, B., Simsek, Y., Stenning, J. & Rounsevell, M. (2023) Creating quantitative scenario projections for the UK shared socioeconomic pathways. *Climate Risk Management*, **40**, 100506.
- Met Office (2013). National Meteorological Library and Archive Fact sheet 4 — Climate of the British Isles. Accessed 21/09/2023. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/library-and-archive/library/publications/factsheets/factsheet_4-climate-of-the-british-isles.pdf
- Økland, T., Halvorsen, R., Lange, H., Nordbakken, J.-F. & Clarke, N. (2023) Climate change drives substantial decline of understory species richness and abundance in Norway spruce forests during 32 years of vegetation monitoring. *Journal of Vegetation Science*, **34**, e13191.
- Pardow, A. & Lakatos, M. (2013) Desiccation Tolerance and Global Change: Implications for Tropical Bryophytes in Lowland Forests. *Biotropica*, **45**, 27-36.
- Patiño, J. & Vanderpoorten, A. (2018) Bryophyte Biogeography. *Critical Reviews in Plant Sciences*, **37**, 175-209.
- Pearce-Higgins, J.W., Beale, C.M., Oliver, T.H., August, T.A., Carroll, M., Massimino, D., Ockendon, N., Savage, J., Wheatley, C.J., Ausden, M.A., Bradbury, R.B., Duffield, S.J., Macgregor, N.A., McClean, C.J., Morecroft, M.D., Thomas, C.D., Watts, O., Beckmann, B.C., Fox, R., Roy, H.E., Sutton, P.G., Walker, K.J. & Crick, H.Q.P. (2017) A national-scale assessment of climate change impacts on species: Assessing the balance of risks and opportunities for multiple taxa. *Biological Conservation*, **213**, 124-134.
- Pearson, R.G., Raxworthy, C.J., Nakamura, M. & Townsend Peterson, A. (2007) ORIGINAL ARTICLE: Predicting species distributions from small numbers of occurrence records: a test case using cryptic geckos in Madagascar. *Journal of Biogeography*, **34**, 102-117.
- Perry, A.L., Low, P.J., Ellis, J.R. & Reynolds, J.D. (2005) Climate Change and Distribution Shifts in Marine Fishes. *Science*, **308**, 1912-1915.

- Persson, H. (1950) *Marsupella alpina* (G.) Bernet, a New Member of the Group of Hyperoceanic Bryophytes in North America. *The Bryologist*, **53**, 172-174.
- Pescott, O. & Preston, C. (2014) Some environmental factors influencing the distribution of bryophytes in Britain and Ireland. *Atlas of British and Irish Bryophytes*. Newbury, UK: Pisces Publications.
- Pescott, O.L., Simkin, J.M., August, T.A., Randle, Z., Dore, A.J. & Botham, M.S. (2015) Air pollution and its effects on lichens, bryophytes, and lichen-feeding Lepidoptera: review and evidence from biological records. *Biological Journal of the Linnean Society*, **115**, 611-635.
- Policy, H.W., Johnson, H.B., Marinot, B.D. & Mayeux, H.S. (1993) Increase in C3 plant water-use efficiency and biomass over Glacial to present CO2 concentrations. *Nature*, **361**, 61-64.
- Pörtner, H.-O., Roberts, D.C., Poloczanska, E.S., Mintenbeck, K., Tignor, M., Alegría, A., Craig, M., Langsdorf, S., Lösschke, S. & Möller, V. (2022) IPCC, 2022: Summary for policymakers.
- Posit team (2023). RStudio: Integrated Development Environment for R. Posit Software, PBC, Boston, MA. Available at: <http://www.posit.co/>
- Preston, C.D., Harrower, C.A. & Hill, M.O. (2013) A comparison of distribution patterns in British and Irish mosses and liverworts. *Journal of Bryology*, **35**, 71-87.
- Preston, C.D. & Hill, M.O. (1999) The geographical relationships of the British and Irish flora: a comparison of pteridophytes, flowering plants, liverworts and mosses. *Journal of Biogeography*, **26**, 629-642.
- Proctor, M.C.F. (2000) The bryophyte paradox: tolerance of desiccation, evasion of drought. *Plant Ecology*, **151**, 41-49.
- Qian, L.-S., Shi, H.-H., Ou, X.-K. & Sun, H. (2022) Elevational patterns of functional diversity and trait of *Delphinium* (Ranunculaceae) in Hengduan Mountains, China. *Plant Diversity*, **44**, 20-29.
- Ratcliffe, D.A. (1968) An Ecological Account of Atlantic Bryophytes in the British Isles. *The New Phytologist*, **67**, 365-439.
- Rathore, M.K. & Sharma, L.K. (2023) Efficacy of species distribution models (SDMs) for ecological realms to ascertain biological conservation and practices. *Biodiversity and Conservation*, **32**, 3053-3087.
- Reid, C., Hornigold, K., McHenry, E., Nichols, C., Townsend, M., Lewthwaite, K., Elliot, M., Pullinger, R., Hotchkiss, A. & Gilmartin, E. (2021) State of the UK's Woods and Trees 2021. *Grantham: The Woodland Trust*.
- Riahi, K., van Vuuren, D.P., Kriegler, E., Edmonds, J., O'Neill, B.C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J.C., Kc, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., Ebi, K., Hasegawa, T., Havlik, P., Humpenöder, F., Da Silva, L.A., Smith, S., Stehfest, E., Bosetti, V., Eom, J., Gernaat, D., Masui, T., Rogelj, J., Strefler, J., Drouet, L., Krey, V., Luderer, G., Harmsen, M., Takahashi, K., Baumstark, L., Doelman, J.C., Kainuma, M., Klimont, Z., Marangoni, G., Lotze-Campen, H., Obersteiner, M., Tabeau, A. & Tavoni, M. (2017) The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change*, **42**, 153-168.
- Rixen, C. & Mulder, C.P.H. (2005) Improved water retention links high species richness with increased productivity in arctic tundra moss communities. *Oecologia*, **146**, 287-299.
- Rotherham, I.D. (2017) *Recombinant ecology-a hybrid future?* Springer.

- Ruklani, S., Rubasinghe, S.C.K. & Jayasuriya, G. (2021) A review of frameworks for using bryophytes as indicators of climate change with special emphasis on Sri Lankan bryoflora. *Environmental Science and Pollution Research*, **28**, 60425-60437.
- Sabovljevic, M., Papp, B., Blockeel, T., Ignatov, M., Hallingbäck, T & Söderström, L. 2019. *Metzgeria leptoneura* (Europe assessment). *The IUCN Red List of Threatened Species* 2019: e.T87538940A87781397. Accessed on 22 September 2023.
- Schaffers, A.P. & Sýkora, K.V. (2000) Reliability of Ellenberg indicator values for moisture, nitrogen and soil reaction: a comparison with field measurements. *Journal of Vegetation Science*, **11**, 225-244.
- Sebastien Le, Julie Josse, Francois Husson (2008). FactoMineR: An R Package for Multivariate Analysis. *Journal of Statistical Software*, 25(1), 1-18. DOI: 10.18637/jss.v025.i01
- Sérgio, C., Figueira, R. & Menezes, R. (2011) Modeling the distribution of *Sematophyllum substrumulosum* (Hampe) E. Britton as a signal of climatic changes in Europe. *Bryophyte ecology and climate change*. Cambridge Univ. Press, Cambridge, 427-440.
- Serk, H., Nilsson, M.B., Bohlin, E., Ehlers, I., Wieloch, T., Olid, C., Grover, S., Kalbitz, K., Limpens, J., Moore, T., Münchberger, W., Talbot, J., Wang, X., Knorr, K.-H., Pancotto, V. & Schleucher, J. (2021) Global CO₂ fertilization of Sphagnum peat mosses via suppression of photorespiration during the twentieth century. *Scientific Reports*, **11**, 24517.
- Shaw, A.J., Szövényi, P. & Shaw, B. (2011) Bryophyte diversity and evolution: Windows into the early evolution of land plants. *American Journal of Botany*, **98**, 352-369.
- Shea, K. & Chesson, P. (2002) Community ecology theory as a framework for biological invasions. *Trends in Ecology & Evolution*, **17**, 170-176.
- Sillett, S.C. & Antoine, M.E. (2004) Lichens and bryophytes in forest canopies. *Forest canopies*, **2**, 151-174.
- Sim-Sim, M., Garcia, C., Garilleti, R., Infante, M., Porley, R.D. & Sergio, C. 2019. *Radula holtii*. *The IUCN Red List of Threatened Species* 2019: e.T87544353A87715654. <https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T87544353A87715654.en>. Accessed on 22 September 2023.
- Sim-Sim, M., Garcia, C., Garilleti, R., Infante, M., Porley, R.D. & Sergio, C. 2019. *Radula carringtonii*. *The IUCN Red List of Threatened Species* 2019: e.T87544340A87715649. <https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T87544340A87715649.en>. Accessed on 22 September 2023.
- Sinclair, S.J., White, M.D. & Newell, G.R. (2010) How Useful Are Species Distribution Models for Managing Biodiversity under Future Climates? *Ecology and Society*, **15**.
- Song, L., Ma, W.-Z., Yao, Y.-L., Liu, W.-Y., Li, S., Chen, K., Lu, H.-Z., Cao, M., Sun, Z.-H., Tan, Z.-H. & Nakamura, A. (2015) Bole bryophyte diversity and distribution patterns along three altitudinal gradients in Yunnan, China. *Journal of Vegetation Science*, **26**, 576-587.
- Spicer, M.E. & Woods, C.L. (2022) A case for studying biotic interactions in epiphyte ecology and evolution. *Perspectives in Plant Ecology, Evolution and Systematics*, **54**, 125658.
- Spill, J. (2021). *Species Distribution Modelling of Hyperoceanic Epiphytic Bryophytes under present and projected future climate in Wales* (Unpublished master's thesis). King's College London, London, United Kingdom.
- Starzomski, B.M. (2013) Novel Ecosystems and Climate Change. *Novel Ecosystems*, pp. 88-101.

- Szymura, T.H., Szymura, M. & Macioł, A. (2014) Bioindication with Ellenberg's indicator values: A comparison with measured parameters in Central European oak forests. *Ecological Indicators*, **46**, 495-503.
- Szymura, T.H., Szymura, M. & Macioł, A. (2014) Bioindication with Ellenberg's indicator values: A comparison with measured parameters in Central European oak forests. *Ecological Indicators*, **46**, 495-503.
- Tabari, H. (2020) Climate change impact on flood and extreme precipitation increases with water availability. *Scientific Reports*, **10**, 13768.
- ter Braak, C.J.F. (1986) Canonical Correspondence Analysis: A New Eigenvector Technique for Multivariate Direct Gradient Analysis. *Ecology*, **67**, 1167-1179.
- Terrer, C., Phillips, R.P., Hungate, B.A., Rosende, J., Pett-Ridge, J., Craig, M.E., van Groenigen, K.J., Keenan, T.F., Sulman, B.N., Stocker, B.D., Reich, P.B., Pellegrini, A.F.A., Pendall, E., Zhang, H., Evans, R.D., Carrillo, Y., Fisher, J.B., Van Sundert, K., Vicca, S. & Jackson, R.B. (2021) A trade-off between plant and soil carbon storage under elevated CO₂. *Nature*, **591**, 599-603.
- Thuiller, W., Albert, C., Araújo, M.B., Berry, P.M., Cabeza, M., Guisan, A., Hickler, T., Midgley, G.F., Paterson, J., Schurr, F.M., Sykes, M.T. & Zimmermann, N.E. (2008) Predicting global change impacts on plant species' distributions: Future challenges. *Perspectives in Plant Ecology, Evolution and Systematics*, **9**, 137-152.
- Tng, D.Y.P., Dalton, P.J. & Jordan, G.J. (2009) Does Moisture Affect the Partitioning of Bryophytes between Terrestrial and Epiphytic Substrates within Cool Temperate Rain Forests? *The Bryologist*, **112**, 506-519.
- Toet, S., Cornelissen, J.H.C., Aerts, R., van Logtestijn, R.S.P., de Beus, M. & Stoevelaar, R. (2006) Moss Responses to Elevated CO₂ and Variation in Hydrology in a Temperate Lowland Peatland. *Plant Ecology*, **182**, 27-40.
- Turetsky, M.R. (2003) The Role of Bryophytes in Carbon and Nitrogen Cycling. *The Bryologist*, **106**, 395-409.
- van Vuuren, D.P., Kriegler, E., O'Neill, B.C., Ebi, K.L., Riahi, K., Carter, T.R., Edmonds, J., Hallegatte, S., Kram, T., Mathur, R. & Winkler, H. (2014) A new scenario framework for Climate Change Research: scenario matrix architecture. *Climatic Change*, **122**, 373-386.
- VanDerWal, J., Murphy, H.T., Kutt, A.S., Perkins, G.C., Bateman, B.L., Perry, J.J. & Reside, A.E. (2013) Focus on poleward shifts in species' distribution underestimates the fingerprint of climate change. *Nature Climate Change*, **3**, 239-243.
- Vohra, K., Marais, E.A., Suckra, S., Kramer, L., Bloss, W.J., Sahu, R., Gaur, A., Tripathi, S.N., Van Damme, M., Clarisse, L. & Coheur, P.F. (2021) Long-term trends in air quality in major cities in the UK and India: a view from space. *Atmos. Chem. Phys.*, **21**, 6275-6296.
- Wand, S.J.E., Midgley, G.F., Jones, M.H. & Curtis, P.S. (1999) Responses of wild C₄ and C₃ grass (Poaceae) species to elevated atmospheric CO₂ concentration: a meta-analytic test of current theories and perceptions. *Global Change Biology*, **5**, 723-741.
- Wen, Y., Qin, D.-w., Leng, B., Zhu, Y.-f. & Cao, K.-f. (2018) The physiological cold tolerance of warm-climate plants is correlated with their latitudinal range limit. *Biology Letters*, **14**, 20180277.
- Wieczynski, D.J., Boyle, B., Buzzard, V., Duran, S.M., Henderson, A.N., Hulshof, C.M., Kerkhoff, A.J., McCarthy, M.C., Michaletz, S.T., Swenson, N.G., Asner, G.P., Bentley, L.P., Enquist, B.J. & Savage, V.M. (2019) Climate shapes and shifts functional biodiversity in forests worldwide. *Proceedings of the National Academy of Sciences*, **116**, 587-592.

- Wisn, M.S., Hijmans, R.J., Li, J., Peterson, A.T., Graham, C.H., Guisan, A. & Group, N.P.S.D.W. (2008) Effects of sample size on the performance of species distribution models. *Diversity and Distributions*, **14**, 763-773.
- Wolf, J. (1993) Diversity Patterns and Biomass of Epiphytic Bryophytes and Lichens Along an Altitudinal Gradient in the Northern Andes. *Annals of the Missouri Botanical Garden*, **80**, 928-960.
- Wood, A.J. (2007) The nature and distribution of vegetative desiccation-tolerance in hornworts, liverworts and mosses. *The Bryologist*, **110**, 163-177, 115.
- Wyatt, R. (1982) Population ecology of bryophytes. *The Journal of the Hattori Botanical Laboratory*, **52**, 179-198.
- Yoshikawa, K., Overduin, P.P. & Harden, J.W. (2004) Moisture content measurements of moss (Sphagnum spp.) using commercial sensors. *Permafrost and Periglacial Processes*, **15**, 309-318.
- Zanatta, F., Engler, R., Collart, F., Broennimann, O., Mateo, R.G., Papp, B., Muñoz, J., Baurain, D., Guisan, A. & Vanderpoorten, A. (2020) Bryophytes are predicted to lag behind future climate change despite their high dispersal capacities. *Nature Communications*, **11**, 5601.
- Zelený, D. & Schaffers, A.P. (2012) Too good to be true: Pitfalls of using mean Ellenberg indicator values in vegetation analyses. *Journal of Vegetation Science*, **23**, 419-431.
- Zhang, Y., He, N. & Liu, Y. (2023) Temperature factors are a primary driver of the forest bryophyte diversity and distribution in the southeast Qinghai-Tibet Plateau. *Forest Ecology and Management*, **527**, 120610.

Appendix

Appendix 1: Current Distribution SDM R Code

```
## -----  
##  
## Script Name: Current Distribution Mode.R  
##  
## Purpose of the script: This script uses pre-existing record data for nine  
## hyperoceanic bryophyte species. Three species (Daltonia splachnoides, Colura  
## calyptrifolia and Lejeunea patens) were identified during field observations  
## and the remaining six are threatened from extinction. These records are used  
## to create one species distribution model for each species using five model  
## methods with 10 replicates for each method.  
##  
## Author: Oliver Morgan - Swansea University MRes Student  
##  
## Date Created: September 2023  
##  
## Email: [REDACTED]  
##  
## -----
```

```
### We use these packages to enable a a number of functions.
```

```
library("sdm")  
library("maptools")  
library("raster")  
library("dismo")  
library("geodata")  
library(corrplot)  
library(kernlab)  
library(e1071)
```

```

library(earth)
library(randomForest)
library(sdm)
library(devtools)
library(remotes)
library(mecofun)
library(usdm)
library("mapview")

## Here we download climatic data from the worldclim database.

bio <- raster::getData('worldclim',var='bio',res=2.5)
bio

## Here we crop the worldclim data to the UK for plotting.

UK_extentcurrent <- extent(-12,2,49,60)

## Worldclim temperature data is stored as °C * 10. Here we return temperature
## values to true values. Bio3 is also stored

UK_Data_current[["bio1"]] <- UK_Data_current[["bio1"]]/10
UK_Data_current[["bio2"]] <- UK_Data_current[["bio2"]]/10
UK_Data_current[["bio3"]] <- UK_Data_current[["bio3"]]/100
UK_Data_current[["bio5"]] <- UK_Data_current[["bio5"]]/10
UK_Data_current[["bio6"]] <- UK_Data_current[["bio6"]]/10
UK_Data_current[["bio7"]] <- UK_Data_current[["bio7"]]/10
UK_Data_current[["bio8"]] <- UK_Data_current[["bio8"]]/10
UK_Data_current[["bio9"]] <- UK_Data_current[["bio9"]]/10
UK_Data_current[["bio10"]] <- UK_Data_current[["bio10"]]/10
UK_Data_current[["bio11"]] <- UK_Data_current[["bio11"]]/10

## We can inspect the worldclim data of the UK.

```

```

plot(UK_Data_current[[1]])

## Here we test for multicollinearity and remove variables that are highly correlated.

v1 <- vifstep(as.data.frame(bio))
climatefocus1 <- exclude(UK_Data_current, v1)
UK_Data_current1 <- crop(climatefocus1, UK_extentcurrent)

#####

## Daltonia splachnoides

## Here we download species occurrence records.

sp <- gbif("Daltonia", "splachnoides", download = T, geo=T, sp=F)

class(sp)

w <- which(is.na(sp$lon))
sp <- sp[-w,]
w <- which(is.na(sp$lat))
sp$species <- 1
sp <- sp[,c('lon', 'lat', 'species')]
head(sp)

# convert to spatial point

coordinates(sp) <- ~lon + lat
class(sp)
head(sp)

par(mfrow=c(1,1))
plot(UK_Data_current1[[1]])
points(sp, cex=0.5, pch=16)

```

```

proj4string(sp) <- projection(raster())
mapview(sp)

head(sp)
nrow(sp)

d <- sdmData(species~., sp, predictors = UK_Data_current1, bg = list(n=1000))
d

getmethodNames()
m <- sdm(species~., d, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

m

p <- predict(m, UK_Data_current1)
p

plot(p[[26]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Daltonia
splachnoides (W.J.Hooker & Taylor, 1818)")

## Here we can visually inspect the data to see which model method best
## explains the output by changing the selected column above [[1]] / [[3]]

points(sp, cex=0.5, pch=16)
#####

## Acrobolbus wilsonii

## Here we download species occurrence records.

spAW <- gbif("Acrobolbus ", "wilsonii", download = T, geo=T, sp=F)

class(spAW)

```

```

wAW <- which(is.na(spAW$lon))
spAW <- spAW[-wAW,]
wAW <- which(is.na(spAW$lat))
spAW$species <- 1
spAW <- spAW[,c('lon', 'lat', 'species')]
head(spAW)

# convert to spatial point

coordinates(spAW) <- ~lon + lat
class(spAW)
head(spAW)

plot(UK_Data_current1[[1]])
points(spAW, cex=0.5, pch=16)

proj4string(spAW) <- projection(raster())
mapview(spAW)

head(spAW)
nrow(spAW)

dAW <- sdmData(species~., spAW, predictors = UK_Data_current1, bg = list(n=1000))
dAW

getmethodNames()
mAW <- sdm(species~., dAW, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mAW

pAW <- predict(mAW, UK_Data_current1)
pAW

```

```
plot(pAW[[26]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Acrobolbus wilsonii, VU")
```

```
## A good rule of thumb if your machine is struggling with the modelling is to
```

```
## free unused R memory as this may speed up run times.
```

```
#####
```

```
## Lejeunea mandonii
```

```
## Here we download species occurrence records.
```

```
spCS <- gbif("Lejeunea ", "mandonii", download = T, geo=T, sp=F)
```

```
class(spCS)
```

```
wCS <- which(is.na(spCS$lon))
```

```
spCS <- spCS[-wCS,]
```

```
wCS <- which(is.na(spCS$lat))
```

```
spCS$species <- 1
```

```
spCS <- spCS[,c('lon', 'lat', 'species')]
```

```
head(spCS)
```

```
# convert to spatial point
```

```
coordinates(spCS) <- ~lon + lat
```

```
class(spCS)
```

```
head(spCS)
```

```
plot(UK_Data_current1[[1]])
```

```
points(spCS, cex=0.5, pch=16)
```

```
proj4string(spCS) <- projection(raster())
```

```
mapview(spAW)
```

```

head(spCS)
nrow(spCS)

dCS <- sdmData(species~., spCS, predictors = UK_Data_current1, bg = list(n=1000))
dCS

getmethodNames()
mCS <- sdm(species~., dCS, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mCS

pCS <- predict(mCS, UK_Data_current1)
pCS

plot(pCS[[27]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Lejeunea
mandonii")

#####

## Metzgeria leptoneura

## Here we download species occurrence records.

spML <- gbif("Metzgeria ", "leptoneura", download = T, geo=T, sp=F)

class(spML)

wML <- which(is.na(spML$lon))
spML <- spML[-wML,]
wML <- which(is.na(spML$lat))
spML$species <- 1
spML <- spML[,c('lon', 'lat', 'species')]

```

```

head(spML)

# convert to spatial point

coordinates(spML) <- ~lon + lat
class(spML)
head(spML)

plot(UK_Data_current[[1]])
points(spML, cex=0.5, pch=16)

proj4string(spML) <- projection(raster())
mapview(spML)

head(spML)
nrow(spML)

dML <- sdmData(species~., spML, predictors = UK_Data_current1, bg = list(n=1000))
dML

getmethodNames()
mML <- sdm(species~., dML, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mML

pML <- predict(mML, UK_Data_current1)
pML

plot(pML[[22]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Metzgeria
leptoneura")

```

```
#####
```

```
## Radula carringtonii
```

```
## Here we download species occurrence records.
```

```
spRC <- gbif("Radula ", "carringtonii", download = T, geo=T, sp=F)
```

```
class(spRC)
```

```
wRC <- which(is.na(spRC$lon))
```

```
spRC <- spRC[-wRC,]
```

```
wRC <- which(is.na(spRC$lat))
```

```
spRC$species <- 1
```

```
spRC <- spRC[,c('lon', 'lat', 'species')]
```

```
head(spRC)
```

```
# convert to spatial point
```

```
coordinates(spRC) <- ~lon + lat
```

```
class(spRC)
```

```
head(spRC)
```

```
plot(UK_Data_current1[[1]])
```

```
points(spRC, cex=0.5, pch=16)
```

```
proj4string(spRC) <- projection(raster())
```

```
mapview(spRC)
```

```
head(spRC)
```

```
nrow(spRC)
```

```
dRC <- sdmData(species~., spRC, predictors = UK_Data_current1, bg = list(n=1000))
```

```
dRC
```

```

getmethodNames()
mRC <- sdm(species~., dRC, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mRC

pRC <- predict(mRC, UK_Data_current1)
pRC

plot(pRC[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Radula
carringtonii")

#####

## Radula holtii

## Here we download species occurrence records.

spRH <- gbif("Radula ", "holtii", download = T, geo=T, sp=F)

class(spRH)

wRH <- which(is.na(spRH$lon))
spRH <- spRH[-wRH,]
wRH <- which(is.na(spRH$lat))
spRH$species <- 1
spRH <- spRH[,c('lon', 'lat','species')]
head(spRH)

# convert to spatial point

coordinates(spRH) <- ~lon + lat
class(spRH)
head(spRH)

```

```

plot(UK_Data_current1[[1]], xlim=c(-12, 5), ylim=c(48, 64))
points(spRH, cex=0.5, pch=16)

proj4string(spRH) <- projection(raster())
mapview(spRH)

head(spRH)
nrow(spRH)

dRH<- sdmData(species~., spRH, predictors = UK_Data_current1, bg = list(n=1000))
dRH

getmethodNames()
mRH <- sdm(species~., dRH, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mRH

pRH <- predict(mRH, UK_Data_current1)
pRH

plot(pRH[[27]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Radula
holtii")

#####

## Radula voluta

## Here we download species occurrence records.

spRV <- gbif("Radula ", "voluta", download = T, geo=T, sp=F)

class(spRV)

wRV <- which(is.na(spRV$lon))

```

```

spRV <- spRV[~wRV,]
wRV <- which(is.na(spRV$lat))
spRV$species <- 1
spRV <- spRV[,c('lon', 'lat', 'species')]
head(spRV)

# convert to spatial point

coordinates(spRV) <- ~lon + lat
class(spRV)
head(spRV)

plot(UK_Data_current1[[1]])
points(spRV, cex=0.5, pch=16)

proj4string(spRV) <- projection(raster())
mapview(spRV)

head(spRV)
nrow(spRV)

dRV<- sdmData(species~., spRV, predictors = UK_Data_current1, bg = list(n=1000))
dRV

getmethodNames()
mRV <- sdm(species~., dRV, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mRV

pRV <- predict(mRV, UK_Data_current1)
pRV

```

```
plot(pRV[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Radula  
voluta")
```

```
#####
```

```
## Colura calyptrifolia
```

```
## Here we download species occurrence records.
```

```
spCC <- gbif("Colura ", "calyptrifolia", download = T, geo=T, sp=F)
```

```
class(spCC)
```

```
wCC <- which(is.na(spCC$lon))
```

```
spCC <- spCC[-wCC,]
```

```
wCC <- which(is.na(spCC$lat))
```

```
spCC$species <- 1
```

```
spCC <- spCC[,c('lon', 'lat', 'species')]
```

```
head(spCC)
```

```
# convert to spatial point
```

```
coordinates(spCC) <- ~lon + lat
```

```
class(spCC)
```

```
head(spCC)
```

```
plot(UK_Data_current1[[1]])
```

```
points(spCC, cex=0.5, pch=16)
```

```
proj4string(spCC) <- projection(raster())
```

```
mapview(spCC)
```

```
head(spCC)
```

```
nrow(spCC)
```

```

dCC<- sdmData(species~., spCC, predictors = UK_Data_current1, bg = list(n=1000))
dCC

getmethodNames()
mCC <- sdm(species~., dCC, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mCC

pCC <- predict(mCC, UK_Data_current1)
pCC

plot(pCC[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Colura
caltryptrifolia")

#####

## Lejeunea patens

## Here we download species occurrence records.

spLP <- gbif("Lejeunea ", "patens", download = T, geo=T, sp=F)

class(spLP)

wLP <- which(is.na(spLP$lon))
spLP <- spLP[-wLP,]
wLP <- which(is.na(spLP$lat))
spLP$species <- 1
spLP <- spLP[,c('lon', 'lat', 'species')]
head(spLP)

# convert to spatial point

```

```

coordinates(spLP) <- ~lon + lat
class(spLP)
head(spLP)

plot(UK_Data_current1[[1]])
points(spLP, cex=0.5, pch=16)

proj4string(spLP) <- projection(raster())
mapview(spLP)

head(spLP)
nrow(spLP)

dLP<- sdmData(species~., spLP, predictors = UK_Data_current1, bg = list(n=1000))
dLP

getmethodNames()
mLP <- sdm(species~., dLP, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mLP

pLP <- predict(mLP, UK_Data_current1)
pLP

plot(pLP[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Lejeunea
patens")

#####

## Here we set the graphical parameters to display 1 row of 3 plots.

par(mfrow=c(1,3))

```

```
## Here we plot the non-ensemble SDMs.
```

```
plot(p[[27]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Daltonia  
splachnoides (W.J.Hooker & Taylor, 1818)")
```

```
plot(pCC[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Colura  
caltryptrifolia")
```

```
plot(pLP[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Lejeunea  
patens")
```

```
## Here we set the graphical parameters to display 3 row of 2 plots per row.
```

```
par(mfrow=c(3,2))
```

```
## Here we plot the non-ensemble SDMs.
```

```
plot(pRV[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Radula  
voluta")
```

```
plot(pRH[[7]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Radula  
holtii")
```

```
plot(pRC[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Radula  
carringtonii")
```

```
plot(pML[[1]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Metzgeria  
leptoneura")
```

```
plot(pCS[[1]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Lejeunea  
mandonii")
```

```
plot(pAW[[5]], xlim=c(-12, 5), ylim=c(48, 64), xlab="Longitude", ylab="Latitude", main="Acrobolbus  
wilsonii, VU")
```

```
## Here we can plot the ensemble of the model methods by weighted average of AUC scores
```

```
## Here we set the graphical parameters to display 1 plot at a time.
```

```
par(mfrow=c(1,1))
```

```
## Here we plot the three species identified during field sampling.
```

```

plot(ensemble(m, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

plot(ensemble(mCC, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

plot(ensemble(mLP, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

## Here we set the graphical parameters to display 3 row of 2 plots per row.

par(mfrow=c(3,2))

## Here we model the six threatened species.

plot(ensemble(mAW, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

text(x= -14, y= 59.5, "A", cex = 2)

plot(ensemble(mCS, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

text(x= -14, y= 59.5, "B", cex = 2)

plot(ensemble(mRC, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

text(x= -14, y= 59.5, "C", cex = 2)

plot(ensemble(mML, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

text(x= -14, y= 59.5, "D", cex = 2)

plot(ensemble(mRH, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

text(x= -14, y= 59.5, "E", cex = 2)

plot(ensemble(mRV, UK_Data_current1, setting = list(method='weighted', stat =
'AUC')),xlab="Longitude", ylab="Latitude")

text(x= -14, y= 59.5, "F", cex = 2)

```

Appendix 2: Future Distribution SDM R Code

```
## -----  
##  
## Script Name: FUTURES.DMS.R  
##  
## Purpose of the script: This script uses pre-existing record data for nine  
## hyperoceanic bryophyte species. Three species (Daltonia splachnoides, Colura  
## calyptrifolia and Lejeunea patens) were identified during field observations  
## and the remaining six are threatened from extinction. These records were  
## modelled against future predicted climate conditions using worldclim data. This  
## data is based on Shared Socio-economic Pathway 3 (SSP3). The species records  
## are used to create one species distribution model for each species using  
## five model methods with 10 replicates for each method.  
##  
## Author: Oliver Morgan - Swansea University MRes Student  
##  
## Date Created: September 2023  
##  
## Email: [REDACTED]  
##  
## -----
```

```
### We use these packages to enable a number of functions.
```

```
library("sdm")  
library("maptools")  
library("raster")  
library("dismo")  
library("geodata")  
library("usdm")  
library("mapview")  
library("kernlab")
```

```
library(e1071)
```

```
library(earth)
```

```
library(randomForest)
```

```
## Here we download the future projected worldclim data.
```

```
clim_fut <- geodata::cmip6_world(model='ACCESS-ESM1-5', ssp='370', time='2081-2100', var='bioc',  
download=F, res=2.5, path='data')
```

```
## Here we set out the coordinates of the UK to reduce the size of the worldclim
```

```
## data to just data of the UK.
```

```
UK_extentFuture <- extent(-12,2,49,60)
```

```
## Here we check for multicollinearity and remove variables.
```

```
v2 <- vifstep(as.data.frame(clim_fut))
```

```
climatefocus2 <- exclude(clim_fut, v2)
```

```
## Here we crop the worldclim data using the coordinates we set out previously.
```

```
UK_Data_Fut <- crop(climatefocus2, UK_extentFuture)
```

```
## Here we can inspect the data to ensure all of the UK is plotted.
```

```
par(mfrow=c(1,1))
```

```
plot(UK_Data_Fut[[5]])
```

```
## Here we download species presence data for all nine species.
```

```
spLP <- gbif("Lejeunea ", "patens", download = T, geo=T, sp=F)
```

```
spCC <- gbif("Colura ", "calyptrifolia", download = T, geo=T, sp=F)
```

```
spRV <- gbif("Radula ", "voluta", download = T, geo=T, sp=F)
```

```
spRH <- gbif("Radula ", "holtii", download = T, geo=T, sp=F)
```

```

spRC <- gbif("Radula ", "carringtonii", download = T, geo=T, sp=F)
spML <- gbif("Metzgeria ", "leptoneura", download = T, geo=T, sp=F)
spCS <- gbif("Lejeunea ", "mandonii", download = T, geo=T, sp=F)
spAW <- gbif("Acrobolbus ", "wilsonii", download = T, geo=T, sp=F)
sp <- gbif("Daltonia", "splachnoides", download = T, geo=T, sp=F)

```

```

#####
#####

```

```

## Lejeunea patens

```

```

## Here we check that the class of the object is a data.frame.

```

```

class(spLP)

```

```

## Here we remove any na values for longitude and latitude data.

```

```

wLP <- which(is.na(spLP$lon))
spLP <- spLP[-wLP,]
wLP <- which(is.na(spLP$lat))
spLP$species <- 1
spLP <- spLP[,c('lon', 'lat', 'species')]
head(spLP)

```

```

# convert to spatial point

```

```

coordinates(spLP) <- ~lon + lat
class(spLP)
head(spLP)

```

```

## Here we can inspect the data in the mapview package.

```

```

proj4string(spLP) <- projection(raster())
mapview(spLP)

```

```

## Here we can inspect the first row and the number of rows of the dataset.

head(spLP)
nrow(spLP)

## Here we set up the SDM data that will be used to create the SDM.

dLP<- sdm::sdmData(species~. , spLP, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
dLP

## Here we get the names of model methods we can use. Five were chosen.

getmethodNames()

## Here we create the Species Distribution Model using five model methods of
## a single species using 10 bootstrap replicates per model method.

mLP <- sdm(species~., dLP, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mLP

## Here we can combine the results from the different models by their mean
## weighted AUC scores.

ensembleLP <- ensemble(mLP, raster::stack(UK_Data_Fut), setting = list(method='weights',
stat="AUC"))

plot(ensembleLP, xlim=c(-12,5), ylim=c(48,64), main="lejeunea patens")

## Code from here is a repeat of the previous species unless otherwise stated.

#####

```

```

class(spAW)

wAW <- which(is.na(spAW$lon))
spAW <- spAW[-wAW,]
wAW <- which(is.na(spAW$lat))
spAW$species <- 1
spAW <- spAW[,c('lon', 'lat', 'species')]
head(spAW)

coordinates(spAW) <- ~lon + lat
class(spAW)
head(spAW)

proj4string(spAW) <- projection(raster())
mapview(spAW)

head(spAW)
nrow(spAW)

dAW <- sdm::sdmData(species~. , spAW, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
dAW

getmethodNames()
mAW <- sdm(species~., dAW, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)

mAW

ensembleAW <- ensemble(mAW, raster::stack(UK_Data_Fut), setting = list(method='weights',
stat="AUC"))

plot(ensembleAW, xlim=c(-12,5), ylim=c(48,64), main="acrobolbus wilsonii")

```

```
#####
```

```
class(spCS)
```

```
wCS <- which(is.na(spCS$lon))
```

```
spCS <- spCS[-wCS,]
```

```
wCS <- which(is.na(spCS$lat))
```

```
spCS$species <- 1
```

```
spCS <- spCS[,c('lon', 'lat', 'species')]
```

```
head(spCS)
```

```
coordinates(spCS) <- ~lon + lat
```

```
class(spCS)
```

```
head(spCS)
```

```
proj4string(spCS) <- projection(raster())
```

```
mapview(spAW)
```

```
head(spCS)
```

```
nrow(spCS)
```

```
dCS <- sdmData(species~., spCS, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
dCS
```

```
getmethodNames()
```

```
mCS <- sdm(species~., dCS, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

```
mCS
```

```
ensembleCS <- ensemble(mCS, raster::stack(UK_Data_Fut), setting = list(method='weights',  
stat="AUC"))
```

```
plot(ensembleCS, xlim=c(-12,5), ylim=c(48,64), main="lejeunea mandonii")
```

```
#####
```

```
class(spML)
```

```
wML <- which(is.na(spML$lon))
```

```
spML <- spML[-wML,]
```

```
wML <- which(is.na(spML$lat))
```

```
spML$species <- 1
```

```
spML <- spML[,c('lon', 'lat', 'species')]
```

```
head(spML)
```

```
coordinates(spML) <- ~lon + lat
```

```
class(spML)
```

```
head(spML)
```

```
proj4string(spML) <- projection(raster())
```

```
mapview(spML)
```

```
head(spML)
```

```
nrow(spML)
```

```
dML <- sdmData(species~., spML, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
dML
```

```
getMethodNames()
```

```
mML <- sdm(species~., dML, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

```
mML
```

```
ensembleML <- ensemble(mML, raster::stack(UK_Data_Fut), setting = list(method='weights',  
stat="AUC"))
```

```
plot(ensembleML, xlim=c(-12,5), ylim=c(48,64), main="metzgeria leptoneura")
```

```
#####
```

```
class(spRC)
```

```
wRC <- which(is.na(spRC$lon))
```

```
spRC <- spRC[-wRC,]
```

```
wRC <- which(is.na(spRC$lat))
```

```
spRC$species <- 1
```

```
spRC <- spRC[,c('lon', 'lat', 'species')]
```

```
head(spRC)
```

```
coordinates(spRC) <- ~lon + lat
```

```
class(spRC)
```

```
head(spRC)
```

```
proj4string(spRC) <- projection(raster())
```

```
mapview(spRC)
```

```
head(spRC)
```

```
nrow(spRC)
```

```
dRC <- sdmData(species~., spRC, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
dRC
```

```
getmethodNames()
```

```
mRC <- sdm(species~., dRC, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

```
mRC
```

```
ensembleRC <- ensemble(mRC, raster::stack(UK_Data_Fut), setting = list(method='weighted',  
stat="AUC"))
```

```
plot(ensembleRC, xlim=c(-12,5), ylim=c(48,64), main="radula carringtonii")
```

```
#####
```

```
class(spRH)
```

```
wRH <- which(is.na(spRH$lon))
```

```
spRH <- spRH[-wRH,]
```

```
wRH <- which(is.na(spRH$lat))
```

```
spRH$species <- 1
```

```
spRH <- spRH[,c('lon', 'lat', 'species')]
```

```
head(spRH)
```

```
coordinates(spRH) <- ~lon + lat
```

```
class(spRH)
```

```
head(spRH)
```

```
proj4string(spRH) <- projection(raster())
```

```
mapview(spRH)
```

```
head(spRH)
```

```
nrow(spRH)
```

```
dRH <- sdmData(species~., spRH, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
dRH
```

```
getMethodNames()
```

```
mRH <- sdm(species~., dRH, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

```
mRH
```

```
ensembleRH <- ensemble(mRH, raster::stack(UK_Data_Fut), setting = list(method='weights',
stat="AUC"))
```

```
plot(ensembleRH, xlim=c(-12,5), ylim=c(48,64), main="radula holtii")
```

```
#####
```

```
class(spRV)
```

```
wRV <- which(is.na(spRV$lon))
```

```
spRV <- spRV[-wRV,]
```

```
wRV <- which(is.na(spRV$lat))
```

```
spRV$species <- 1
```

```
spRV <- spRV[,c('lon', 'lat','species')]
```

```
head(spRV)
```

```
coordinates(spRV) <- ~lon + lat
```

```
class(spRV)
```

```
head(spRV)
```

```
proj4string(spRV) <- projection(raster())
```

```
mapview(spRV)
```

```
head(spRV)
```

```
nrow(spRV)
```

```
dRV<- sdmData(species~., spRV, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
dRV
```

```
getMethodNames()
```

```
mRV <- sdm(species~., dRV, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

```
mRV
```

```
ensembleRV <- ensemble(mRV, raster::stack(UK_Data_Fut), setting = list(method='weights',
stat="AUC"))
```

```
plot(ensembleRV, xlim=c(-12,5), ylim=c(48,64), main="radula voluta")
```

```
#####
```

```
class(spCC)
```

```
wCC <- which(is.na(spCC$lon))
```

```
spCC <- spCC[-wCC,]
```

```
wCC <- which(is.na(spCC$lat))
```

```
spCC$species <- 1
```

```
spCC <- spCC[,c('lon', 'lat', 'species')]
```

```
head(spCC)
```

```
coordinates(spCC) <- ~lon + lat
```

```
class(spCC)
```

```
head(spCC)
```

```
proj4string(spCC) <- projection(raster())
```

```
mapview(spCC)
```

```
head(spCC)
```

```
nrow(spCC)
```

```
dCC<- sdmData(species~., spCC, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
dCC
```

```
getMethodNames()
```

```
mCC <- sdm(species~., dCC, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

```
mCC
```

```
ensembleCC <- ensemble(mCC, raster::stack(UK_Data_Fut), setting = list(method='weighted',  
stat="AUC"))
```

```
plot(ensembleCC, xlim=c(-12,5), ylim=c(48,64), main="Colura Caltryp")
```

```
#####
```

```
class(sp)
```

```
w <- which(is.na(sp$lon))
```

```
sp <- sp[-w,]
```

```
w <- which(is.na(sp$lat))
```

```
sp$species <- 1
```

```
sp <- sp[,c('lon', 'lat', 'species')]
```

```
head(sp)
```

```
coordinates(sp) <- ~lon + lat
```

```
class(sp)
```

```
head(sp)
```

```
proj4string(sp) <- projection(raster())
```

```
mapview(sp)
```

```
head(sp)
```

```
nrow(sp)
```

```
d <- sdmData(species~., sp, predictors = raster::stack(UK_Data_Fut), bg = list(n=1000))
```

```
d
```

```
getMethodNames()
```

```
m <- sdm(species~., d, methods = c('glm', 'svm', 'rf', 'brt', 'mars'), replications=c('boot'),n=10)
```

m

```
ensembleM <- ensemble(m, raster::stack(UK_Data_Fut), setting = list(method='weights', stat="AUC"))
```

```
plot(ensembleM, xlim=c(-12,5), ylim=c(48,64), main="Daltonia")
```

```
#####
```

```
## Now that all models have been created we can begin to plot them.
```

```
## First we set out the graphical parameters for nine plots across three rows
```

```
## with three raster maps per row.
```

```
par(mfrow=c(3,3))
```

```
## Here we plot each model, label the X and Y axes and add a letter (A-I) for
```

```
## use within the thesis.
```

```
plot(ensembleM, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "A", cex = 2)
```

```
plot(ensembleCC, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "B", cex = 2)
```

```
plot(ensembleRV, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "C", cex = 2)
```

```
plot(ensembleRH, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "D", cex = 2)
```

```
plot(ensembleRC, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "E", cex = 2)
```

```
plot(ensembleML, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "F", cex = 2)
```

```
plot(ensembleCS, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "G", cex = 2)
```

```
plot(ensembleAW, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "H", cex = 2)
```

```
plot(ensembleLP, xlim=c(-12,5), ylim=c(48,64), cex.main=2,legend.width=4,xlab="Longitude",  
ylab="Latitude")
```

```
text(x= -14, y= 59.5, "I", cex = 2)
```

Appendix 3: Swansea University Science Fieldwork Risk Assessment

Science fieldwork risk assessment (UG/PGT/PGR)

You must not carry out fieldwork until this risk assessment has been approved by your Supervisor. See the [Fieldwork Risk Assessment Guidance](#) document to complete this form.

Risk Assessment Outcome:

Risk Rating: **Negligible/Low risk**

Submitted Date: 10 Feb 2023

Approved Date: 13 Feb 2023

Approved by: Penelope Neyland

Student Details

Student Number:

██████

Project Supervisor: Dr Penelope Neyland

Course:

Biosciences Masters by Research Full-time

Level:

7

| | | | |
|--|-------------------------------|------------------------------------|-------------|
| Assessor: | Oliver Morgan | Assessment Date: | 13/02/2023 |
| Contact Number: | 07464819861 | No. of Participants: | 1 |
| Next of Kin: | Angela Morgan (Parent) | Next of Kin Contact Number: | 07803795402 |
| Name of field assistant(s) – Lone working is only permitted in exceptional circumstances, with the agreement of your Supervisor. | | | |
| Buddy system to be implemented to ensure no lone working. NRW site sign in system to be used. | | | |
| Brief outline of the research / fieldwork activity* | | | |
| Ecological field sampling of bryophyte abundance in addition to taking a range of tree measurements (age, diameter etc.). | | | |
| List of methods to be used. Use the button 'Add Method' below to add each method details. | | | |
| Field identification of bryophyte and lichen species using gained knowledge and field ID guides. | | | |
| Use of scientific equipment pertaining to the collection of: climate data, soil conditions and tree measurements (diameter). | | | |
| Ethics approval number: | SU-Ethics-Student-300123/6138 | | |
| Activity Start Date:* | 31/01/2023 | Activity End Date:* | 30/09/2023 |
| Location of activity (site name, region etc.):* | | | |
| South Wales peatlands (multiple locations). | | | |
| UK Map Reference or LAT LON (if outside UK): | SS 87137 99236 | | |
| What 3 words Reference (what3words.com): | ///wedge.deriving.nature | | |
| Nearest hospital with A&E (incl. postcode for use with a satnav / app):* | | | |
| Neath Port Talbot Hospital - Baglan Way, Port Talbot, SA12 7BX | | | |
| Approx. distance from field site: | 12.9 miles. | | |
| Is there mobile phone coverage? | No | | |
| If there is no phone reception, how will you summon help? | | | |
| Only a small portion of the area is unreachable to phone reception. Some services require no mobile reception to contact emergency services in addition to bringing a GPS device for identification exact locations. A portable battery will also be brought to ensure adequate mobile phone charge to contact emergency services. | | | |
| Contact Name for Check-in/Safe return (Ensure that they know where you are going, your expected return time, your Supervisor's name). | | | |
| Dr Penny Neyland. | | | |
| Frequency of check-ins/Communication Plan (e.g. start and end of each day) | | | |
| Start and end of each day. | | | |
| Map of field site (Identify route to nearest hospital with an A&E Department) | | | |

[Field Site to Hospital.jpg](#)

Risk Assessment - Hazards

Fill in the grid with the appropriate information. Extend the table as required.

See Examples of some hazards associated with fieldwork in [Fieldwork Risk Assessment Guidance](#) document.

| Step1 | Step2 | Step3 |
|-----------------------|-------------------------------|--|
| Describe of Hazard | Who may be harmed and how | Controls/actions required (to eliminate/reduce the risk) |
| | S L R | S L R |
| | Myself and others who may use | Carry out appropriate manual handling |

Manual handling the equipment - bodily injury may

| | | | | |
|--|---|----------------------------|---|----------------------------|
| <ul style="list-style-type: none"> 1 2 | <p>2 field equipment. occur through incorrect loading handling training. of equipment.</p> <p>All participants may be harmed -</p> | <p>2</p> <p>2</p> <p>4</p> | <p>techniques and if required conduct manual</p> <p>Wear appropriate footwear for the conditions, take care on wet or loose surfaces, be aware of</p> | |
| <p>Slippery and / or uneven surfaces.</p> | <p>Slips, trips and falls may causing non-serious to serious injury.</p> | <p>2</p> <p>2</p> <p>4</p> | <p>tripping hazards out in the field such as low objects out of eyeline, change path of travel if necessary.</p> | <p>1</p> <p>2</p> <p>2</p> |
| <p>Risk of injury from direct contact with contamination organisms</p> | <p>All participants may be harmed - Ensure an antibacterial wipes or sanitizer is available to clean wounds especially before drinking, wounds must be covered before of an open wound or through digestion.</p> <p>All participants may be harmed 0</p> | <p>2</p> <p>1</p> <p>2</p> | <p>Contact with soil micro-organisms, engaging in fieldwork, first aid kit to be included (one participant will bring one).</p> <p>When handling plant material with low visibility</p> | <p>1</p> <p>1</p> <p>1</p> |
| <p>Risk of injury from contact with plant material.</p> | <p>Handling any plant species that may have sharp defence mechanisms such as thorns or as long trousers and if necessary, gloves.</p> | <p>2</p> <p>1</p> <p>2</p> | <p>such as in a hedgerow or area of dense vegetation then wear appropriate clothing such as waterproofs and spare</p> <p>Appropriate clothing will be required for fieldwork which will change based on weather</p> | <p>1</p> <p>1</p> <p>1</p> |
| <p>Weather sessions to</p> | <p>may cause ground instability, clothing or colder temperatures, hyperthermia in ensure this. During more serious warmer conditions or risk of weather conditions, sessions may be serious injury during storms from lightning.</p> | <p>2</p> <p>2</p> | <p>forecast will be checked before heading to conditions.</p> <p>extreme cold weather, an emergency foil blanket may be required).</p> | |
| <p>and being stranded of fuel before departing</p> | <p>All participants in vehicles - journey and more in an emergency and carry a first aid kit. In the event of an emergency, a compass will be carried and map of the area. Ensure any vehicles have a sufficient amount of fuel before departing on any journey. Participants must comply with UK Highway Code rules.</p> | <p>2</p> <p>1</p> <p>2</p> | <p>Ensure that any vehicles used by participants comply with current safety standards such as tread depth, have enough fuel for the planned Travel to Breakdowns, running out of fuel fieldwork site. & ensure any vehicles have a sufficient amount of fuel before departing on any journey. Participants must comply with UK Highway Code rules.</p> <p>Insect bite cream will be carried, participants must remain aware and vigilant of wild animals,</p> | |
| <p>Proximity to wild animals.</p> | <p>All participants may be harmed - Bites, stings or scratches may cause irritation, allergic reaction, 2 2 4 internal injury, infection or have ticks. If a participant has made contact with</p> | <p>2</p> <p>1</p> <p>2</p> | <p>vegetation, trousers may be tucked into socks 1 1 1 and arms to be covered if the area is known to serious injury. an animal, they should use an antiseptic wipes on the areas of contact immediately.</p> | |
| <p>Food or water borne illness.</p> | <p>All participants consuming food on site or following fieldwork may be harmed - Soil borne pathogens on hands from</p> | <p>2</p> <p>1</p> <p>2</p> | <p>Hand sanitizer or an antiseptic wipes will be carried 1 Hand sanitizer or an antiseptic wipes will be carried 1</p> | <p>1</p> <p>1</p> |

fieldwork which may transfer drinking. place. bodies. A strict hygiene regime will be kept in when eating or

| | | | | | | | |
|---|--|---|---|---|---|---|---|
| | All participants may be harmed the area often has industrial vehicles travelling through to equipment entry and exit points for traffic and stay aware of any large vehicles that may pass whilst in the field. If working near roads during low visibility additional traffic may pose risk of (at night or during foggy weather), participants should wear high-visibility clothing. bruises, broken bones, bleeding or death. | 2 | 2 | 4 | 2 | 1 | 2 |
| Roads, pathways | Ensure all participants are aware of traffic routes, transport number and entry and exit points for traffic and stay aware of any large vehicles that may pass whilst in the field. If working near roads during low visibility additional traffic may pose risk of (at night or during foggy weather), participants should wear high-visibility clothing. bruises, broken bones, bleeding or death. | | | | | | |
| COVID-19 | All participants are at risk from COVID-19 infection on a household member does develop COVID-19 symptoms. Vehicles must not be shared with a participant that has tested positive for COVID-19. | 2 | 1 | 1 | 1 | 1 | 1 |
| Proximity to domesticated animals. | All participants may be at risk - Bites from dogs or farm animals may pose risk of infection or wounds. Farm animals may also kick, stamp or crush participants injury. participants should be aware of any animal waste. | 2 | 2 | 4 | 1 | 1 | 1 |
| Tripping hazards such as fences, stumps or rocks. | All participant may be harmed - tripping over object may result in cuts, bruises, broken bones or severe injury. All participants in the field may be harmed - Slopes may result in uneven footing, slips or falling terrain. causing injury, broken bones, cuts, bruising. | 2 | 1 | 2 | 1 | 1 | 1 |
| Steep slopes | Stuck to main paths and tracks where possible, be aware of any sloping terrain. causing injury, broken bones, cuts, bruising. | 2 | 2 | 4 | 1 | 1 | 1 |

Tripping over branches, logs, Woodland stumps, low vegetation or number 1 2 2 wooded area, stick to main roads unless 1 1 1 debris. may result in tripping, cuts, necessary. bruises, bleeding or broken bones.

| | | | | | | | |
|---------------|---|---|---|---|---|---|---|
| Lone working. | Any participants that may be lone working alone may be harmed working cannot be avoided, other person(s) will be contacted to inform them of participants risk of a lack from other people location and to check in prior to and following in the area, animal attack, le | 2 | 1 | 2 | 1 | 1 | 1 |
|---------------|---|---|---|---|---|---|---|

. alone in event of emergency.

Risk (R) = (SxL): **LOW (1-2)**, **MODERATE (3-5)**, **HIGH (6-9)**.

Coronavirus: Whilst coronavirus remains in circulation you must include this hazard in your risk assessment.

Are you working near water?

No

If yes, please address the following questions:

What, if any, is the degree of immersion (i.e. none, boat, wade, swim etc.)

What is the nature of the wet environment (river, beach, still water etc.)

Can you and your field assistant(s) swim?

In moving water, specify any additional hazards to consider regarding the rate of flow, depth, water temperature etc.

I will assess flow rate and risk on-site before entering the water and monitor throughout the experiment.

| | | |
|--|--|--|
| If applicable: What are the dates for the date(s) of activity? | | |
| Is the water polluted? | | |
| If yes, what protection measures are you taking? | | |
| Work in or around water is potentially dangerous. Additional personal protective equipment (PPE) is required. You and your assistant(s) need to know how to use these items. | PPE Buoyancy aid | |
| | Throw Line | |
| | Wet suit/dry suit/waders/boots required (specify)? | |
| | Other (specify)? | |

National Emergency Tel: 999. University Switchboard +44 (0)1792 205678 (non-emergency).

Working method statement

Detail here the field methods you will be using and any controls / actions you will take to reduce the risk. Include Standard Operating Procedures or append references as appropriate.

Field methods to be employed include the identification of lichen and bryophytes in the field which may pose risk from natural plant defences including thorns or toxins. As a control to reduce risk, care will be taken when handling plant material in addition to the use of gloves when necessary. Tree measurements will also be taken which may pose risk of tripping over branches or low lying objects around the tree. To control this risk, all participants will ensure that they remain aware of objects on the ground when moving around trees. Climate data will also be measured in the field using a multiple pieces of scientific equipment. To reduce the risk from this, participants will ensure that they are aware on the correct operating procedure of each piece of equipment in addition to applying an antibacterial wipes or sanitizer after handling plant materials or after coming in contact with soil.

Personal checks (student):

In signing this form, I agree that:

I consent to this information being shared in accordance with the General Data Protection Regulations.

I have assessed the risks associated with the activity. I will put in place the controls / activities identified in the risk assessment. I understand that no research activity can be totally risk free.

- I have discussed with my Supervisor any disability or medical condition that may affect my Health and Safety in the field. I will discuss with them any additional controls or reasonable adjustments that I require.
- I will notify my contact that I will be in the field, I will communicate with them according to the agreed communication plan. I will take with me appropriate contact numbers and means for summoning help.
- I have established the location of the nearest hospital with an accident and emergency department. I have included the post code for the hospital as this may assist if using a sat. nav.
- I have a plan in the event that mobile phones will not work on site either due to reception or failure of equipment.
- I have a map and compass for location and navigation in the field (check only if required).
- I am familiar with the use of all field equipment and will work within the approved method statements.
- I will secure written permission to access the field site and will carry with me a copy of the agreement including any permits to collect samples.
- I will ensure that all participants are suitably equipped and capable of working safely in the field.
- I will brief my field assistant(s) and advise them of emergency procedures. I will discuss the work plan, risks and safety arrangements with the field assistant(s) as part of my briefing.
- I will access the site with due care (following the Country Code).
- I will engage politely and professionally with any members of the public with whom I interact during fieldwork and take the time to explain to them what I am doing if this is appropriate.
- I will work safely in a manner respectful of others.
- I will log all accidents and "near-misses" using the adverse event system (<https://www.swansea.ac.uk/about-us/safety-and-security/health-and-safety/report-it/>) and ensure that my Supervisor is informed.
- I will work safely, implementing the controls identified within the risk assessment. In the event that my methods change or that the environment changes I will dynamically re-assess the risk and cease the activity if the environment or activity becomes unsafe or if conditions move beyond the scope of this assessment.

Supervisor checks:

Directly test and challenge the student before approval – in the event of a NO answer to any of these questions the student must review the assessment with their Supervisor and then re-test:

Has the student personally assessed the risks associated with this activity? Yes No

Has the student identified appropriate controls / actions to reduce risk so far as is reasonably practicable? Yes No

Additional controls and/or reasonable adjustments are in place, if required? Yes No

Is lone working permitted? Yes No

If yes, are you complying with the [Lone Working Policy Arrangements](#)? No Yes

Is the level of risk acceptable for this student activity to take place? Yes No

Does the student know what actions to take in the event of a foreseeable emergency? No Yes

Have you given the student the opportunity to ask questions about the activity? Yes No

Have you checked that the student understands what they are doing and why, the controls required to reduce risks and actions to take in the event of an emergency? Yes No

Are you satisfied that the risks have been appropriately assessed and suitable controls have been identified, such that the student can work safely within the remit of the assessment? Yes No

If you have answered no to any of the questions, do not sign the form approving this activity.

Students travelling overseas, for University business purposes, must comply with the [Internal Travel Policy](#) and take with them a copy of the Swansea University Travel Cover Summary document.

Links to uploaded files:

[Lost Peatlands Risk Assessments - ALL - Reviewed RP Oct 2022 \(1\).pdf](#)

Appendix 4: Lost Peatlands Risk Assessments



Lost Peatlands Risk Assessments

This document contains all RA's for project activity at all CWS and HRA sites covering:

1. Practical Conservation tasks
2. Lone working
3. Vehicle Use
4. Contact with animals
5. Covid-19 and site work
6. Surveying
7. Guided Walks
8. Surveying Alongside Roads
9. Working in wetlands
10. Arts and Crafts Event
11. School Outdoor Learning
12. General Volunteer Task Day
13. School field trips
14. Safety on Site - Welsh Gov. Woodland Estate & PYC Windfarm

* Site Specific RA's should be carried out where deemed appropriate by lead officer*

***** SITE LOCATION DETAILS AND EMERGENCY MEET POINTS AT END OF THIS DOC*****

Team Contact Details:

1. Richy Pulman - Project Manager - 07791638201 (work) 07914699019 (personal)
2. Sarah Reed - Volunteer Co-ordinator - 07870483819 (work) 07922193894 (personal)
3. Joseph Pickard - Ecologist - 07870 483821 (work) 07784444972 (personal)
4. Mike Shewring - Ecologist - 07504992636 (personal)

Other useful numbers:

1. Vattenfall (PYC Windfarm) - 01736334632 (hwb) 01434620129 (emergency)
2. NPT Council - 01639 686868
3. RCT Council - 01443 425005
4. NRW - 0300 065 3000

| Activity to be Assessed | | Assessment Number | | |
|---|--|-------------------|----------|------------|
| General Safety on site for conservation projects | | BG/G09 | | |
| Persons undertaking or affected by the activity | | | | |
| Service <input checked="" type="checkbox"/> Employees <input type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Pupil <input type="checkbox"/> User Other <input checked="" type="checkbox"/> ...Partners..... | | | | |
| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level |
| 1 | Contact with hand tools | 3 | 2 | 6Y |
| 2 | General manual handling | 3 | 3 | 9 |
| 3 | Slips, trips and falls | 3 | 3 | 9 |
| 4 | Refreshments/scalding from hot drinks | 3 | 3 | 9 |
| 5 | Contact with soil borne micro organisms | 2 | 2 | 4 |
| 6 | Handling of timber | 3 | 3 | 9 |
| 7 | Use of Gas equipment | 2 | 4 | 8 |
| 8 | Personal attack | 3 | 3 | 9 |
| 9 | Food borne illness | 3 | 3 | 9 |
| 10 | Risk of injury from sharps whilst litter picking (including infection with Tetanus, HIV and Hep A) | 3 | 3 | 9 |
| 11 | Back strain from repetitive bending whilst clearing litter | 3 | 3 | 9 |
| 12 | Injury from Chemo- and Bio hazardous waste | 2 | 4 | 8 |
| 13 | Contact with plant sap | 2 | 4 | 8 |
| 14 | Adverse Weather | 3 | 3 | 9 |
| 15 | Contact with underground services: electricity, gas, water etc. | 2 | 4 | 8 |
| 16 | Contact with moving traffic | 2 | 4 | 8 |
| Existing Control Measures / Additional Control Measures Required | | | | |
| 1 | Inspect handles of tools before use and do not use any tools that have damaged or lose handles. No gloves to be worn when using swinging tools, unless other hazards such as plant sap are greater, if so, the safe working distance is at least 20 metres. Ensure the correct tool is used for each job. Suitable footwear to be worn. Assign a designated first aider | | | |

| | |
|---|--|
| 2 | <p>Plan in advance any lifting of heavy or awkward items. A safety talk is to be given on safe lifting, carrying, moving techniques and use of tools. Check the health of participant before allowing anyone to carry out manual handling of any heavy items, for example, bad back or pregnancy. Designate someone to load and unload tools, use carrying aids such as a wheelbarrow if needed, heavy items to be carried by two people, limit the number of tools/items one person carries. DON'T stand for a lazy mans load. If sustained, repetitive or very heavy manual handling is to be carried out, a detailed Manual Handling Assessment will be undertaken.</p> |
| 3 | <p>Inspect site and clear mark any trip hazards. Keep site, tools and materials tidy, correct placement of tools when not in use will have been shown in the safety talk given at the start of activity.</p> |
| 4 | <p>When in use never leave equipment unattended. Erect sign to warn of temperature of equipment or ensure dangers are pointed out to everyone on site. Ensure the equipment has cooled down sufficiently enough for transportation from site after use. Don't overfill cups with hot drinks.</p> |

| | |
|----|--|
| 5 | <p>Ensure water/wipes are available on site to clean hands before eating, drinking or smoking. Any broken skin must be covered before work. The designated first aider on site must promptly treat any cuts received during activities. If practical wear gloves to protect hands.</p> |
| 6 | <p>Cut logs to an appropriate size for habitat piles and apply manual handling techniques. Clear all tripping hazards prior to moving timber final destination. If large amounts of lifting are to be carried out a detailed manual handling assessment is to be written up. Use carrying aids such as a wheelbarrow to move logs on site.</p> |
| 7 | <p>Follow information from LPG association Do not use faulty or leaking equipment. Site gas well away from vehicles and combustibles when in use No smoking within 5 metres of gas bottles Inspect and check all equipment before and after use. Switch off / turn valve after use</p> |
| 8 | <p>Leave no one isolated on site Lock personal valuables out of site Issue a mobile phone for lone working or group working on remote sites, checking that signal is present before relying on this safety (phone signal could be checked when carrying out site assessment the day before). If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented.</p> |
| 9 | <p>Ensure any cuts are protected from contact with food Mugs, spoons etc to be clean and fit for use Ensure that participants can clean hands before eating, drinking or smoking. If sufficient water, soap and drying facilities are not available, ensure that suitable hand wipes are provided If food is being prepared on site a separate and detailed risk assessment must be undertaken and implemented.</p> |
| 10 | <p>Care to be taken whilst handling glass. Instruction on how to deal with syringes found on site to be undertaken. Any syringes found to be reported and put into a sharps box by a trained person. Heavy-duty work gloves to be worn at all times, a litter picker to be used when picking through piles of rubbish. Use of hands to be discouraged.</p> |

| | |
|----|--|
| 11 | A litter picker to be used to prevent repetitive bending instruction in manual handling to be given |
| 12 | Do not touch unidentified cans or canisters, oil drums, poisons or insecticides Do not touch clinical waste, other hazardous substances, condoms or syringes |
| 12 | Identify any hazardous plants on site before carrying out activity, for example: Hogweed, wild carrot. Plan work to avoid hazardous plants Wear long sleeved tops and trousers when working close to hazardous plants Wear protective gloves Wash exposed skin thoroughly after any contact with skin, before drinking or smoking In case of an allergic reaction following accidental contact with plant sap, identify the plant and monitor casualty for shock. If condition of the casualty deteriorates, call an ambulance immediately and ensure that a sample of the plant accompanies the casualty to hospital to ensure correct diagnosis and treatment A first aider should be on site |
| 14 | Avoid sunburn risk by not exposing skin, even when some cloud cover exists Ensure that participants have suitable high factor sun block. Do not provide sun block to participants unless they can confirm that they have used the product before without adverse reactions Extra clothing as appropriate for the terrain and conditions to be carried, noting details on local precautions. Stop work promptly if people are not prepared for the conditions, uncomfortable or the work is becoming hazardous. |
| 15 | Carry out visual check for services and / or with landowner. If present: Check services maps obtained from utilities companies before starting work Ask utility to identify on site and mark line of service Follow instructions and conditions provided by service provider (terms vary) In high risk urban areas, use CAT to identify any services that utilities are unable to. Hand dig when unsure If digging within a 5m line, use only wooden handled spades Watch for buried marker tape indicating pipe or cable and then dig to side and not over the marked area. Follow guidance in HSG 47 “avoiding danger from underground services Be aware also of low hanging electrical cables, especially if a crane is to be used on site |
| 16 | Unloading and reloading of vehicle will be arranged so people and materials are well clear of passing traffic For roadside unloading place cones or tape. Erect signs warning of work hazards/preventing access on approaching site Post a lookout able to halt work and manage public access to work area Leave vehicle parked on site so you are able to leave quickly in case of an emergency All workers to wear high visibility jackets which include two reflective bands of material |

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|--|------------|----------|------------|
| 1 | Contact with hand tools | 2 | 2 | 4 |
| 2 | General manual handling | 2 | 3 | 6G |
| 3 | Slips, trips and falls | 2 | 3 | 6G |
| 4 | Refreshments/scalding from hot drinks | 2 | 3 | 6G |
| 5 | Contact with soil borne micro organisms | 1 | 2 | 2 |
| 6 | Handling of timber | 2 | 3 | 6G |
| 7 | Use of Gas equipment | 1 | 4 | 4 |
| 8 | Personal attack | 2 | 3 | 6G |
| 9 | Food borne illness | 2 | 3 | 6G |
| 10 | Risk of injury from sharps whilst litter picking (including infection with Tetanus, HIV and Hep A) | 2 | 3 | 6G |
| 11 | Back strain from repetitive bending whilst clearing litter | 2 | 3 | 6G |

| 12 | Injury from Chemo- and Bio hazardous waste | 2 | 4 | 8 | | | | | | |
|---|---|--|----------------------|--------------------|----|----------|-------------|-----------|-----|---|
| 13 | Contact with plant sap | 2 | 4 | 8 | | | | | | |
| 14 | Weather | 2 | 3 | 6G | | | | | | |
| 15 | Contact with underground services: electricity, gas, water etc. | 2 | 4 | 8 | | | | | | |
| 16 | Contact with moving traffic | 1 | 4 | 4 | | | | | | |
| Name Chaela Carrell | | Signed | | Date 15/03/2007 | | | | | | |
| Position Community Wildlife Project Officer | | | | | | | | | | |
| Reviews | Key | | | | | | | | | |
| Review Date : Sept 08 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 | |
| Reviewed by: C Gaeyi | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | | 4 | 4 | 8 | 12 | 16 | 20 | |
| Review Date : Sept 10 | | | | 3 | 3 | 6G | 9 | 12 | 15 | |
| Reviewed by: C Evans | | | | 2 | 2 | 4 | 6Y | 8 | 10Y | |
| Review Date : Sept 2011 | | | | 1 | 1 | 2 | 3 | 4 | 5G | |
| Reviewed by: R Pulman | | | | 0 | | 1 | 2 | 3 | 4 | 5 |
| Review Date : Oct 2022 | | | | Severity of Injury | | | | | | |
| | | | | | | Low Risk | Medium Risk | High Risk | | |

CF/04/02 (col)

| Activity to be Assessed | | Assessment Number | | |
|---|---|-------------------|----------|------------|
| Lone worker (General Safety on site for conservation projects) | | BG/LW12 | | |
| Persons undertaking or affected by the activity | | | | |
| Service <input checked="" type="checkbox"/> Employees <input type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Pupil <input type="checkbox"/> User Other <input checked="" type="checkbox"/> ...Partners..... | | | | |
| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level |
| 1 | Physical attack – outdoor work | 3 | 3 | 9 |
| 2 | Exposure or weather related conditions | 3 | 3 | 9 |
| 3 | Evening or weekend work | 3 | 3 | 9 |
| 4 | Driving | 3 | 3 | 9 |
| Existing Control Measures / Additional Control Measures Required | | | | |
| 1 | Avoid problem areas where known (see Potentially Violent Persons register). Do not lone work if unsure of safety. Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency Avoid one to one site meetings with unknown individuals Stay calm, avoid aggressive language and body posture Do not give home or personal details to anyone met on site Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return. When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager. | | | |
| 2 | Check weather forecast and carry spare clothing and waterproofs Use sunscreen (SPF +15 recommended) and cover exposed skin in high temperatures | | | |
| 3 | Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return. When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager. Avoid one to one site meetings with unknown individuals Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency Do not give home or personal details to anyone met on site or at meetings. | | | |

4

Ensure doors are locked and windows only partially open when you are stationary in your vehicle
Do not leave valuables on view in your vehicle when you are driving or stationary, for example mobile phone or cash.
Don't pick up hitch hikers
Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency All pool vehicles are governed by Fleet Policy and includes membership of a roadside rescue service.
Park in well lit places and check vehicle for any signs of a break in before getting into it.
In case of a breakdown, stay with your vehicle with your doors locked and await emergency rescue services (unless on a motorway or busy roundabout – if possible stand by barrier away from vehicle) If followed, drive to a busy area or to the nearest police station and report details to them.
Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return. When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager.
Avoid one to one site meetings with unknown individuals

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|--|------------|----------|------------|
| 1 | Physical attack – outdoor work | 2 | 3 | 6G |
| 2 | Exposure or weather related conditions | 2 | 3 | 6G |
| 3 | Evening or weekend work | 2 | 3 | 6G |
| 4 | Driving | 2 | 3 | 6G |

| | | |
|--|--------|---------------|
| Name Catrin Evans | Signed | Date 15/03/08 |
| Position Biodiversity Project Director | | |

| Reviews | Key | | | | | | | | |
|-------------------------|---|--|----------------------|--------------------|----------|-------------|-----------|----|-----|
| Review Date : Sept 10 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: C Evans | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : Sept 2011 | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: R Sharp | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review Date : Sept 2019 | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: R Pulman | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : Oct 2022 | | | | Severity of Injury | | | | | |
| Reviewed by: | | | | | Low Risk | Medium Risk | High Risk | | |

CF/04/02 (col)

| Activity to be Assessed | | Assessment Number | | | | | | | | |
|--|---|--------------------|--------------------------|------------|--------------------------|--------|--------------------------|-------|--------------------------|------|
| Vehicle use | | BG/V18 | | | | | | | | |
| Persons undertaking or affected by the activity | | | | | | | | | | |
| Service | <input checked="" type="checkbox"/> | Employees | <input type="checkbox"/> | Contractor | <input type="checkbox"/> | Public | <input type="checkbox"/> | Pupil | <input type="checkbox"/> | User |
| Other | <input checked="" type="checkbox"/> |Partners..... | | | | | | | | |
| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level | | | | | | |
| 1 | General Faults | 3 | 3 | 9 | | | | | | |
| 2 | Driving | 3 | 4 | 12 | | | | | | |
| 3 | Becoming stranded, causing damage to vehicle and injury driver/passenger | 3 | 4 | 12 | | | | | | |
| 4 | Adverse Weather Conditions | 3 | 4 | 12 | | | | | | |
| 5 | Driving for long periods | 3 | 4 | 12 | | | | | | |
| 6 | Vehicle loading | 3 | 4 | 12 | | | | | | |
| Existing Control Measures / Additional Control Measures Required | | | | | | | | | | |
| 1 | General checks -Check lights, tyres for adequate tread, wipers and washer working, fuel gauge adequate for distance to be travelled, adjust mirrors and check visibility, check dashboard warning lights. Any faults do not drive and report to concierge. | | | | | | | | | |
| 2 | <p>All passengers must be seated and be wearing seat belts. Large or heavy equipment/materials must be in a fastened locker or tightly secured with straps/rope. An AFFF extinguisher and first aid kit, in full order, must be carried in any pool vehicle used in line with Fleet Policy.</p> <p>Drivers must adopt safe defensive driving techniques. Keep all doors unlocked, unless stationary when driving alone. Do not use a mobile phone whilst driving. Stop and switch engine off to use phone. Drivers only permitted to drive vehicles that they are qualified to drive (see driving licence). Off –road 4x4 driving to be undertaken by suitably training drivers.</p> | | | | | | | | | |
| 3 | <p>All pool vehicles are governed by Fleet Policy and includes membership of a roadside rescue service. Refer to lone working policy for guidance for calling for assistance. All pool cars carry first aid kit, all lone workers issued with own first aid kit. For serious injuries phone ambulance.</p> | | | | | | | | | |
| 4 | <p>Do not drive in adverse weather conditions unless absolutely necessary. Utilise 4x4 and suitably trained driver. Take suitable provisions: water, warm clothing, shovel. Use fog lights in poor visibility. Refer to lone working procedure and ensure buddy knows of your location and when you leave/arrive your destination.</p> | | | | | | | | | |
| 5 | <p>If travelling for long periods take regular breaks. If become tired stop and sleep. If travelling with someone else share the driving.</p> | | | | | | | | | |

| 6 | Fuel can must be carried upright, secured and where practical not in the passenger compartment. Don't carry anymore than 5 Litres at a time. No smoking in vehicle, it is against the law Load must be distributed evenly in all storage areas Train all in safe lifting, carrying and moving techniques Keep blades of tools covered, sort tools and keep lockers tidy | | | | | | | | |
|---|---|--|----------------------|--------------------|----|-------------|----|-----------|-----|
| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level | | | | | |
| 1 | General Faults | 2 | 3 | 6G | | | | | |
| 2 | Driving | 2 | 4 | 8 | | | | | |
| 3 | Becoming stranded, causing damage to vehicle and injury to driver/passenger | 2 | 4 | 8 | | | | | |
| 4 | Adverse Weather Conditions | 1 | 4 | 4 | | | | | |
| 5 | Diving for long periods | 1 | 4 | 4 | | | | | |
| 6 | Vehicle loading | 2 | 4 | 8 | | | | | |
| Name Chaela Carrell | | Signed | | Date | | | | | |
| Position Community Wildlife Project Officer | | | | 01/03/08 | | | | | |
| Reviews | Key | | 8 | | | | | | |
| Review Date : Sept 08 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: C Gaeyi | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : Sept 10 | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: C Evans | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review Date : Sept 11 | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: R Sharp | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : Oct 2022 | | | | Severity of Injury | | | | | |
| Reviewed by: R Pulman | | | | Low Risk | | Medium Risk | | High Risk | |

CF/04/02 (col)

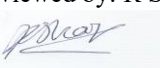

| | | | | |
|---|--|-------------------|----------|------------|
| Activity to be Assessed | | Assessment Number | | |
| Contact with animals | | | | |
| Persons undertaking or affected by the activity | | | | |
| Service <input type="checkbox"/> * Employees <input type="checkbox"/> * Contractor <input type="checkbox"/> * Public <input type="checkbox"/> * Pupil <input type="checkbox"/> * User Other <input type="checkbox"/> | | | | |
| Identified Hazards Associated Risks | | Likelihood | Severity | Risk Level |
| 1 | Domestic animals - sudden confrontation, bites and scratches. | 3 | 4 | 12 |
| 2 | Farm animals - sudden confrontation, kicks, bites, goring, stamping, crushing, emotional trauma, cuts, bruises, broken bones, external and internal injuries. Infections and allergic reactions. | 3 | 5 | 15 |
| 3 | Snakes - sudden confrontation and poisonous bites. | 3 | 4 | 12 |
| 4 | Insects - bites and stings. | 4 | 3 | 12 |
| 5 | Wild Animals - sudden confrontation, bites scratches, contact with excrement. | 3 | 4 | 12 |
| 6 | Rats - infection through cuts, scratches, abrasions or by mouth. | 4 | 5 | 20 |
| 7 | Ticks - bite resulting in rash, flu symptoms, joint pains, headaches. | 4 | 3 | 12 |
| 8 | Wild animals during surveys – bites, scratches, contact with excrement | 4 | 3 | 12 |
| Existing Control Measures / Additional Control Measures Required | | | | |
| 1 | Wear appropriate clothing for walking in the countryside and keep a sharp lookout for loose dogs. Avoid physical contact with all animals. Employees to avoid contact with animals and report any loose animals to the supervisor. Dazer available to be taken on site and used on aggressive animals where fleeing is not possible. | | | |
| 2 | Do not approach to pet or feed. If contact is unavoidable, avoid sudden moves and do not place yourself between a female animal and its young. Do not run or show signs of fear. Leave the animal enclosure as quickly as possible, without running. If walking a dog, keep it under close control. If stock animals charge, let dog go and leave enclosure as above. Potential danger areas to be identified in advance and avoided where possible. | | | |
| 3 | Wear walking boots with a solid grip and ankle protection. Keep a sharp lookout, to avoid stepping on or disturbing an adder. Potential danger areas to be identified in advance and avoided where possible. | | | |
| 4 | Wear long trousers (tucked into socks) and long sleeved top, to cover arms and legs. Take care not to disturb hives or nests and keep well clear of swarming bees or wasps. Use insect repellent at times and in areas where insects are known to be active, particularly if you suffer severe reaction to insect bites or stings. Potential danger areas to be identified in advance and avoided where possible. | | | |

| | |
|---|--|
| 5 | <p>Keep a sharp lookout for animal movements. Avoid contact with animals and their excrement. Do not disturb their dens or interfere with their young.</p> <p>If den inspection is required this should be undertaken during the time of day when animals are least active. Move away from the den if any signs of an animal are noted, such as hearing movement, growling etc. Wash hands thoroughly after inspection. Washing facilities (such as antibacterial gel) will be available on site.</p> <p>Potential danger areas to be identified in advance and avoided where possible.</p> |
| 6 | <p>In the right conditions the Leptospirosis bacteria can survive for a number of days after leaving the host animal and it has the potential to infect during that period.</p> <p>When working in water, wear protective clothing and boots and avoid rubbing your nose, mouth or eyes with your hands.</p> <p>After contact with water that may be infected or with contaminated boots or clothing, wash affected parts of the body thoroughly with soap and water, paying particular attention to fingernails. Do not eat until you have thoroughly cleaned your hands and arms.</p> <p>Wet clothing and footwear should be thoroughly cleaned as soon as possible after use.</p> <p>Potential danger areas to be identified in advance and avoided if possible.</p> <p>Working in water or in direct contact with water should be avoided.</p> <p>Gloves should be used as appropriate.</p> <p>Supervisors should monitor and halt activities if contamination is suspected.</p> |
| 7 | <p>Wear long trousers (tucked into socks) and long sleeved top, to cover arms and legs. Ticks can be seen more easily on light coloured clothes.</p> <p>When working in tick infested areas inspect body for ticks every few hours and if possible, at the end of the day's outdoor activity, undress and inspect body for ticks. Remove tick by grasping it close to the skin, with tweezers and apply gentle pressure, twisting anti-clockwise and upwards, repeating as necessary.</p> |
| 8 | <p>Only people specifically trained in surveying for that species to undertake surveys where contact with the animal is necessary, or people under direct supervision of suitably trained person. Ensure hands and arms are cleaned after handling animals</p> |

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|--|------------|----------|------------|
| 1 | Domestic animals - sudden confrontation, bites and scratches. | 2 | 4 | 8 |
| 2 | Farm animals - sudden confrontation, kicks, bites, goring, stamping, crushing, emotional trauma, cuts, bruises, broken bones, external and internal injuries. Infections and allergic reactions. | 2 | 5 | 10Y |
| 3 | Snakes - sudden confrontation and poisonous bites. | 2 | 4 | 8 |
| 4 | Insects - bites and stings. | 2 | 3 | 6Y |
| 5 | Wild Animals - sudden confrontation, bites scratches, contact with excrement. | 2 | 4 | 8 |
| 6 | Rats - infection through cuts, scratches, abrasions or by mouth. | 2 | 5 | 10Y |
| 7 | Ticks - bite resulting in rash, flu symptoms, joint pains, headaches. | 2 | 3 | 6Y |
| 8 | Wild animals during surveys – bites, scratches, contact with excrement | 4 | 2 | 8 |

| | | |
|---|--------|-----------------|
| Name Chaela Carrell | Signed | Date 01/09/2010 |
| Position Community Wildlife Project Officer | | |

| | | | | | | | | | |
|-------------------------|------------|----------|---|----|-----|----|----|----|--|
| Reviews | Key | | | | | | | | |
| Review Date : Sept 2011 | Likelihood | Severity | 5 | 5Y | 10R | 15 | 20 | 25 | |

| | | | | | | | | | |
|---|---|--|----------------------|--------------------|-------------|-----------|----|----|-----|
| Reviewed by: R Sharp  | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | Likelihood of Injury | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : March 2013 | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by:  | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review Date : February 2014 | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : Oct 2022 | | | | Severity of Injury | | | | | |
| Reviewed by: R Pulman | | | | Low Risk | Medium Risk | High Risk | | | |

CF/04/02 (col)

Risk Assessment Form



Corporate Health & Safety Section

| | | | | |
|---|-------------------------|-------------------|----------|------------|
| Activity to be Assessed | | Assessment Number | | |
| External site visits and maintenance work whilst COVID-19 measures are in place. This RA is to be followed in conjunction with the relevant task based RA. | | CV1- 2020 | | |
| Persons undertaking or affected by the activity | | | | |
| Service <input checked="" type="checkbox"/> Employees <input checked="" type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Pupil <input checked="" type="checkbox"/> User <input type="checkbox"/> Other | | | | |
| Identified Hazards Associated Risks | | Likelihood | Severity | Risk Level |
| 1 | Exposure to COVID-19 | 5 | 5 | 25 |
| 2 | Violence and Aggression | 3 | 3 | 9 |
| 3 | Pedestrian Interaction | 5 | 5 | 25 |
| Existing Control Measures / Additional Control Measures Required | | | | |

| | |
|---|---|
| 1 | <p>☐ Identify and allow to self-isolate all employees who fall into the following extremely vulnerable group as per Public Health Wales guidance and have received a letter from the NHS:</p> <ul style="list-style-type: none"> A. Solid organ transplant recipients. B. People with specific Cancers. C. Server respiratory conditions including all cystic fibrosis, severe asthma and severe COPD. D. Employees with rare diseases and inborn errors of metabolism that significantly increase the risk of infections (such as SCID, Homozygous sickle cell) E. Employees on Immunosuppression therapies sufficient to significantly increase risk of infection. F. Employees who are pregnant with significant heart disease congenital or acquired who may be at risk by carrying out their work duties. <ul style="list-style-type: none"> • All site visits to be approved by C&WTL in discussion with HoS / PPM, with urgent / essential works only being undertaken. • All employees to be given awareness training / team talks incorporating the potential risks, symptoms of COVID-19 and control measures (PPE distribution, hand hygiene etc.). • Ensure a 2 m distance is kept between work colleagues wherever practicable. • Employees to be issued with disposable/single use gloves, or ordinary gloves with nitrile gloves underneath. • Employee to be supplied with additional PPE e.g. coveralls, safety glasses etc. if required • Anti-bacterial wipes and hand sanitizer to be kept in the works vehicles at all times and used when necessary. • Employees will not share vehicles and if necessary, will make use of their own vehicle (with business cover) to travel. • Employees to refrain from touching your eyes, nose, and mouth. • Personnel hygiene must be paramount. • Officers must wash hands / use sanitiser (with minimum 60% ethanol content) throughout the day and as a minimum before and after each separate activity ☐ Officers to change and wash clothing at the end of each day. • Do not leave wet clothing in the vehicles. • Should there be the need to make use of a work shared vehicle, the driver of the vehicle must ensure the vehicle controls and interior (gear stick, indicators, steering wheel, door handles, dashboard etc.) are thoroughly cleaned every morning and at the end of the |
| | <p>working day. If any staff member has any symptoms, or their family has symptoms the vehicle that they travelled in needs to be thoroughly cleaned, if that is not possible, the vehicle must be securely parked up and not used for 72 hours.</p> |
| 2 | <ul style="list-style-type: none"> • Altercation and conflict must be avoided. • Any issues of conflict must be reported immediately to your supervisor. • All incidents of violence and aggression towards NPT employees must be recorded on the Online Accident Reporting System (OARS). • All employees will have Emergency Contact Numbers. • If you feel threatened, walk away from the situation, find a safe place and report it to your supervisor. |

| | |
|---|--|
| 3 | <ul style="list-style-type: none"> • If possible, try to work at a time of day when the public / services users are least likely to be around the work area. • Staff to stop work if they become aware of members of the public / contractors encroaching the work area. • Where feasible to do so working areas are to be cordoned off to designate a defined working area to prevent residents, road users, service users, contractors or the general public. • When working in areas where the public have access, priority must be given to pedestrians. • If member of the public refuses to keep a 2 meter social distance when you are working, the work must be left. |
| | <p style="text-align: center;">Mandatory control measures to be implemented</p> <ul style="list-style-type: none"> • All staff members are to ensure PPE is worn when carrying out the task. • All staff members are advised that suitable and appropriate footwear to be worn on all occasions. • All staff members to be made aware of the accident/incident reporting instructions. • All staff members to be aware that they are responsible for their own health and safety at all times. • All staff members to report any incident/accident to their supervisor immediately. • Supervisors to monitor at regular intervals. |

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|-------------------------|------------|----------|------------|
| 1 | Exposure to COVID-19 | 2 | 5 | 10 |
| 2 | Violence and Aggression | 2 | 1 | 2 |
| 3 | Pedestrian Interaction | 2 | 1 | 2 |

| | | |
|--|---|---------------|
| Name: Catrin Evans Position : Countryside and Wildlife Team Leader | Signed :  | Date : 9/4/20 |
|--|---|---------------|

| Reviews | | Key | | | | | | | | |
|-------------------------------|--------------------|------------|----------------------|----------|----------|---------------------|----|-----------|----|----|
| Review Date : | Likelihood | Severity | Likelihood of injury | 5 | 5 | 10 | 15 | 20 | 25 | |
| Reviewed by: | 1 very unlikely | 1 nuisance | | 4 | 4 | 8 | 12 | 16 | 20 | |
| Review Date : | | | 3 | 3 | 6 | 9 | 12 | 15 | | |
| Reviewed by: | | | 2 unlikely | 2 minor | 2 | 2 | 4 | 6 | 8 | 10 |
| Review Date : | | | | | 1 | 1 | 2 | 3 | 4 | 5 |
| Reviewed by: | | | | | 3 likely | 3 medical treatment | 0 | 1 | 2 | 3 |
| Review Date : Oct 2022 | Severity of Injury | | | | | | | | | |
| Reviewed by: R Pulman | 4 very likely | 4 major | | Low Risk | | Medium Risk | | High Risk | | |
| | 5 certainty | 5 fatal | | | | | | | | |

CF/04/04 (col)





Risk Assessment Form

| Activity to be Assessed | | Assessment Number | | | |
|---|--|-------------------|----------|------------|--|
| General Safety on site for surveying | | | | | |
| Persons undertaking or affected by the activity | | | | | |
| Service <input checked="" type="checkbox"/> Employees <input type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Pupil <input type="checkbox"/> User | | | | | |
| Other <input checked="" type="checkbox"/>volunteers..... | | | | | |
| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level | |
| 1 | Biological/ stings and bites | 4 | 2 | 8 | |
| 2 | Slips, trips and falls | 3 | 3 | 9 | |
| 3 | Dogs | 3 | 2 | 6G | |
| 4 | Contact with soil borne micro organisms | 2 | 2 | 4 | |
| 5 | Ponds / deep water | 3 | 3 | 9 | |
| 6 | Personal attack | 3 | 3 | 9 | |
| 7 | Food borne illness | 3 | 3 | 9 | |
| 8 | Horses/livestock | 4 | 2 | 8 | |
| 9 | Electric fences/barbed wire | 3 | 3 | 9 | |
| 10 | Injury from Chemo- and Bio hazardous waste | 4 | 2 | 8 | |
| 11 | Contact with plant sap | 4 | 2 | 8 | |
| 12 | Weather | 3 | 3 | 9 | |
| 13 | Lone working | 3 | 3 | 9 | |
| 14 | Using a car | 4 | 2 | 8 | |
| Existing Control Measures / Additional Control Measures Required | | | | | |
| 1 | Wear long trousers and long sleeved tops to limit tick bites. Wash hands before eating. If known allergy to stings take appropriate medication on site. If feeling unwell after a site visit seek medical attention. | | | | |
| 2 | Wear appropriate footwear. Take care when walking through areas of deep habitat or areas where there is poor footing visibility. Avoid areas of poor footing visibility if possible. Take care when footing is not clearly visible. Look for signs nearby of structures eg, partially collapsed fence. | | | | |
| 3 | Be wary of dogs off leads. Disinfect any bites and seek medical attention. | | | | |
| 4 | Ensure water/wipes are available on site to clean hands before eating, drinking or smoking. Any broken skin must be covered. Any cuts received during surveying must be treated promptly and covered to avoid infection. | | | | |
| 5 | Take care when near water bodies. Do not walk near to the pond. If working in deep water see separate Risk Assessment for Wetland work. | | | | |

| | |
|----|---|
| 6 | <p>Use your instincts. If you don't feel safe stay/get back to your car/main road. Lock personal valuables out of sight in your vehicle. Carry a mobile phone for lone working on remote sites, checking that signal is present, before relying on this (phone signal could be checked when carrying out site assessment the day before). If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented. It is important that you let someone know where and when you are going on site and an approximate time of when you plan to finish. Let the designated 'buddy' know when you are off site and on your way home.</p> |
| 7 | <p>Ensure any cuts are protected from contact with food Ensure that you clean hands before eating, drinking or smoking. If sufficient water, soap and drying facilities are not available, ensure that suitable hand wipes are used.</p> |
| 8 | <p>Do not enter any field containing bulls or livestock with young without first assessing the situation or if you have a dog with you as the livestock will consider the dog a threat to their young etc. Stay close to the fence line or hedge. If you are charged at you can either make yourself look bigger by waving your arms frantically and making a lot of noise or you can find the nearest exit point out of the field. If you are charged at and you have a dog on the lead with you, let the dog off the lead.</p> |
| 9 | <p>Check for electric fences (you can check to see if a fence is live by putting a blade of grass to the wire and seeing if the blade of grass bounces against the wire, if it does it is live!), do not climb over fences, use the nearest gate or stile</p> |
| 10 | <p>Do not touch unidentified cans or canisters, oil drums, poisons or insecticides Do not touch clinical waste, other hazardous substances, condoms or syringes</p> |
| 11 | <p>Identify any hazardous plants on site before carrying out activity, for example: Hogweed, wild carrot. Plan walk to avoid hazardous plants if possible. Wear long sleeved tops and trousers when working close to hazardous plants Wear protective gloves if appropriate. Wash exposed skin thoroughly after any contact with skin, before drinking or smoking In case of an allergic reaction following accidental contact with plant sap, identify the plant and monitor casualty for shock. If condition of the casualty deteriorates, call an ambulance immediately and ensure that a sample of the plant accompanies the casualty to hospital to ensure correct diagnosis and treatment.</p> |
| 12 | <p>Wear appropriate clothing; e.g. waterproof coat/trousers if it's raining, light clothing & hat for sunny/warm weather. Avoid sunburn risk by not exposing skin, even when some cloud cover exists Ensure that you have suitable high factor sun block. Do not provide sun block to others unless they can confirm that they have used the product before without adverse reactions Extra clothing as appropriate for the terrain and conditions to be carried, noting details on local precautions. If hot weather then ensure you have drinking water with you. Stop surveying promptly if you are not prepared for the conditions, uncomfortable or the work is becoming hazardous.</p> |

| | |
|----|---|
| 13 | <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented.</p> <p>Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return. When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager/contact in office.</p> <p>Avoid one to one site meetings with unknown individuals</p> <p>Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency</p> <p>Consider being a member of a rescue service in case your vehicle breaks down or in case of a minor accident</p> <p>Let the designated ‘buddy’ know when you are off site and on your way home. Do not give home or personal details to anyone met on site</p> |
| 14 | <p>Always reverse into a parking space, enabling a quick exit if needed.</p> <p>Ensure doors are locked and windows only partially open when you are stationary in your vehicle.</p> <p>Do not leave valuables on view in your vehicle when you are driving or stationary, for example mobile phone or cash.</p> <p>Don’t pick up hitch hikers.</p> <p>Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency.</p> <p>Consider being a member of a rescue service in case your vehicle breaks down or in case of a minor accident.</p> <p>Park in well lit places and check vehicle for any signs of a break in before getting into it. In case of a breakdown, stay with your vehicle with your doors locked and await emergency rescue services (unless on a motorway or busy roundabout – if possible stand by barrier away from vehicle).</p> <p>If followed, drive to a busy area or to the nearest police station and report details to them. When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager.</p> <p>Avoid one to one site meetings with unknown individuals.</p> |

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|--|------------|----------|------------|
| 1 | Biological/ stings and bites | 2 | 2 | 4 |
| 2 | Slips, trips and falls | 2 | 3 | 6Y |
| 3 | Dogs | 2 | 2 | 4 |
| 4 | Contact with soil borne micro organisms | 1 | 2 | 2 |
| 5 | Ponds / deep water | 2 | 3 | 6Y |
| 6 | Personal attack | 2 | 3 | 6Y |
| 7 | Food borne illness | 2 | 3 | 6Y |
| 8 | Horses/livestock | 2 | 2 | 4 |
| 9 | Electric fences/barbed wire | 1 | 3 | 3 |
| 10 | Injury from Chemo- and Bio hazardous waste | 2 | 2 | 4 |
| 11 | Contact with plant sap | 2 | 2 | 4 |

| | | | | | | | | | |
|---|---|---|----------------------|--------------------|----|-------------|----|-----------|-----|
| 12 | Weather | 1 | 3 | 3 | | | | | |
| 13 | Lone working | 2 | 3 | 6Y | | | | | |
| 14 | Using a car | 3 | 2 | 6G | | | | | |
| Name: Elen Richards | | Signed | | Date | | | | | |
| Position: Coed Cymru Officer | |  | | 01/10/13 | | | | | |
| Reviews | Key | | | | | | | | |
| Review Date : Sept 2019 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Sharp  | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : Oct 2022 | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: R Pulman | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review Date : | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : | | | | Severity of Injury | | | | | |
| Reviewed by: | | | | Low Risk | | Medium Risk | | High Risk | |

CF/04/02 (col)



Cyngor Castell-nedd Port Talbot
Neath Port Talbot Council

Risk Assessment Form

| Activity to be Assessed | Assessment Number |
|--|-------------------|
| <p>General Safety on site for guided nature walks. [walk description/length/time]</p> <p>Contact as contact on site: Phone No</p> <p>Is there a 1st Aider leading Y/N</p> <p>OS grid ref Site information for emergency vehicles. Nearest A&E Unit: Details</p> <p>OR Minor Injury unit in Neath: Baglan Way. Port Talbot. SA12 7BX</p> | |

Persons undertaking or affected by the activity

Service Employees Contractor Public Pupil User

Other

| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level |
|--------------------|---|------------|----------|------------|
| 1 | Biological/ stings and bites | 3 | 2 | 6G |
| 2 | Slips, trips and falls | 3 | 3 | 9 |
| 3 | Walking at dusk/night (16.30) | 3 | 3 | 9 |
| 4 | Contact with micro-organisms inc. Leptospirosis | 2 | 3 | 6G |
| 5 | River / deep water | 3 | 3 | 9 |
| 6 | Personal attack | 3 | 3 | 9 |
| 7 | Dog/animal faeces | 3 | 3 | 9 |
| 8 | Electric fences/barbed wire | 3 | 3 | 9 |
| 9 | Fire | 1 | 4 | 4 |
| 10 | Weather | 4 | 3 | 9 |
| 11 | Lone working | 3 | 3 | 9 |
| 12 | Using a car | 4 | 2 | 8 |
| 13 | Contact with plant sap | 4 | 2 | 8 |

| Existing Control Measures / Additional Control Measures Required | |
|--|---|
| 1 | Wear long trousers and long sleeved tops to limit tick bites. If known allergy to stings take appropriate medication on site. If feeling unwell after a site visit seek medical attention. Advise members of public prior to walk to wear appropriate clothing. |
| 2 | Wear appropriate footwear and advise public to wear appropriate footwear. Take care when walking through areas of deep habitat or areas where there is poor footing visibility. Avoid areas of poor footing visibility if possible. Everyone encouraged to think safely at all times. |
| 3 | Route checked prior to walk. Participants will be grouped, with a group leader. If children come along it will be made clear that parents are responsible for their own children. |


| | |
|---|---|
| 4 | Advise attendees to clean hands before eating, drinking or smoking and to cover any broken skin. Any cuts that occur during walk must be treated promptly and covered to avoid infection. Inform attendees of Weil's disease (Leptospirosis). |
| 5 | Take care when near water bodies. Do not walk close to rivers, advise of water's edge where possible. Event to be cancelled if river levels are too high/ swollen. Parents told they are responsible for their own children and advised of water route before the walk. |

| | |
|----|---|
| 6 | <p>Using instincts. If you don't feel safe stay/get back to your car/main road. Lock personal valuables out of sight in your vehicle. Carry a mobile phone for lone working on remote sites, checking that signal is present, before relying on this (phone signal could be checked when carrying out site assessment the day before).</p> <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented. Follow lone working procedure It is important that you let someone know where and when you are going on site and an approximate time of when you plan to finish. Let the designated 'buddy' know when you are off site and on your way home.</p> |
| 7 | <p>Visual pre-walk check. An alternative route offered if needed. Inform appropriate member of staff to report problem areas.</p> |
| 8 | <p>Pre-walk check for electric fences or barbed wire on ground. Where possible stick to footpaths. Only cross fences where there is a structure (gate/stile) to do so.</p> |
| 9 | <p>None</p> |
| 10 | <p>Wear appropriate clothing; e.g. waterproof coat/trousers if it's raining, light clothing & hat for sunny/warm weather. Extra clothing as appropriate for the terrain and conditions to be carried, noting details on local precautions. If hot weather: carry drinking water. Stop the walk promptly if not prepared for the conditions, uncomfortable or the walk becomes hazardous.</p> |
| 11 | <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented. Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager/contact in office. Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency. Let the designated 'buddy' know when you are off site and on your way home. Do not give home or personal details to anyone met on site</p> |

12 Always reverse into a parking space, enabling a quick exit if needed.
 Ensure doors are locked and windows only partially open when you are stationary in your vehicle.
 Do not leave valuables on view in your vehicle when you are driving or stationary, for example mobile phone or cash. Don't pick up hitch hikers.
 Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency.
 Consider being a member of a rescue service in case your vehicle breaks down or in case of a minor accident.
 Park in well lit places and check vehicle for any signs of a break in before getting into it. In case of a breakdown, stay with your vehicle with your doors locked and await emergency rescue services (unless on a motorway or busy roundabout – if possible stand by barrier away from vehicle).
 If followed, drive to a busy area or to the nearest police station and report details to them.

13 Identify any hazardous plants on site before carrying out activity, for example: Hogweed, wild carrot.
 Plan walk to avoid hazardous plants if possible.
 Wear long sleeved tops and trousers when working close to hazardous plants Wear protective gloves if appropriate.
 Wash exposed skin thoroughly after any contact with skin, before drinking or smoking In case of an allergic reaction following accidental contact with plant sap, identify the plant and monitor casualty for shock. If condition of the casualty deteriorates, call an ambulance immediately and ensure that a sample of the plant accompanies the casualty to hospital to ensure correct diagnosis and treatment.

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|---|------------|----------|------------|
| 1 | Biological/ stings and bites | 2 | 2 | 4 |
| 2 | Slips, trips and falls | 2 | 3 | 6Y |
| 3 | Walking/surveying at dusk/night | 2 | 3 | 6Y |
| 4 | Contact with micro-organisms inc. Leptospirosis | 1 | 2 | 2 |
| 5 | Ponds / deep water | 2 | 3 | 6Y |
| 6 | Personal attack | 2 | 3 | 6Y |
| 7 | Animal/dog faeces | 2 | 3 | 6Y |
| 8 | Electric fences/barbed wire | 1 | 3 | 3 |
| 9 | Fire | 1 | 4 | 4 |
| 10 | Weather | 1 | 3 | 3 |
| 11 | Lone working | 2 | 3 | 6Y |
| 12 | Using a car | 3 | 2 | 6G |
| 13 | Contact with plant sap | 2 | 2 | 4 |

| | | | | | | | | | |
|--|-----------------|--|----------------------|---------------------|-----------|-----|----|----|----|
| Name: Laura Palmer Position: Biodiversity Implementation Officer | | Signed  x | | Date 19/07/2019 | | | | | |
| Reviews | Key | | | | | | | | |
| Review Date : Oct 2022 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Pulman | 1 very unlikely | 1 nuisance | Likelihood of Injury | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : | 2 unlikely | 2 minor | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: | 3 likely | | | 3 medical treatment | 2 | 2 | 4 | 6Y | 8 |
| Review Date : | 4 very likely | 4 major | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : | | | | Severity of Injury | | | | | |
| Reviewed by: | 5 certainty | 5 fatal | Low Risk | Medium Risk | High Risk | | | | |

CF/04/02 (col)

| Activity to be Assessed | | Assessment Number | | | |
|--|--|-------------------|----------|------------|--|
| Safety on site for surveying along roads | | | | | |
| Persons undertaking or affected by the activity | | | | | |
| Service <input checked="" type="checkbox"/> Employees <input type="checkbox"/> Contractor <input type="checkbox"/> Public <input type="checkbox"/> Pupil <input type="checkbox"/> User | | | | | |
| Other <input type="checkbox"/>volunteers..... | | | | | |
| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level | |
| 1 | Biological/ stings and bites | 4 | 2 | 8 | |
| 2 | Slips, trips and falls | 3 | 3 | 9 | |
| 3 | Dogs | 3 | 2 | 6G | |
| 4 | Contact with soil borne micro organisms | 2 | 2 | 4 | |
| 5 | Ponds / deep water | 3 | 3 | 9 | |
| 6 | Personal attack | 3 | 3 | 9 | |
| 7 | Food borne illness | 3 | 3 | 9 | |
| 8 | Horses/livestock | 4 | 2 | 8 | |
| 9 | Electric fences/barbed wire | 3 | 3 | 9 | |
| 10 | Injury from Chemo- and Bio hazardous waste | 4 | 2 | 8 | |
| 11 | Contact with plant sap | 4 | 2 | 8 | |
| 12 | Weather | 3 | 3 | 9 | |
| 13 | Lone working | 3 | 3 | 9 | |
| 14 | Using a car | 4 | 2 | 8 | |
| 15 | Road traffic accident | 3 | 4 | 12 | |
| Existing Control Measures / Additional Control Measures Required | | | | | |
| 1 | Wear long trousers and long sleeved tops to limit tick bites. Wash hands before eating. If known allergy to stings take appropriate medication on site. If feeling unwell after a site visit seek medical attention. | | | | |
| 2 | Wear appropriate footwear. Take care when walking through areas of deep habitat or areas where there is poor footing visibility. Avoid areas of poor footing visibility if possible. Take care when footing is not clearly visible. Look for signs nearby of structures eg, partially collapsed fence. | | | | |
| 3 | Be wary of dogs off leads. Disinfect any bites and seek medical attention. | | | | |


| | |
|----|---|
| 4 | <p>Ensure water/wipes are available on site to clean hands before eating, drinking or smoking.</p> <p>Any broken skin must be covered.</p> <p>Any cuts received during surveying must be treated promptly and covered to avoid infection.</p> |
| 5 | <p>Take care when near water bodies. Do not walk near to the pond. If working in deep water see separate Risk Assessment for Wetland work.</p> |
| 6 | <p>Use your instincts. If you don't feel safe stay/get back to your car/main road.</p> <p>Lock personal valuables out of sight in your vehicle.</p> <p>Carry a mobile phone for lone working on remote sites, checking that signal is present, before relying on this (phone signal could be checked when carrying out site assessment the day before).</p> <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented.</p> <p>It is important that you let someone know where and when you are going on site and an approximate time of when you plan to finish. Let the designated 'buddy' know when you are off site and on your way home.</p> |
| 7 | <p>Ensure any cuts are protected from contact with food</p> <p>Ensure that you clean hands before eating, drinking or smoking. If sufficient water, soap and drying facilities are not available, ensure that suitable hand wipes are used.</p> |
| 8 | <p>Do not enter any field containing bulls or livestock with young without first assessing the situation or if you have a dog with you as the livestock will consider the dog a threat to their young etc. Stay close to the fence line or hedge. If you are charged at you can either make yourself look bigger by waving your arms frantically and making a lot of noise or you can find the nearest exit point out of the field. If you are charged at and you have a dog on the lead with you, let the dog off the lead.</p> |
| 9 | <p>Check for electric fences (you can check to see if a fence is live by putting a blade of grass to the wire and seeing if the blade of grass bounces against the wire, if it does it is live!), do not climb over fences, use the nearest gate or stile</p> |
| 10 | <p>Do not touch unidentified cans or canisters, oil drums, poisons or insecticides</p> <p>Do not touch clinical waste, other hazardous substances, condoms or syringes</p> |
| 11 | <p>Identify any hazardous plants on site before carrying out activity, for example: Hogweed, wild carrot.</p> <p>Plan walk to avoid hazardous plants if possible.</p> <p>Wear long sleeved tops and trousers when working close to hazardous plants Wear protective gloves if appropriate.</p> <p>Wash exposed skin thoroughly after any contact with skin, before drinking or smoking In case of an allergic reaction following accidental contact with plant sap, identify the plant and monitor casualty for shock. If condition of the casualty deteriorates, call an ambulance immediately and ensure that a sample of the plant accompanies the casualty to hospital to ensure correct diagnosis and treatment.</p> |

| | |
|----|--|
| 12 | <p>Wear appropriate clothing; e.g. waterproof coat/trousers if it's raining, light clothing & hat for sunny/warm weather.</p> <p>Avoid sunburn risk by not exposing skin, even when some cloud cover exists</p> <p>Ensure that you have suitable high factor sun block. Do not provide sun block to others unless they can confirm that they have used the product before without adverse reactions</p> <p>Extra clothing as appropriate for the terrain and conditions to be carried, noting details on local precautions.</p> <p>If hot weather then ensure you have drinking water with you.</p> <p>Stop surveying promptly if you are not prepared for the conditions, uncomfortable or the work is becoming hazardous.</p> |
| 13 | <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented.</p> <p>Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return. When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager/contact in office.</p> <p>Avoid one to one site meetings with unknown individuals</p> <p>Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency</p> <p>Consider being a member of a rescue service in case your vehicle breaks down or in case of a minor accident</p> <p>Let the designated 'buddy' know when you are off site and on your way home. Do not give home or personal details to anyone met on site</p> |
| 14 | <p>Always reverse into a parking space, enabling a quick exit if needed.</p> <p>Ensure doors are locked and windows only partially open when you are stationary in your vehicle.</p> <p>Do not leave valuables on view in your vehicle when you are driving or stationary, for example mobile phone or cash.</p> <p>Don't pick up hitch hikers.</p> <p>Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency.</p> <p>Consider being a member of a rescue service in case your vehicle breaks down or in case of a minor accident.</p> <p>Park in well lit places and check vehicle for any signs of a break in before getting into it. In case of a breakdown, stay with your vehicle with your doors locked and await emergency rescue services (unless on a motorway or busy roundabout – if possible stand by barrier away from vehicle).</p> <p>If followed, drive to a busy area or to the nearest police station and report details to them.</p> <p>When you have an individual such as your partner to be your buddy, ensure they know what procedure to carry out in case of no return and that they have contact details for your line manager.</p> <p>Avoid one to one site meetings with unknown individuals.</p> |

| | |
|----|--|
| 15 | <p>No lone working on roads without pavements. Nominate a person to be responsible for watching for traffic and warning surveyor when vehicles are present. Stick to pavements where possible. On highways with no pavement put out Men at Work signage Wear high visibility tops</p> |
|----|--|

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|--|------------|----------|------------|
| 1 | Biological/ stings and bites | 2 | 2 | 4 |
| 2 | Slips, trips and falls | 2 | 3 | 6Y |
| 3 | Dogs | 2 | 2 | 4 |
| 4 | Contact with soil borne micro organisms | 1 | 2 | 2 |
| 5 | Ponds / deep water | 2 | 3 | 6Y |
| 6 | Personal attack | 2 | 3 | 6Y |
| 7 | Food borne illness | 2 | 3 | 6Y |
| 8 | Horses/livestock | 2 | 2 | 4 |
| 9 | Electric fences/barbed wire | 1 | 3 | 3 |
| 10 | Injury from Chemo- and Bio hazardous waste | 2 | 2 | 4 |
| 11 | Contact with plant sap | 2 | 2 | 4 |
| 12 | Weather | 1 | 3 | 3 |
| 13 | Lone working | 2 | 3 | 6Y |
| 14 | Using a car | 3 | 2 | 6G |
| 15 | Road traffic accident | 1 | 4 | 4 |

| | | |
|--------------------------------|---|--------------------|
| Name: Laura Palmer | Signed  | Date 10/05/2016 |
| Position: Biodiversity Officer | | |

| Reviews | Key | | | | | | | | |
|---|---|--|----------------------|--------------------|----------|-------------|-----------|----|-----|
| Review Date : Sept 2019 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Sharp  | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : Oct 2022 | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: R Pulman | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review Date : | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : | | | | Severity of Injury | | | | | |
| Reviewed by: | | | | | Low Risk | Medium Risk | High Risk | | |

Risk Assessment Form

| Activity to be Assessed | | Assessment Number | | |
|--|---|-------------------------------------|--|--|
| Wetland work, including ponds, rivers and streams | | BG/W19 | | |
| Persons undertaking or affected by the activity | | | | |
| Service | <input checked="" type="checkbox"/> Employees | <input type="checkbox"/> Contractor | <input checked="" type="checkbox"/> Public | <input type="checkbox"/> Pupil <input type="checkbox"/> User |
| Other | <input type="checkbox"/> | | | |
| Identified Hazards | Associated Risks | Likelihood | Severity | Risk Level |
| 1 | Chest waders | 1 | 1 | 1 |
| 2 | Contact with micro-organisms inc. Leptospirosis | 2 | 3 | 6G |
| 3 | Contact with sharp or swinging tools | 3 | 3 | 9 |
| 4 | Dead animals | 2 | 3 | 6 |
| 5 | Deep or fast flowing water | 3 | 5 | 15 |
| 6 | Exposure to harmful substances | 2 | 3 | 6G |
| 7 | General manual handling | 3 | 3 | 9 |
| 8 | Slips, trips and falls | 3 | 3 | 9 |
| 9 | Submerged objects | 2 | 3 | 6G |
| 10 | Use of small boats | 3 | 5 | 15 |
| 11 | Weirs | 3 | 5 | 15 |
| Existing Control Measures / Additional Control Measures Required | | | | |
| 1 | All wearers of chest waders to have instruction on how to get out of them before using them. | | | |
| 2 | Advise participants to have Tetanus inoculation. Do not drink or wash hands in stream or pond water, use clean water and antibacterial wash/soap solution or hand wipes. Wash hands before eating, drinking or smoking. Wear strong rubber gloves and give the option to use barrier cream. Cover all cuts with waterproof plasters. Inform all participants working in water of Weil's disease (Leptospirosis). | | | |
| 3 | Do not use when handles are wet and slippery. Do not wear gloves when using swinging tools. Ensure a firm, stable stance. Keep guards and covers on tools when not in use. Instruct volunteers in safe working distances appropriate to tools and task. | | | |

| | |
|----|---|
| 4 | <p>Dead animals should be touched only when absolutely necessary and then with extreme caution and wearing rubber gauntlets.</p> <p>Wash hands and arms immediately afterwards with anti-bacterial soap.</p> <p>Disinfect all protective clothing that may have come into contact with the corpse. Inform Environment Agency or equivalent before disposing of the corpse.</p> |
| 5 | <p>Waders must be worn for water above welly and below thigh height; chest waders for water above mid-thigh and below waist height.</p> <p>Always wear lifejackets/buoyancy aid when working on or above deep or fast flowing water.</p> <p>Do not work alone in water.</p> <p>Ensure there is always someone on the banks to act in the event of an emergency.</p> <p>Have ropes, poles, and lifebelts readily to hand to avoid others having to enter the water.</p> <p>Plan rescue systems in advance.</p> <p>Still water over waist deep or fast flowing water above knee height must not be worked in.</p> |
| 6 | <p>If there is any concern over content of water, have water tested before working in it.</p> <p>Do not work on any site where sewage is known to be present.</p> <p>If hazardous substances are found, stop work and report to the Environment Agency or equivalent.</p> |
| 7 | <p>Advise all that wet materials are much heavier than their equivalent dry ones.</p> <p>Instruct all in safe lifting, carrying and moving techniques for working in water.</p> |
| 8 | <p>Movement around and in water must not be rushed, walk slowly.</p> <p>Provide grab fines/ropes and non-slip planks.</p> <p>Tread carefully on gravel banks.</p> <p>Use safe access points to water, avoiding steep banks.</p> <p>Carry out a survey of the work area and mark out soft spots, sudden drops, etc. Use corrugated iron 'duckboards' to prevent sinking into mud.</p> |
| 9 | <p>Wear sturdy footwear, with sole and toe protection.</p> <p>Wear sturdy rubber gloves, unless using swinging tools.</p> |
| 10 | <p>Do not overload boat with people or materials.</p> <p>Only trained competent persons to be in charge of a boat.</p> <p>Work from opposite sides to avoid tipping over and carry spare oars, bailer and rope.</p> <p>If boat is to be taken more than 50 metres from shore, undertake detailed assessment for work and control measures.</p> |
| 11 | <p>A specific detailed assessment should be undertaken if work on or near a weir is planned.</p> |

| Reassessment of Activity Hazards | | Likelihood | Severity | Risk Level |
|----------------------------------|---|------------|----------|------------|
| 1 | Chest Waders | 1 | 1 | 1 |
| 2 | Contact with micro-organisms inc. Leptospirosis | 2 | 3 | 6G |
| 3 | Contact with sharp or swinging tools | 2 | 3 | 6G |
| 4 | Dead animals | 2 | 2 | 4 |
| 5 | Deep or fast flowing water | 1 | 5 | 5 |
| 6 | Exposure to harmful substances | 2 | 3 | 6G |
| 7 | General manual handling | 2 | 3 | 6G |
| 8 | Slips, trips and fails | 2 | 3 | 6G |
| 9 | Submerged objects | 2 | 3 | 6G |

| 10 | Use of small boats | 1 | 5 | 5 | | | | | |
|---|---|--|----------------------|--------------------|----------|-------------|-----------|----|-----|
| 11 | Weirs | 1 | 5 | 5 | | | | | |
| Name Chaela Carrell | | Signed | | Date | | | | | |
| Position Wildlife Community Project Officer | | | | 01/03/08 | | | | | |
| Reviews | Key | | | | | | | | |
| Review Date : Sept 08 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: C Gaeyi | 1 very unlikely 2 unlikely 3 likely 4 very likely 5 certainty | 1 nuisance 2 minor 3 medical treatment 4 major 5 fatal | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : Sept 10 | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: C Evans | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review Date : Sept 2011 | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: R Sharp | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : Oct 2022 | | | | Severity of Injury | | | | | |
| Reviewed by: R Pulman | | | | | Low Risk | Medium Risk | High Risk | | |

CF/04/02 (col)



| Corporate Risk Assessment | | Risk Assessment Reference Number: DPP/10 | | |
|---|---|--|---|---|
| Name of assessor | Sarah Reed | Section | Planning Policy | |
| Activity being assessed: | Lost Peatlands - Arts and Craft Event | Subsection | Countryside & Wildlife Team | |
| Persons undertaking or affected by the activity | | Risk assessment created on: 15/10/2021 Review date due: 15/10/2024 | | |
| <input checked="" type="checkbox"/> Employees <input checked="" type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Service User <input type="checkbox"/> Pupil <input type="checkbox"/> Other | | | | |
| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
| Use of work equipment | Tools should be maintained properly. Tools, equipment and materials must be checked before use. Any item identified as faulty must be removed from service until repaired or replaced. All defects must be reported to the person in charge. Tools, equipment and materials, especially those with sharp edges etc, must be used in the proper manner and only for purpose for which they are designed. Suitable information, instruction and training must be provided before using tools, equipment and materials. | 1 - Very unlikely | 1 - Negligible | 1 - Low Risk |
| Exposure to Animal / Bird Urine and Droppings | Area must be checked prior to task commencing. Biological waste i.e. animal / bird urine and droppings must be disposed of in the proper manner appropriate to the nature of the substance. Seek advice if there is any doubt or if a substance cannot be identified. Cuts and open wounds must be covered, preventing the possibility of infection. Maintain good personal hygiene standards. Do not to touch your face, smoke, eat or drink following any possible contact with dead animals / birds unless you have washed your hands and face thoroughly with soap and water. If significant contamination has occurred a shower should be taken as soon as possible. | 2 - Unlikely | 1 - Negligible | 2 - Low Risk |

| | | | | |
|----------------------------|--|-------------------|-----------|--------------|
| | | | | |
| Contact with sharp objects | <p>Site inspected prior to use</p> <p>Broken glass must be removed and disposed of correctly and safely.</p> <p>Litter and debris must be carefully examined before collection and never handled with bare hands.</p> <p>Operatives handling sharp equipment/tools, e.g. scissors, must hold the handle, not the blade</p> <p>Operatives should not move around with sharp equipment/tools</p> | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |
| Adverse weather conditions | In extreme weather, especially during winter months, event leaders will assess conditions prior to carrying out tasks. | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|----------------------------|---|--|---|---|
| Adverse weather conditions | Suitable (weather appropriate) protective clothing and footwear will be provided and shall be worn. Sun cream to be supplied and applied if necessary. | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |

| | | | | |
|--|---|-------------------|-----------------------|-----------------|
| Slip, Trip and Falls | <p>Outdoors: Before starting work outside, ground conditions must be assessed. Any slip, trip or fall hazards that can't be removed/made safe should be highlighted to participants. Participants must be wearing appropriate footwear. Access and egress routes and working areas must be kept clear and tidy.</p> <p>Indoors: Access and egress routes and working areas must be kept clear and tidy. Any item(s) left on the ground/floor, that could cause a trip hazard, must be removed or arrangements made to have them removed. In the event the hazard cannot be removed, the area is to be made safe through the use of barriers, cones and appropriate signage etc where possible and/or participants informed of the hazard. Participants requested to walk around venue and not run</p> | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |
| Contact with Sharps or Needle sticks | <p>Site will be inspected prior to use. If employees have any concerns of materials being present that have the potential to cause injury, they will leave, make participants aware of the hazard, and move to an alternative area to work in. Needles or syringes must not be picked up.</p> | 1 - Very unlikely | 3 - Medical treatment | 3 - Low Risk |
| Manual Handling of inanimate loads (objects and materials) | <p>The risk has been reduced by assessing the environment in which the activity is taking place, the weight, size and shape of the load to be handled including consideration to sharp edges. Individual lifting capacity should not be exceeded. Where necessary break down loads into smaller more practical loads, or seek assistance to share the load and use team lifting, or use manual handling aids such as trolleys to transport loads.</p> | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Dealing with Unpredictable / Challenging / Inappropriate Behaviour | <p>Unpredictable / challenging / inappropriate behaviour from members of the public/pupils/service users must be reported as soon as possible.</p> | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Exposure to COVID-19 | <p>All individuals are to be meticulous with their hand washing; washing thoroughly for at least 20 seconds on a regular basis. If hand washing facilities are not available, hand sanitiser is to be provided. Clean all high contact areas (e.g. hard surfaces) particularly if more than one person is likely to use the working area. Cover your cough or sneeze with a flexed elbow or tissue; immediately dispose of the tissue safely and wash/sanitise your hands Refrain from touching own eyes, nose, and mouth. If any individual displays symptoms related to covid-19 (a new cough, high temperature, shortness of breath) they must not attend and self-isolate in line with</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|----------------------|--|--|---|---|
| Exposure to COVID-19 | Public Health Wales guidance. Social distancing must be maintained at all times wherever possible to avoid being coughed or sneezed upon and therefore reducing the risk of the spread of the COVID19 virus. If two employees are required to carry out a task/visit they should travel in separate vehicles as a distance of 2metres cannot be kept if travelling in the same vehicle. Masks should be worn during an event indoors Some windows must be open to facilitate sufficient ventilation. If hiring a venue, COVID-19 guidelines for the venue should be adhered to. If an indoor event limit numbers of participants and amount of time spent indoors. | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |

Personnel Protective Equipment



Other Appropriate clothing and footwear to be worn for the activity and the weather. Face masks to be worn indoors.

Additional Risk Information

Mean Average is derived by the calculation of the identified risk rating multiplied by the amount of hazards identified in the overall task.

3 - Low Risk

In the event of an incident / accident, please contact your nearest first aider.
 All incidents/accidents must be recorded on NPT's Online Accident Reporting System.
 Suitable information, instruction and training on how to use, store and maintain Personal Protective Equipment (PPE) correctly to be provided. All staff to have regard for their and others health and safety at all times.

Please identify how this risk assessment has been communicated.

One to one

Emergency procedures

Contact name: Sarah Reed

Contact number: 07870483819

Contact number (out of hours): 07922193894

| Risk assessments must be reviewed as a result of change in working practices / legislation or following an incident / accident | | | | | | | | |
|--|---|--|---------------------------|----------|----|-------------|----|----|
| Reviews | Key | | Likelihood of Injury | | | | | |
| Review date : Oct 2022 | Likelihood | Severity | | 5 | 5Y | 10R | 15 | 20 |
| Reviewed by: R Pulman | <ol style="list-style-type: none"> Very Unlikely - This will probably never happen/occur Unlikely - Do not expect it to happen/recur but it is possible it may do so Likely - Might happen or recur occasionally Very Likely - Will probably happen/recur, but it is not a persisting issue/circumstance Certainty - Will undoubtedly happen/recur, possibly frequently | <ol style="list-style-type: none"> Negligible - Minor injuries or discomfort. No medical treatment or measurable physical effects. Minor - Injuries or illness requiring on site first aid. Temporary impairment. Medical Treatment - Injuries or illness requiring hospital treatment. Major - Injury or illness resulting in permanent impairment. Fatal - Fatality. | | 4 | 4 | 8 | 12 | 16 |
| Review date : | | | | 3 | 3 | 6G | 9 | 12 |
| Reviewed by: | | | | 2 | 2 | 4 | 6Y | 8 |
| Review date : | | | | 1 | 1 | 2 | 3 | 4 |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 |
| Review date : | | | Severity of Injury | | | | | |
| Reviewed by: | | | | Low Risk | | Medium Risk | | |



| Corporate Risk Assessment | | Risk Assessment Reference Number: DPP/11 | | |
|---|---|--|---|---|
| Name of assessor | Sarah Reed | Section | Planning Policy | |
| Activity being assessed: | School grounds improvement activities | Subsection | Countryside & Wildlife Team | |
| Risk assessment created on: 27/01/2022 | | Review date due: 27/01/2025 | | |
| Persons undertaking or affected by the activity | | | | |
| <input checked="" type="checkbox"/> Employees | <input type="checkbox"/> Contractor | <input type="checkbox"/> Public | <input checked="" type="checkbox"/> Service User | <input checked="" type="checkbox"/> Pupil |
| <input type="checkbox"/> Other | | | | |
| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
| Slip, Trip and Falls | Any item(s) left on the ground/floor, that could cause a trip hazard, must be removed or arrangements made to have them removed. In the event the hazard cannot be removed, the area is to be made safe through the use of barriers, cones and appropriate signage etc. Before starting work outside, ground conditions must be assessed. The working area must be free from slip, trip or fall hazards, and kept tidy. | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |

| | | | | |
|-----------------------|---|-------------------|-----------------------|--------------|
| | | | | |
| Use of work equipment | <p>Electrical equipment must be checked for an up to date P.A.T Test sticker prior to use. If the sticker is missing or out of date, it must be reported immediately. The operating switch must be in the 'off' position before connecting equipment to the power supply. Electrical equipment must be isolated from the electricity supply when not in use.</p> <p>Equipment must be correctly set up and adjusted before use. Guards fitted to, or supplied with equipment, must be used. Machinery safety devices must be fully engaged and locked before entering the full working range of the machine. Loose clothing to be removed and long hair to be tied up. When the machine is in motion, a safe distance must be maintained from the full working range of the equipment.</p> <p>Power to tools must be isolated (e.g. unplugged) before any adjustments are undertaken. The ignition keys must be removed from the equipment when not in use.</p> <p>Hand tools must be checked before use. Any equipment identified as faulty must be removed from service until repaired or replaced. All defects must be reported to the</p> | 1 - Very unlikely | 3 - Medical treatment | 3 - Low Risk |

| Hazard | Control measure | Likelihood | Severity | Risk Level |
|--------|-----------------|--|---|---------------------------------------|
| | | 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Likelihood x Severity = Risk Level |

| | | | | |
|----------------------------|--|-------------------|-----------------------|--------------|
| Use of work equipment | <p>person in charge. Hand tools, especially those with sharp cutting edges, must be used in the proper manner and only for purpose for which they are designed. Maintain tools properly by keeping cutting edges sharp. Participants advised not to walk around holding tools unless they are designed to be used in such a manner.</p> <p>Suitable information, instruction and training must be provided to participants/employees before operating the machinery. In accordance with training received and manufacturer's instructions, equipment must only be used for the purpose for which it has been designed.</p> <p>Session leaders to be advised of any participants with allergies to materials being used and those participants should be directed towards and alternative activity. Participants advised not to place fingers into mouths, eyes etc and not to eat or drink during activity. Participants advised to wash hands thoroughly at the end of the session.</p> | 1 - Very unlikely | 3 - Medical treatment | 3 - Low Risk |
| Contact with sharp objects | <p>Participants must follow all instructions/health and safety guidance given by session leader regarding the correct handling and use of equipment. If session leader is from an external organisation instructions/health and safety guidance given should reflect content of risk assessments in place for their organisation.</p> <p>Participants handling sharp equipment must hold the handle, not the blade. When using a sharp implement / equipment / utensil, the operatives are made aware of any moving parts, use the protective guards, accordingly and follow the session leader's/manufacturer's instructions. Participants should refrain from moving around the workspace as much as possible</p> | 2 - Unlikely | 2 - Minor | 4 - Low Risk |

Personnel Protective Equipment



Other as indicated by
manufacturer's guidelines

Additional Risk Information

Mean Average is derived by the calculation of the identified risk rating multiplied by the amount of hazards identified in the overall task.

3 - Low Risk

In the event of an incident / accident, please contact your nearest first aider.

All incidents/accidents must be recorded on NPT's Online Accident Reporting System.

Suitable information, instruction and training on how to use, store and maintain Personal Protective Equipment (PPE) correctly to be provided. All staff to have regard for their and others health and safety at all times.

Please identify how this risk assessment has been communicated.

One to one

Emergency procedures

Contact name: Sarah Reed

Contact number: 07870483819

Contact number (out of hours): 07870483819

| Risk assessments must be reviewed as a result of change in working practices / legislation or following an incident / accident | | | | | | | | | |
|--|---|--|----------------------|---------------------------|----------|-----|-------------|----|-----------|
| Reviews | Key | | Likelihood of Injury | | | | | | |
| Review date : Oct 2022 | Likelihood | Severity | | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Pulman | <ol style="list-style-type: none"> Very Unlikely - This will probably never happen/occur Unlikely - Do not expect it to happen/recur but it is possible it may do so Likely - Might happen or recur occasionally Very Likely - Will probably happen/recur, but it is not a persisting issue/circumstance Certainty - Will undoubtedly happen/recur, possibly frequently | <ol style="list-style-type: none"> Negligible - Minor injuries or discomfort. No medical treatment or measurable physical effects. Minor - Injuries or illness requiring on site first aid. Temporary impairment. Medical Treatment - Injuries or illness requiring hospital treatment. Major - Injury or illness resulting in permanent impairment. Fatal - Fatality. | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review date : | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review date : | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review date : | | | | Severity of Injury | | | | | |
| Reviewed by: | | | | | Low Risk | | Medium Risk | | High Risk |



| Corporate Risk Assessment | | Risk Assessment Reference Number: DPP/08 | | |
|--|--|--|---|---|
| Name of assessor | Rebecca Sharp | Section | Planning Policy | |
| Activity being assessed: | Volunteer task days and events (Outdoors) | Subsection | Countryside & Wildlife Team | |
| Persons undertaking or affected by the activity | | Risk assessment created on: 14/09/2021 Review date due: 14/09/2023 | | |
| <input checked="" type="checkbox"/> Employees <input type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Service User <input type="checkbox"/> Pupil <input type="checkbox"/> Other | | | | |
| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
| Exposure to Animal / Bird Urine and Droppings | Area must be checked prior to task commencing. Biological waste i.e. animal / bird urine and droppings must be disposed of in the proper manner appropriate to the nature of the substance. Seek advice if there is any doubt or if a substance cannot be identified. Cuts and open wounds must be covered, preventing the possibility of infection. Maintain good personal hygiene standards. Do not to touch your face, smoke, eat or drink following any possible contact with dead animals / birds unless you have washed your hands and face thoroughly with soap and water. If significant contamination has occurred a shower should be taken as soon as possible. If practical wear gloves to protect hands | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |

| | | | | |
|--|--|-------------------|-----------|--------------|
| Dealing with Unpredictable / Challenging / Inappropriate Behaviour | <p>Anyone identified with having unpredictable / challenging / inappropriate behavioural needs, must be made known to staff.</p> <p>Unpredictable / challenging / inappropriate behaviour from members of the public/pupils/service users must be reported as soon as possible.</p> <p>Leave no one isolated on site</p> <p>Lock personal valuables out of site</p> <p>Issue a mobile phone for lone working or group working on remote sites, checking that signal is present before relying on this safety (phone signal could be checked when carrying out site assessment the day before).</p> | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |
| Violence and Aggression | <p>All employees will have Emergency Contact Numbers.</p> <p>All incidents of violence and aggression towards NPT employees must be recorded on the Online Accident Reporting System (OARS).</p> <p>Altercation and conflict with residents or road users must be avoided. ANY issues of conflict must be reported immediately to your supervisor.</p> <p>If you feel threatened, walk away from the situation, find a safe place.</p> | 1 - Very unlikely | 2 - Minor | 2 - Low Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|--------------------------------------|--|--|---|---|
| Proximity to Water | <p>Extreme caution must be taken when undertaking river studies, particularly in water that is more than ankle deep.</p> <p>Great care must be taken when undertaking activities on steep river banks.</p> <p>Hazards / safe practice relating to activities around water, must be fully communicated.</p> <p>To minimise risk of individuals falling in, an adequate level of supervision must be in place.</p> | 1 - Very unlikely | 3 - Medical treatment | 3 - Low Risk |
| Contact with Sharps or Needle sticks | <p>If employees/volunteers have any concerns of materials presented that have potential to cause injury, they will leave, contact supervisor immediately and await instruction.</p> <p>Needles or syringes must not be picked up.</p> <p>Litter and debris are to be carefully investigated before collection. Never clear with bare hands, always use suitable PPE.</p> <p>Employees/volunteers who come into contact with sharps and needles should be vaccinated.</p> | 1 - Very unlikely | 3 - Medical treatment | 3 - Low Risk |

| | | | | |
|----------------------------|---|-------------------|----------------|--------------|
| Movement of Vehicles | Contractors/ visitors must be made aware of site rules including restricted vehicle movements. Employees/volunteers to stay a safe distance away from moving vehicle. In the event of a vehicle breakdown, it will be decided whether the passengers will remain on the vehicle or disembark, depending on the circumstances/ environment at the time. Reversing of vehicles must be reduced wherever possible. To avoid a collision with moving vehicles, individuals must stay on the pedestrian routes. | 1 - Very unlikely | 4 - Major | 4 - Low Risk |
| Injured by an animal | All wounds on exposed skin are suitably covered. Anyone known to have allergic reactions to specific animals have restricted access. Good general hygiene and hand washing followed. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Adverse weather conditions | In extreme weather, especially during winter months, managers will assess conditions prior to employees/volunteers carrying out their tasks. Suitable (weather appropriate) protective clothing and footwear will be provided and shall be worn. Sun cream to be supplied and applied if necessary. | 4 - Very likely | 1 - Negligible | 4 - Low Risk |
| Use of vehicle (Driving) | An adequate supply of fuel must be maintained in the vehicle. Any change to employee's driving record i.e. driving ban, any health condition affecting individual's ability to drive, e.g. high blood pressure, heart condition, eyesight defect, are to be notified to their Line Manager. Drivers must hold a current UK driving license. Driving forms must be completed and checked by the appropriate person. NPTC's Driver & Vehicle Risk Management Policy & Strategy Document must be adhered to. The use of mobile phones while driving is prohibited. Vehicle must be maintained in good working order. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|--------------------------|---|--|---|---|
| Use of vehicle (Driving) | Vehicles must have a valid MOT (if applicable) and road tax. When using a personal vehicle drivers must be insured for business use. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |

| | | | | |
|---|--|--------------|-----------------------|-----------------|
| Slip, Trip and Falls | <p>Access and egress routes must be kept clear.</p> <p>Additional care must be taken when visiting a location that is unfamiliar.</p> <p>Before starting work outside, ground conditions must be assessed.</p> <p>Prior to outdoor play, the ground / grassed areas must be assessed to ensure that they are unsuitable e.g. not too wet/ icy.</p> <p>Where employees/volunteers are working on uneven or sloping ground, they must ensure a firm foot base.</p> <p>Where floors are likely to get wet or be subject to spillages, employees/volunteers must ensure that slip resistant footwear is worn to help prevent slip accidents.</p> | 3 - Likely | 2 - Minor | 6 - Medium Risk |
| Use of work equipment | <p>Hand tools must be checked before use. Any equipment identified as faulty must be removed from service until repaired or replaced. All defects must be reported to the person in charge.</p> <p>Hand tools, especially those with sharp cutting edges, must be used in the proper manner and only for purpose for which they are designed. Maintain tools properly by keeping cutting edges sharp.</p> <p>Suitable information, instruction and training must be provided before using tools No gloves to be worn when using swinging tools, unless other hazards such as plant sap are greater, if so, the safe working distance is at least 20 metres.</p> <p>Ensure the correct tool is used for each job.</p> <p>Suitable footwear to be worn.</p> <p>Assign a designated first aider.</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Exposure to Legionnaire's Disease / Pneumonia, etc (Waterborne Pathogens) | <p>The employee leading to ensure that all members of the group wash their hands in clean water after the activity and prior to eating. Where possible use local hand washing facilities. Where these are not available carry liquid soap.</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Manual Handling of inanimate loads (objects and materials) | <p>Suitable footwear to be worn for all manual handling activities.</p> <p>The risk has been reduced by assessing the environment in which the activity is taking place, the weight, size and shape of the load to be handled including consideration to sharp edges. Individual lifting capacity should not be exceeded. Where necessary break down loads into smaller more practical loads, or seek assistance to share the load and use team lifting, or use manual handling aids such as trolleys to transport loads.</p> <p>At induction, staff must attend a 1/2 day WLGA inanimate loads training as soon as possible (cook, domestic, office staff etc).</p> <p>Where possible equipment is fitted with wheels to minimise the need to manually handle the equipment.</p> <p>Plan in advance any lifting of heavy or awkward items.</p> <p>A safety talk is to be given on safe lifting, carrying, moving techniques and use of tools.</p> <p>Check the health of participant before allowing anyone to carry out manual handling of</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|--|---|--|---|---|
| Manual Handling of inanimate loads (objects and materials) | any heavy items, for example, bad back or pregnancy. Designate someone to load and unload tools, use carrying aids such as a wheelbarrow if needed, heavy items to be carried by two people, limit the number of tools/items one person carries. DON'T stand for a lazy mans load. | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Contact with underground services | Maintain a safe distance away from underground utility services when excavating. The work area must be subject to a services map check and scanned using the cable avoidance tool prior to excavating. Hand dig when unsure. If digging within a 5m line, use only wooden handled spades Watch for buried marker tape indicating pipe or cable and then dig to side ad not over the marked area. Follow guidance in HSG 47 "avoiding danger from underground services Be aware also of low hanging electrical cables, especially if a crane is to be used on site Suitable information, instruction and training must be provided before operating the cable avoidance tool. | 2 - Unlikely | 4 - Major | 8 - Medium Risk |

| | | | | |
|----------------------|--|--------------|-----------|-----------------|
| Exposure to COVID-19 | <p>Cover your cough or sneeze with a flexed elbow or tissue; immediately dispose of the tissue safely and wash/sanitise your hands.</p> <p>Employees/volunteers to refrain from touching their eyes, nose, and mouth. If any individual displays symptoms related to covid-19 (a new cough, high temperature, shortness of breath) they must self-isolate in line with Public Health Wales guidance.</p> <p>If two employees are required to carry out a task/visit they should travel in separate vehicles as a safe distance cannot be kept if travelling in the same vehicle. Public Health Wales guidance must be followed at all times.</p> <p>Social distancing must be maintained at all times wherever possible to avoid being coughed or sneezed upon and therefore reducing the risk of the spread of the COVID19 virus.</p> <p>Signage to be placed in prominent places to remind volunteers of COVID-19 restrictions</p> <p>Limit number of volunteers working on site to numbers easily supervised by staff at safe working distances</p> <p>Disinfect/wash all tools used at the end of the day</p> <p>Clean working gloves to be labelled provided to each volunteer to take home and bring back for each session</p> <p>Social distancing to be maintained during work breaks – staff to only provide water – volunteers advised to own refreshments.</p> <p>Health and safety briefing at beginning of every session to include COVID-19 risks and management</p> <p>If any individual displays symptoms related to covid-19 (a new cough, high</p> | 2 - Unlikely | 4 - Major | 8 - Medium Risk |
|----------------------|--|--------------|-----------|-----------------|

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|----------------------|---|--|---|---|
| Exposure to COVID-19 | <p>temperature, shortness of breath) they must self-isolate in line with Public Health Wales guidance.</p> <p>Any volunteers that have been contacted by track and trace and instructed to selfisolate must not meet with the group.</p> <p>BAME community volunteers should be aware of the increased risk of contracting COVID-19 and should be extra careful.</p> <p>Any volunteers with a high temperature or have any symptoms of COVID-19 must not engage in activities and must self-isolate.</p> <p>All task days/events held outside in well ventilated areas.</p> | 2 - Unlikely | 4 - Major | 8 - Medium Risk |

Personnel Protective Equipment



Safety boots must be worn (Safety boots)



Protective gloves must be worn (EN 420

General Requirements for Protective Gloves. EN 420 is the most basic standard that defines the general requirements for protective gloves in terms of construction, fitness of purpose and safety.)

Additional Risk Information

Mean Average is derived by the calculation of the identified risk rating multiplied by the amount of hazards identified in the overall task.

5 - Medium Risk

In the event of an incident / accident, please contact your nearest first aider.

All incidents/accidents must be recorded on NPT's Online Accident Reporting System.

Suitable information, instruction and training on how to use, store and maintain Personal Protective Equipment (PPE) correctly to be provided. All staff to have regard for their and others health and safety at all times.

Please identify how this risk assessment has been communicated.

Other Circulated to team and volunteers briefed as necessary at event and as part of volunteer inductions.

Emergency procedures

Contact name: Rebecca Sharp

Contact number: 01639686149

Contact number (out of hours): 07985182887

| Risk assessments must be reviewed as a result of change in working practices / legislation or following an incident / accident | | | | | | | | | |
|--|---|--|----------------------|---------------------------|----|-------------|----|-----------|-----|
| Reviews | Key | | Likelihood of Injury | | | | | | |
| Review date : Oct 2022 | Likelihood | Severity | | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Pulman | <ol style="list-style-type: none"> Very Unlikely - This will probably never happen/occur Unlikely - Do not expect it to happen/recur but it is possible it may do so Likely - Might happen or recur occasionally Very Likely - Will probably happen/recur, but it is not a persisting issue/circumstance Certainty - Will undoubtedly happen/recur, possibly frequently | <ol style="list-style-type: none"> Negligible - Minor injuries or discomfort. No medical treatment or measurable physical effects. Minor - Injuries or illness requiring on site first aid. Temporary impairment. Medical Treatment - Injuries or illness requiring hospital treatment. Major - Injury or illness resulting in permanent impairment. Fatal - Fatality. | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review date : | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review date : | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review date : | | | | Severity of Injury | | | | | |
| Reviewed by: | | | | Low Risk | | Medium Risk | | High Risk | |



| | | | | | |
|---|------------------------|---|--|--|--|
| Corporate Risk Assessment | | | | Risk Assessment Reference Number: DPP/03 | |
| Name of assessor Megan Price | | Section Planning Policy | | Risk assessment created on: 11/02/2021 | |
| Activity being assessed: Site Visits/ Site Surveys (general) | | Subsection Countryside & Wildlife Team | | Review date due: 11/02/2023 | |
| Persons undertaking or affected by the activity | | | | | |
| <input checked="" type="checkbox"/> Employees <input checked="" type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input type="checkbox"/> Service User <input type="checkbox"/> Pupil <input type="checkbox"/> Other | | | | | |
| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level | |

| | | | | |
|--------------------------|---|------------|-----------|-----------------|
| Use of vehicle (Driving) | <p>An adequate supply of fuel must be maintained in the vehicle. Any change to employee's driving record i.e. driving ban, any health condition affecting individual's ability to drive, e.g. high blood pressure, heart condition, eyesight defect, are to be notified to their Line Manager. Drivers must hold a current UK driving license. Driving forms must be completed and checked by the appropriate person. Employees must be familiarise with their route prior to commencing their journey, where ever possible.</p> <p>NPTC's Driver & Vehicle Risk Management Policy & Strategy Document must be adhered to. Sufficient time must be allowed for each journeys so as to avoid the temptation to speed, and to include sufficient rest breaks for both the driver and the passenger. The use of mobile phones while driving is prohibited. The rules of the Highway Code must be adhered to and caution exercised at all times. Vehicles must have a valid MOT (if applicable) and road tax. Always reverse into a parking space, enabling a quick exit if needed. Ensure doors are locked and windows only partially open when you are stationary in your vehicle. Do not leave valuables on view in your vehicle when you are driving or stationary, for example mobile phone or cash. Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency.</p> <p>Park in well lit places and check vehicle for any signs of a break in before getting into it.</p> | 3 - Likely | 2 - Minor | 6 - Medium Risk |
|--------------------------|---|------------|-----------|-----------------|

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|--------------------------|---|--|---|---|
| Use of vehicle (Driving) | In case of a breakdown, stay with your vehicle with your doors locked and await emergency rescue services (unless on a motorway or busy roundabout – if possible stand by barrier away from vehicle). | 3 - Likely | 2 - Minor | 6 - Medium Risk |

| | | | | |
|--|--|--------------|-----------------------|-----------------|
| Proximity to Water | <p>Extreme caution must be taken when undertaking river studies, particularly in water that is more than ankle deep.</p> <p>Great care must be taken when undertaking activities on steep river banks.</p> <p>Hazards / safe practice relating to activities around water, must be fully communicated.</p> <p>Ensure that you clean hands before eating, drinking or smoking. If sufficient water, soap and drying facilities are not available, ensure that suitable hand wipes are used.</p> <p>Ensure you are aware of the risks of Weil's disease (Leptospirosis), ensure good hygiene procedures are followed at all times. If you suffer from a high temperature, headache, nausea/ diarrhoea, aching muscles or joints, red eyes or loss of appetite contact GP immediately and explain you may have been exposed to leptospirosis</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Injured by an animal | <p>All wounds on exposed skin are suitably covered.</p> <p>Wear long trousers and long sleeved tops to limit tick bites. Wash hands before eating. If known allergy to stings take appropriate medication on site. If feeling unwell after a site visit seek medical attention.</p> <p>Do not enter any field containing bulls or livestock with young without first assessing the situation or if you have a dog with you as the livestock will consider the dog a threat to their young etc. Stay close to the fence line or hedge. If you are charged at you can either make yourself look bigger by waving your arms frantically and making a lot of noise or you can find the nearest exit point out of the field. If you are charged at and you have a dog on the lead with you, let the dog off the lead.</p> <p>Be wary of dogs off leads. Disinfect any bites and seek medical attention.</p> <p>If walking through long grass/ bracken/scrub, ensure you are making plenty of noise as you move so that any adders in the area become aware of your presence and can move away safely.</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Dealing with Unpredictable / Challenging / Inappropriate Behaviour | <p>Use your instincts. If you don't feel safe stay/get back to your car/main road.</p> <p>Lock personal valuables out of sight in your vehicle.</p> <p>Carry a mobile phone for lone working on remote sites, checking that signal is present, before relying on this (phone signal could be checked when carrying out site assessment the day before).</p> <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented.</p> <p>It is important that you let someone know where and when you are going on site and</p> | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|--|--|--|---|---|
| Dealing with Unpredictable / Challenging / Inappropriate Behaviour | an approximate time of when you plan to finish. Let the designated 'buddy' know when you are off site and on your way home. | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Slip, Trip and Falls | A torch must be available and used as necessary. Access and egress routes must be kept clear. Additional care must be taken when visiting a location that is unfamiliar. Before starting work outside, ground conditions must be assessed. Wear appropriate footwear Take care when walking through areas of deep habitat or areas where there is poor footing visibility. Avoid areas of poor footing visibility if possible. Take care when footing is not clearly visible. Look for signs nearby of structures eg, partially collapsed fence. | 2 - Unlikely | 3 - Medical treatment | 6 - Medium Risk |
| Adverse weather conditions | In extreme weather, especially during winter months, managers will assess conditions prior to employees carrying out their tasks. Refer to and follow the information and advice in the Snow and Ice Corporate Procedure (CP/38). Suitable (weather appropriate) protective clothing and footwear will be provided and shall be worn. Sun cream to be supplied and applied if necessary. Ensure adequate water is taken with you and regular breaks to drink/ cool down are taken. | 3 - Likely | 2 - Minor | 6 - Medium Risk |

| | | | | |
|----------------------|--|--------------|-----------------------|-----------------|
| Lone Working | <p>An out of hours buddy up system is in place. Ensure a colleague, partner, friend etc. is aware you are working alone and who to contact in the event of overdue contact. Avoid high risk activities where possible (e.g. working at height, strenuous manual handling, avoid use of plant and machinery and work with electricity and flammables) when lone working</p> <p>Be aware of your surroundings at all times. If you have any concerns contact either your immediate supervisor; emergency contact numbers will be supplied and communicated to employees.</p> <p>Carry a means of communication, e.g. radio or mobile phone, for immediate contact with the emergency services if needed.</p> <p>Electronic diaries must be completed and updated, detailing the employees whereabouts.</p> <p>When driving a vehicle onto site then park as closely as possible to the entrance and in a well lit area. Have your car keys available before leaving the building. Work outside regular hours must be agreed in advance.</p> <p>The Lone Working Procedure must be in place, communicated and understood.</p> | 3 - Likely | 3 - Medical treatment | 9 - Medium Risk |
| Movement of Vehicles | <p>Employees to stay a safe distance away from moving vehicle.</p> <p>Site rules must be adhered to and employees must remain vigilant.</p> | 2 - Unlikely | 5 - Fatal | 10 - High Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|----------------------------------|--|---|--|--|
| Exposure to Hazardous Substances | <p>A COSHH Assessment is in place for all substances/materials identified as hazardous to health & the guidance / instructions are followed.</p> <p>PPE (High Vis, Safety boots, dust mask, gloves and overalls) must be worn when handling or exposed to substances</p> <p>Check the asbestos register before attending site if appropriate</p> | 2 - Unlikely | 5 - Fatal | 10 - High Risk |

| | | | | |
|-----------------------------|---|--------------|-----------|----------------|
| Working in a Confined Space | <p>Before entering space must be assessed by trained personnel. If it is assessed as a confined space - refer to appropriate RA</p> <p>If employees become suspicious that the work area may be a confined space, stop and speak to the supervisor or the building owner.</p> <p>All employees have undertaken Confined Space training in line with the Confined Space Regulations and NPTC procedures.</p> | 2 - Unlikely | 5 - Fatal | 10 - High Risk |
|-----------------------------|---|--------------|-----------|----------------|

Personnel Protective Equipment



Other Mobile phone and signal helmets - standard - Manufacturing - plenty of charge be worn (EN 397 worn (Safety boots) Industrial safety for Protective Gloves. suitable for use in External Telecoms.) requirements for protective gloves in terms of construction, fitness of purpose and safety.)

Head protection must be worn (EN 397 worn (Safety boots) Industrial safety for Protective Gloves. suitable for use in External Telecoms.) requirements for protective gloves in terms of construction, fitness of purpose and safety.)

Safety boots must be worn (Hi viz Waterproof clothing) EN 420 is the most Construction - basic standard that

Hi Viz clothing must be worn (EN 420 - clothing) EN 420 is the most Construction - basic standard that

Protective gloves must with General Requirements basic standard that

Additional Risk Information

Mean Average is derived by the calculation of the identified risk rating multiplied by the amount of hazards identified in the overall task.

8 - Medium Risk

In the event of an incident / accident, please contact your nearest first aider.

All incidents/accidents must be recorded on NPT's Online Accident Reporting System.

Suitable information, instruction and training on how to use, store and maintain Personal Protective Equipment (PPE) correctly to be provided. All staff to have regard for their and others health and safety at all times.

Please identify how this risk assessment has been communicated.

One to one

Emergency procedures

Contact name: Rebecca Sharp
 Contact number: 07971547839
 Contact number (out of hours): 07971547839

| Risk assessments must be reviewed as a result of change in working practices / legislation or following an incident / accident | | | | | | | | | |
|--|---|--|---------------------------|-------------|----|-----------|----|----|-----|
| Reviews | Key | | Likelihood of Injury | | | | | | |
| Review date : Oct 2022 | Likelihood | Severity | | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Pulman | <ol style="list-style-type: none"> Very Unlikely - This will probably never happen/occur Unlikely - Do not expect it to happen/recur but it is possible it may do so Likely - Might happen or recur occasionally Very Likely - Will probably happen/recur, but it is not a persisting issue/circumstance Certainty - Will undoubtedly happen/recur, possibly frequently | <ol style="list-style-type: none"> Negligible - Minor injuries or discomfort. No medical treatment or measurable physical effects. Minor - Injuries or illness requiring on site first aid. Temporary impairment. Medical Treatment - Injuries or illness requiring hospital treatment. Major - Injury or illness resulting in permanent impairment. Fatal - Fatality. | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review date : | | | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: | | | | 2 | 2 | 4 | 6Y | 8 | 10Y |
| Review date : | | | | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review date : | | | Severity of Injury | | | | | | |
| Reviewed by: | | Low Risk | | Medium Risk | | High Risk | | | |



| Corporate Risk Assessment | | | Risk Assessment Reference Number: DPP/09 | |
|---|--|--|---|---|
| Name of assessor Sarah Reed | | Section Planning Policy | | Risk assessment created on: 27/09/2021 |
| Activity being assessed: Lost Peatlands School Visits and Outdoor Activities | | Subsection Countryside & Wildlife Team Learning | | Review date due: 27/09/2023 |
| Persons undertaking or affected by the activity | | | | |
| <input checked="" type="checkbox"/> Employees | <input type="checkbox"/> Contractor | <input type="checkbox"/> Public | <input checked="" type="checkbox"/> Service User | <input checked="" type="checkbox"/> Pupil |
| <input type="checkbox"/> Other | | | | |
| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
| Exposure to Animal / Bird Urine and Droppings | Area must be checked prior to task commencing. Open wounds should be covered. Biological waste i.e. animal / bird urine and droppings must be disposed of in the proper manner appropriate to the nature of the substance. Seek advice if there is any doubt or if a substance cannot be identified. Cuts and open wounds must be covered, preventing the possibility of infection. Maintain good personal hygiene standards. Do not to touch your face, smoke, eat or drink following any possible contact with dead animals / birds unless you have washed your hands and face thoroughly with soap and water. If significant contamination has occurred a shower should be taken as soon as possible. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Use of work equipment | Equipment must only be used for the purpose for which it has been designed and as demonstrated. Broken equipment should not be used and if broken whilst using it should be disposed of safely. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |

| | | | | |
|--|---|--------------|-----------|--------------|
| Injured by an animal | All wounds on exposed skin are suitably covered. Good general hygiene and hand washing followed. Participants advised to use brushes to place bugs into bug pots and which insects are ok to hold or not. Participants advised not to place bees/wasps into bug pots. Participants advised of any poisonous plants and advised not to sample/touch these or any fungi. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Dealing with Unpredictable / Challenging / Inappropriate Behaviour | Anyone identified with having unpredictable / challenging / inappropriate behavioural needs, must be made known to project staff. Appropriate supervision levels must be in place, according to the needs of the individual(s). Unpredictable / challenging / inappropriate behaviour from members of the | 2 - Unlikely | 2 - Minor | 4 - Low Risk |

| Hazard | Control measure | Likelihood 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | Severity 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Risk Level Likelihood x Severity = Risk Level |
|--|--|--|---|---|
| Dealing with Unpredictable / Challenging / Inappropriate Behaviour | public/pupils/service users must be reported as soon as possible. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Manual Handling of inanimate loads (objects and materials) | Suitable footwear to be worn for all manual handling activities. Participants advised not to lift logs etc that are too big during a bioblitz The risk has been reduced by assessing the environment in which the activity is taking place, the weight, size and shape of the load to be handled including consideration to sharp edges. Individual lifting capacity should not be exceeded. Where necessary break down loads into smaller more practical loads, or seek assistance to share the load and use team lifting, or use manual handling aids such as trolleys to transport loads. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |
| Hit by moving/flying/falling objects | Assess activity sites for likelihood of deadwood falling from trees and avoid such areas in high winds. Wear goggles or ensure participants close or look down when shaking branches to collect insects onto a sheet for tree sampling. | 2 - Unlikely | 2 - Minor | 4 - Low Risk |

| | | | | |
|----------------------------|---|------------|-----------|-----------------|
| Adverse weather conditions | In extreme weather, especially during winter months, school and project staff will assess conditions prior to carrying out activities. Suitable (weather appropriate) protective clothing and footwear will be worn. Sun cream to be applied if necessary. Refer to and follow the information and advice in the Snow and Ice Corporate Procedure (CP/38). | 3 - Likely | 2 - Minor | 6 - Medium Risk |
| Slip, Trip and Falls | Before starting work outside, ground conditions must be assessed. Prior to outdoor activities, the ground / grassed areas must be assessed to ensure that they are unsuitable e.g. not too wet/ icy. The working area must be free from slip, trip or fall hazards, and kept tidy and any hazards that cannot be removed should be clearly identified to participants . Access and egress routes must be kept clear. Additional care must be taken when visiting a location that is unfamiliar. When using steps / stairs, the handrails provided must be used. Where working on uneven or sloping ground, a firm foot base must be found and participants advised to walk and not run. Appropriate footwear should be worn. | 3 - Likely | 2 - Minor | 6 - Medium Risk |
| Contact with sharp objects | Activity sites to be visually inspected prior to starting Broken glass must be removed and disposed of correctly and safely. Litter and debris must be carefully examined before collection and never handled with bare hands. | 3 - Likely | 2 - Minor | 6 - Medium Risk |
| Exposure to COVID-19 | All individuals are to be meticulous with their hand washing; washing thoroughly for at least 20 seconds on a regular basis. If hand washing facilities are not available, hand | 3 - Likely | 2 - Minor | 6 - Medium Risk |

| Hazard | Control measure | Likelihood | Severity | Risk Level |
|--------|-----------------|--|---|------------------------------------|
| | | 1. Very Unlikely 2. Unlikely 3. Likely 4. Very Likely 5. Certainty | 1. Negligible 2. Minor 3. Medical Treatment 4. Major 5. Fatal | Likelihood x Severity = Risk Level |

| | | | | |
|----------------------|--|------------|-----------|-----------------|
| Exposure to COVID-19 | <p>sanitiser is to be provided. Cover your cough or sneeze with a flexed elbow or tissue; immediately dispose of the tissue safely and wash/sanitise your hands. Employees to refrain from touching their eyes, nose, and mouth. If any individual displays symptoms related to covid-19 (a new cough, high temperature, shortness of breath) they must self-isolate in line with Public Health Wales guidance. Social distancing must be maintained at all times wherever possible to avoid being coughed or sneezed upon and therefore reducing the risk of the spread of the COVID19 virus. School Covid-19 Risk Assessment to be requested prior to visit and school control measures followed.</p> | 3 - Likely | 2 - Minor | 6 - Medium Risk |
|----------------------|--|------------|-----------|-----------------|

Personnel Protective Equipment



Other Suitable footwear,
long sleeves and
trousers, waterproof
clothing, suncream,
insect repellent

Additional Risk Information

Mean Average is derived by the calculation of the identified risk rating multiplied by the amount of hazards identified in the overall task.

5 - Medium Risk

In the event of an incident / accident, please contact your nearest first aider.
All incidents/accidents must be recorded on NPT's Online Accident Reporting System.
Suitable information, instruction and training on how to use, store and maintain Personal Protective Equipment (PPE) correctly to be provided. All staff to have regard for their and others health and safety at all times.

Please identify how this risk assessment has been communicated.

Team brief / Team meeting

Emergency procedures

Contact name: Sarah Reed

Contact number: 07870483819

Contact number (out of hours): 07922193894

Risk assessments must be reviewed as a result of change in working practices / legislation or following an incident / accident

| Reviews | Key | | Likelihood of Injury | Severity of Injury | | | | | | |
|---------------|---|--|----------------------|---------------------------|----|----------|----|-------------|--|--|
| Review date : | Likelihood | Severity | | 5 | 5Y | 10R | 15 | 20 | | |
| Reviewed by: | <ol style="list-style-type: none"> Very Unlikely - This will probably never happen/occur Unlikely - Do not expect it to happen/recur but it is possible it may do so Likely - Might happen or recur occasionally Very Likely - Will probably happen/recur, but it is not a persisting issue/circumstance Certainty - Will undoubtedly happen/recur, possibly frequently | <ol style="list-style-type: none"> Negligible - Minor injuries or discomfort. No medical treatment or measurable physical effects. Minor - Injuries or illness requiring on site first aid. Temporary impairment. Medical Treatment - Injuries or illness requiring hospital treatment. Major - Injury or illness resulting in permanent impairment. Fatal - Fatality. | | 4 | 4 | 8 | 12 | 16 | | |
| Review date : | | | | 3 | 3 | 6G | 9 | 12 | | |
| Reviewed by: | | | | 2 | 2 | 4 | 6Y | 8 | | |
| Review date : | | | | 1 | 1 | 2 | 3 | 4 | | |
| Reviewed by: | | | | 0 | 1 | 2 | 3 | 4 | | |
| Review date : | | | | Severity of Injury | | | | | | |
| Reviewed by: | | | | | | | | | | |
| | | | | | | Low Risk | | Medium Risk | | |

Risk Assessment

Form

| Activity to be Assessed | | Assessment Number | | |
|--|------------|-------------------|------------|--|
| Safety on site – Welsh Government Woodland Estate & Pen Y Cymoedd Windfarm | | 19 | | |
| Persons undertaking or affected by the activity | | | | |
| Service <input checked="" type="checkbox"/> Employees <input checked="" type="checkbox"/> Contractor <input checked="" type="checkbox"/> Public <input checked="" type="checkbox"/> Pupil <input type="checkbox"/> User Other <input type="checkbox"/>volunteers..... | | | | |
| Identified Hazards Associated Risks | Likelihood | Severity | Risk Level | |
| 1 Forestry Operations – live site harvesting: tree felling and contact with heavy plant machinery | 4 | 5 | 20 | |
| 2 Forestry Operations – haulage of timber: road traffic accident or contact with Heavy Goods Vehicles on forestry roads; stacked timber | 3 | 5 | 15 | |
| 3 Peatland Restoration: contact with heavy plant machinery on site or in transit | 3 | 5 | 15 | |
| 4 Windfarm Operations - maintenance of infrastructure: contact with heavy plant machinery or faulty equipment | 3 | 5 | 15 | |
| 5 Biological: stings and bites | 4 | 2 | 8 | |
| 6 Contact with soil borne micro organisms | 2 | 2 | 4 | |
| 7 Slips, trips and falls | 3 | 3 | 9 | |
| 8 Electric fences/barbed wire | 3 | 3 | 9 | |
| 9 Peat / Ponds / Deep water | 3 | 4 | 12 | |
| 10 Weather | 3 | 3 | 9 | |
| 11 Lone working | 3 | 3 | 9 | |
| 12 Using a car | 4 | 2 | 8 | |
| 13 Road traffic accident | 3 | 4 | 12 | |
| 14 Contact with plant sap | 4 | 2 | 8 | |
| 15 | | | | |
| Existing Control Measures / Additional Control Measures Required | | | | |


| | |
|---|--|
| 1 | <p>Ensure land manager (Natural Resources Wales and/or contractor) is aware of proposed activity and any necessary permissions have been granted. Where permissions are not in place, strictly no entry on to what may be deemed a live site. Ongoing operations locations to be sought prior to working on site. Awareness and adherence of signage e.g. ‘do not enter, forestry operations underway, no access to unauthorised persons’ etc.</p> <p>Pre-work health and safety talk to highlight all potential hazards.</p> |
| 2 | <p>Ensure land manager (Natural Resources Wales and/or contractor) is aware of proposed activity and any necessary permissions have been granted.</p> <p>Pre-work health and safety talk to highlight all potential hazards. Hi-viz clothing to be worn if on foot, torches utilised in darker hours, walk on paths off forestry tracks where possible.</p> <p>Hazard lights to be used on vehicles.</p> <p>Do not climb or work around timber stacks.</p> |
| 3 | <p>Ensure land manager (Natural Resources Wales and/or contractor) is aware of proposed activity and any necessary permissions have been granted. Where permissions are not in place, strictly no entry on to what may be deemed a live site. Ongoing operations locations to be sought prior to working on site. Awareness and adherence of signage e.g. ‘do not enter, forestry operations underway, no access to unauthorised persons’ etc.</p> <p>If permission is granted to visit site, agree protocol with excavator operator for approaching machine if needed (e.g. hand signals, bucket on floor, engine off etc). Ensure all PPE (hard hats, hi-viz, steel toe cap boots) in donned. Be wary of material movement and throw such as tree stumps/roots. Site specific RA to be carried out if deemed necessary.</p> <p>Pre-work health and safety talk to highlight all potential hazards.</p> |
| 4 | <p>Ensure land manager (Vattenfall and NRW) is aware of proposed activity and any necessary permissions have been granted. Where permissions are not in place, strictly no entry on to what may be deemed a live site. Ongoing operations locations to be sought prior to working on site.</p> <p>Awareness and adherence of signage e.g. ‘do not enter, forestry operations underway, no access to unauthorised persons’ etc. Pre-work health and safety talk to highlight all potential hazards.</p> |
| 5 | <p>Wear long trousers and long sleeved tops to limit tick bites. Wash hands before eating. If known allergy to stings take appropriate medication on site. Use insect repellent where needed (midges). If feeling unwell after a site visit seek medical attention.</p> |
| 6 | <p>Ensure water/wipes are available on site to clean hands before eating, drinking or smoking.</p> <p>Any broken skin must be covered.</p> <p>Any cuts received during surveying must be treated promptly and covered to avoid infection.</p> |
| 7 | <p>Wear appropriate footwear.</p> <p>Take care when walking through areas of deep habitat or areas where there is poor footing visibility. Avoid areas of poor footing visibility if possible.</p> <p>Take care when footing is not clearly visible. Look for signs nearby of structures eg, partially collapsed fence.</p> |
| 8 | <p>Check for electric fences (you can check to see if a fence is live by putting a blade of grass to the wire and seeing if the blade of grass bounces against the wire, if it does it is live!), do not climb over fences, use the nearest gate or stile</p> |

| | |
|----|---|
| 9 | Take care when near water bodies. Do not walk on wet, deep peat without appropriate measures. See separate Risk Assessment for Wetland work. |
| 10 | <p>Wear appropriate clothing; e.g. waterproof coat/trousers if it's raining, light clothing & hat for sunny/warm weather.</p> <p>Avoid sunburn risk by not exposing skin, even when some cloud cover exists</p> <p>Ensure that you have suitable high factor sun block. Do not provide sun block to others unless they can confirm that they have used the product before without adverse reactions</p> <p>Extra clothing as appropriate for the terrain and conditions to be carried, noting details on local precautions.</p> <p>If hot weather then ensure you have drinking water with you.</p> <p>Stop working promptly if you are not prepared for the conditions, uncomfortable or the work is becoming hazardous.</p> |
| 11 | <p>If lone working is expected, a separate risk assessment and safe working system of work will be drawn up and implemented.</p> <p>Leave clear information with buddy regarding location, travel route, and return times, ensure buddy has a clear understanding of what to do in case of late or no return.</p> |
| 12 | <p>Do not leave valuables on view in your vehicle when you are driving or stationary, for example mobile phone or cash.</p> <p>Ensure mobile phone is fully charged and has good signal, so it can be used in case of an emergency.</p> <p>Consider being a member of a rescue service in case your vehicle breaks down or in case of a minor accident.</p> <p>Adhere to local speed limits.</p> <p>Use hazard lights on site.</p> |
| 13 | <p>Lone working training to be complete.</p> <p>Nominate a person to be responsible for 'buddy system' – make aware of on/off-site. Wear high visibility tops</p> |
| 14 | <p>Identify any hazardous plants on site before carrying out activity, for example: Hogweed, wild carrot.</p> <p>Plan walk to avoid hazardous plants if possible.</p> <p>Wear long sleeved tops and trousers when working close to hazardous plants Wear protective gloves if appropriate.</p> <p>Wash exposed skin thoroughly after any contact with skin, before drinking or smoking In case of an allergic reaction following accidental contact with plant sap, identify the plant and monitor casualty for shock. If condition of the casualty deteriorates, call an ambulance immediately and ensure that a sample of the plant accompanies the casualty to hospital to ensure correct diagnosis and treatment.</p> |

| | | | | |
|----------------------------------|------------|----------|------------|--|
| 15 | | | | |
| Reassessment of Activity Hazards | Likelihood | Severity | Risk Level | |

| | | | | |
|----|---|---|---|-----|
| 1 | Forestry Operations – live site harvesting: tree felling and contact with heavy plant machinery | 1 | 5 | 5G |
| 2 | Forestry Operations – haulage of timber: road traffic accident or contact with Heavy Goods Vehicles on forestry roads; stacked timber | 2 | 5 | 10R |
| 3 | Peatland Restoration: contact with heavy plant machinery on site or in transit | 1 | 5 | 5G |
| 4 | Windfarm Operations - maintenance of infrastructure: contact with heavy plant machinery or faulty equipment | 1 | 5 | 5G |
| 5 | Biological: stings and bites | 2 | 2 | 4 |
| 6 | Contact with soil borne micro organisms | 2 | 2 | 4 |
| 7 | Slips, trips and falls | 2 | 3 | 6Y |
| 8 | Electric fences/barbed wire | 1 | 3 | 3 |
| 9 | Peat / Ponds / Deep water | 2 | 4 | 8 |
| 10 | Weather | 2 | 3 | 6Y |
| 11 | Lone working | 2 | 3 | 6Y |
| 12 | Using a car | 1 | 2 | 2 |
| 13 | Road traffic accident | 2 | 4 | 8 |
| 14 | Contact with plant sap | 1 | 2 | 4 |
| 15 | | | | |

| | | |
|---------------------------|--------|----------|
| Name: Richy Pulman | Signed | Date |
| Position: Project Manager | RP | 17/11/22 |

| Reviews | Key | | | | | | | | |
|--|-------------------------------|--------------------------------|----------------------|---|----|-----|----|----|-----|
| Review Date : Nov 2022 | Likelihood | Severity | Likelihood of Injury | 5 | 5Y | 10R | 15 | 20 | 25 |
| Reviewed by: R Pulman  | 1 very unlikely 2 unlikely | 1 nuisance | | 4 | 4 | 8 | 12 | 16 | 20 |
| Review Date : | 3 likely | 2 minor 3 medical treatment | | 3 | 3 | 6G | 9 | 12 | 15 |
| Reviewed by: | 4 very likely | 4 major | | 2 | 2 | 4 | 6Y | 8 | 10Y |

| | | | | | | | | |
|---------------|-------------|---------|--------------------|-------------|-----------|---|---|----|
| Review Date : | 5 certainty | 5 fatal | 1 | 1 | 2 | 3 | 4 | 5G |
| Reviewed by: | | | 0 | 1 | 2 | 3 | 4 | 5 |
| Review Date : | | | Severity of Injury | | | | | |
| Reviewed by: | | | Low Risk | Medium Risk | High Risk | | | |



Lost Peatlands HRA and CWS Sites

Emergency Meeting Points

| Site Name | Nearest A Road | Meet Point: Grid Ref.; Nearest Post Code; what3words; Google | Nearest Minor Injuries Unit (MIU) & A&E | Notes |
|-------------|----------------|---|---|---|
| Castell Nos | A4233 | SN 97288 00003 CF43 4FP ///pins.data.incur Google Pin – 'Beyond Lands End Car Park' | MIU: Ysbyty Cwm Rhondda CF40 2LX A&E: Royal Glamorgan Hospital, CF72 8XR | Postcode inaccurate Middle of site: SN 96801 00603 Helicopter landing possible |
| Cregan | A4107 | SS 87654 99865 SA13 3DD ///become.pasting.newlyweds Google Pin – 'Willow Springs Campsite' | MIU: NPT Hospital SA12 7BX A&E: Morrison Hospital SA6 6NL | Middle of site: SS 85884 99460 Helicopter landing possible |

| | | | | |
|--------------|-------|---|---|--|
| Cwm-Saerbren | A4107 | SS 91704 95678 CF32 7RH ///searcher.shocked.grinders Google Pin – 'Llynfi Afan Windfarm' | MIU: NPT Hospital SA12 7BX A&E: Morrison Hospital SA6 6NL | Middle of site: SS 92324 97279 Helicopter landing possible |
| PYC Windfarm | A4061 | SN 92161 02495 CF42 5SX ///repeats.suspends.tunnel Google Pin 'Hendre Mynydd Car Park' | MIU: Ysbyty Cwm Rhondda CF40 2LX A&E: Prince Charles, CF47 9DT | Middle of site: SN 91016 00940 Helicopter landing possible (Turbines!) |
| Cymmer | A4107 | SS 86030 96347 SA13 3LN ///infuses.performs.sparkles Goggle Pin 'Bryn Teg House Accommodation' | MIU: NPT Hospital SA12 7BX A&E: Morrison Hospital SA6 6NL | Middle of site: SS 86264 97324 Helicopter landing possible |
| Glyncorrgwg | A4107 | SS 87137 99236 SA13 3BU ///wedge.deriving.nature Google Pin 'Mini B Holiday Let' | MIU: NPT Hospital SA12 7BX A&E: Morrison Hospital SA6 6NL | None |
| Gwynfi | A4107 | SS 88824 96865 SA13 3TY ///confining.perfectly.situated Google Pin 'Tunnel Hotel' | MIU: NPT Hospital SA12 7BX A&E: Morrison Hospital SA6 6NL | None |

| | | | | |
|-------------------|-------|---|---|---|
| Cwm-Parc | A4061 | SS 94304 95739 ///spoken.nature.stroke CF42 6LG Google Pin 'Tremains Hotel' | MIU: Ysbyty Cwm Rhondda CF40 2LX A&E: Royal Glamorgan Hospital, CF72 8XR | Middle of site: SS 94948 96461 Helicopter landing possible |
| Blaenrhondda | | SS 92370 99103 ///slanting.looms.detective CF42 5DG Google Pin 'Pen Pych Forest Car Park' | MIU: Ysbyty Cwm Rhondda CF40 2LX A&E: Royal Glamorgan Hospital, CF72 8XR | None |
| Hendre' Mynydd | | SN 92293 02049 ///plastic.disposing.builds CF42 5RY Google Pin 'Hendre Mynydd Car Park' | MIU: Ysbyty Cwm Rhondda CF40 2LX A&E: Prince Charles, CF47 9DT | None |

Appendix 5: Project Background.

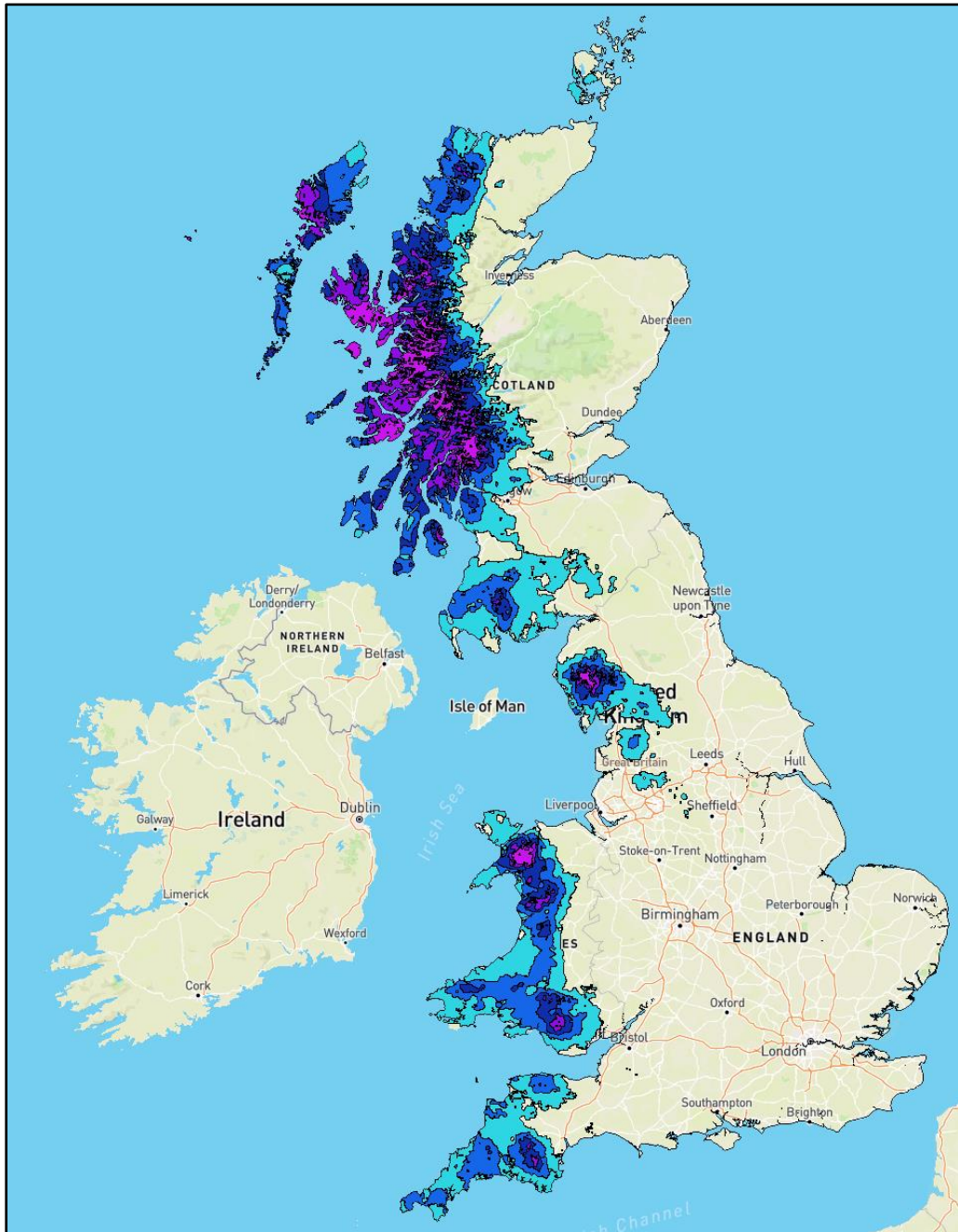


Figure 1: Rainforest zones within the UK mapped using Amann's index of hygrothermy. Oceanic climate (100-150 index of hygrothermy value) – Cyan / Blue; Hyperoceanic climate (150-200+ index of hygrothermy value) – Dark blue / Purple.

Appendix 6: Model Mean Performance

Table 1: Model mean performance of current distributions of nine hyperoceanic bryophytes using five model methods. All values are AUC scores following modelling the distribution.

| <i>Species</i> | <i>GLM</i> | <i>SVM</i> | <i>RF</i> | <i>BRT</i> | <i>MARS</i> |
|------------------------------|------------|------------|-----------|------------|-------------|
| <i>Daltonia splachnoides</i> | 0.9 | 0.93 | 0.98 | 0.94 | 0.95 |
| <i>Colura calyptrifolia</i> | 0.85 | 0.88 | 0.96 | 0.89 | 0.88 |
| <i>Radula voluta</i> | 0.93 | 0.94 | 0.98 | 0.95 | 0.95 |
| <i>Radula holtii</i> | 0.96 | 0.86 | 0.98 | 0.98 | 0.93 |
| <i>Radula carringtonii</i> | 0.97 | 0.95 | 0.99 | 0.98 | 0.97 |
| <i>Metzgeria leptoneura</i> | 0.92 | 0.92 | 0.98 | 0.94 | 0.93 |
| <i>Lejeunea mandonii</i> | 0.93 | 0.95 | 0.97 | 0.96 | 0.92 |
| <i>Acrobolbus wilsonii</i> | 0.95 | 0.9 | 0.99 | 0.97 | 0.95 |
| <i>Lejeunea patens</i> | 0.87 | 0.87 | 0.96 | 0.89 | 0.89 |

Table 2: Table 1: Model mean performance of future distributions of nine hyperoceanic bryophytes using five model methods. All values are AUC scores following modelling the distribution.

| <i>Species</i> | <i>GLM</i> | <i>SVM</i> | <i>RF</i> | <i>BRT</i> | <i>MARS</i> |
|------------------------------|------------|------------|-----------|------------|-------------|
| <i>Daltonia splachnoides</i> | 0.91 | 0.93 | 0.97 | 0.94 | 0.92 |
| <i>Colura calyptrifolia</i> | 0.86 | 0.9 | 0.96 | 0.9 | 0.9 |
| <i>Radula voluta</i> | 0.88 | 0.95 | 0.98 | 0.95 | 0.94 |
| <i>Radula holtii</i> | 0.96 | 0.95 | 0.99 | 0.98 | 0.89 |
| <i>Radula carringtonii</i> | 0.97 | 0.96 | 0.99 | 0.97 | 0.97 |
| <i>Metzgeria leptoneura</i> | 0.92 | 0.94 | 0.98 | 0.95 | 0.94 |
| <i>Lejeunea mandonii</i> | 0.96 | 0.96 | 0.98 | 0.97 | 0.95 |
| <i>Acrobolbus wilsonii</i> | 0.96 | 0.92 | 0.99 | 0.97 | 0.97 |
| <i>Lejeunea patens</i> | 0.87 | 0.86 | 0.96 | 0.89 | 0.88 |

Appendix 7: Significant differences between sites.

Wind speed (m/s) was statistically significantly different across the three sites ($F = 10.63$, $p < 0.001$). Pen-y-Cymoedd wind farm had the highest mean wind speed when compared to both Glyncoerrwg forest ($p < 0.01$) and Rheola Forest ($p < 0.001$). Further, relative humidity was different across the three locations ($F = 8.692$, $p < 0.001$). Rheola forest had the highest observed mean humidity ($74.14\% \pm 12.94\%$) but was not statistically significantly different to Glyncoerrwg forest ($p > 0.05$). However Rheola Forest was significantly different when compared to Pen-y-Cymoedd wind farm ($p < 0.001$). Mean zeta was different between the three sites ($F = 5.228$, $p < 0.01$). Rheola forest and Glyncoerrwg forest share similar mean zeta, however Pen-y-Cymoedd wind farm had a significantly higher mean zeta (0.97 ± 0.11) when compared to Rheola Forest ($p < 0.01$). Species richness was also significantly different between sites ($F_2 = 5.587$, $p < 0.01$). Rheola forest had the highest mean species richness when compared to both Glyncoerrwg forest ($p < 0.05$) and Pen-y-Cymoedd wind farm ($p < 0.05$). Temperature, diameter at breast height and tree height were not significant ($p > 0.05$).

Mean relative humidity recorded using the dataloggers was statistically significantly different amongst the three locations ($F = 28.38$, $p < 0.001$). Pen-y-Cymoedd wind farm had a higher mean humidity ($93.39\% \pm 9.96\%$) when compared to Rheola Forest ($76.67\% \pm 20.08\%$) ($p < 0.001$). Similarly Glyncoerrwg forest had a higher mean humidity ($89.15\% \pm 16.51$) when compared to Rheola Forest ($p < 0.001$). Temperature readings were similarly significantly different between the three locations ($F = 12.63$, $p < 0.001$). Both Rheola Forest and Glyncoerrwg forest had a higher mean temperature when compared to Pen-y-Cymoedd wind farm ($p < 0.001$) but had a very similar mean temperature to each other.

Appendix 8: Environmental Variables

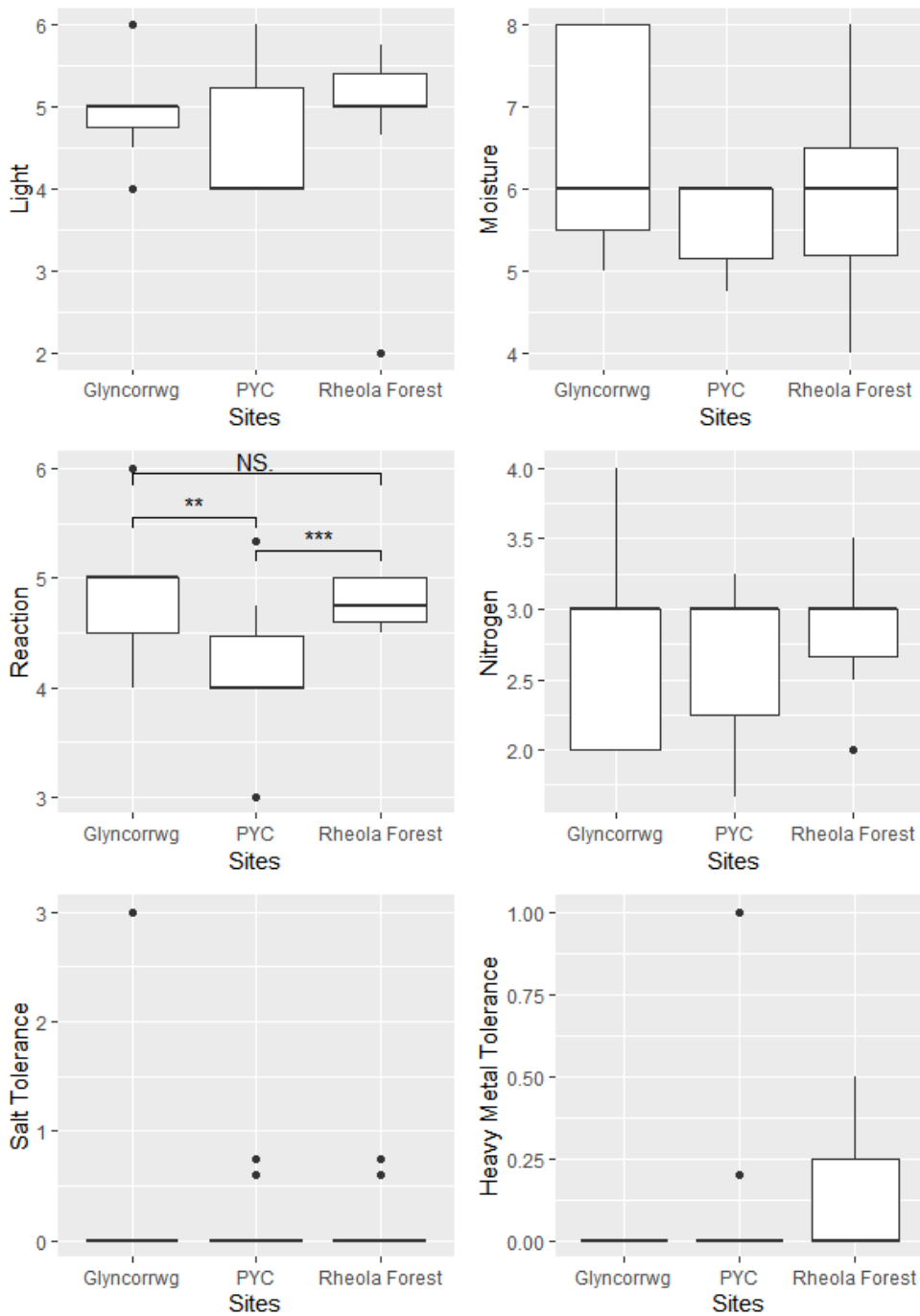


Figure 1: Ellenberg indicator values for light (L), moisture (F), reaction (R), nitrogen (N), salt tolerance (S) and heavy metal tolerance (HM) across each of the three study sites based on a total of 52 samples. Study sites were located in sitka spruce (*Picea sitchensis*) plantations in South Wales.

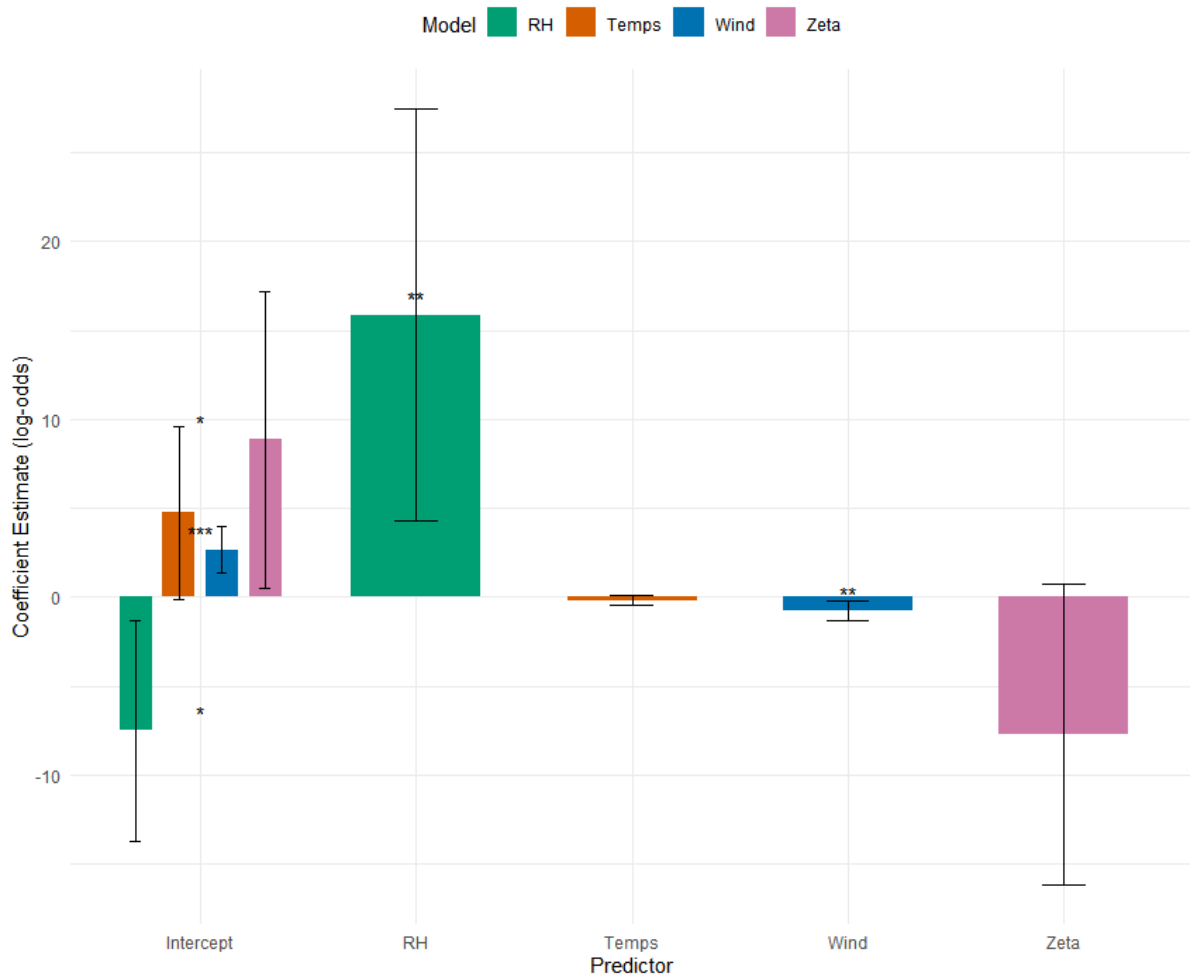


Figure 2: Statistical analysis of the relationship between environmental variables recorded at each sample (N = 52) against the presence or absence of hyperoceanic bryophytes. Significant relationships between the presence of at least one hyperoceanic bryophyte and a given environmental variable indicated by a “*”. Error bars indicate standard deviation.

Table 1: Mean environmental and biotic variables recorded at each sample (N = 52) across the three study sites including standard deviation (\pm).

| <i>Study Location</i> | <i>Mean Species Richness</i> | <i>Mean Wind Speed (m/s)</i> | <i>Mean Humidity (RH %)</i> | <i>Mean Temperature ($^{\circ}$C)</i> | <i>Mean Zeta</i> | <i>Mean Tree DBH (cm)</i> | <i>Mean Tree Height (m)</i> |
|--------------------------|------------------------------|------------------------------|-----------------------------|--|------------------|---------------------------|-----------------------------|
| <i>Glyncorrwg</i> | 1.40 \pm 1.07 | 0.23 \pm 0.7 | 65.22% \pm 7.97% | 16.71 \pm 3.08 | 0.89 \pm | 12.46 \pm 5.25 | 3.98 \pm 1.23 |
| <i>PYC</i> | 1.55 \pm 1.63 | 1.87 \pm 4.69 | 57.40% \pm 14.37% | 16.48 \pm 2.24 | 0.97 \pm | 16.74 \pm 16.02 | 3.41 \pm 4.22 |
| <i>Rheola</i> | 2.91 \pm 1.54 | 0.17 \pm 0.60 | 74.14% \pm 12.94% | 15.73 \pm 3.57 | 0.84 \pm | 21.27 \pm 9.07 | 5.69 \pm 3.14 |

Appendix 9: Field Observations

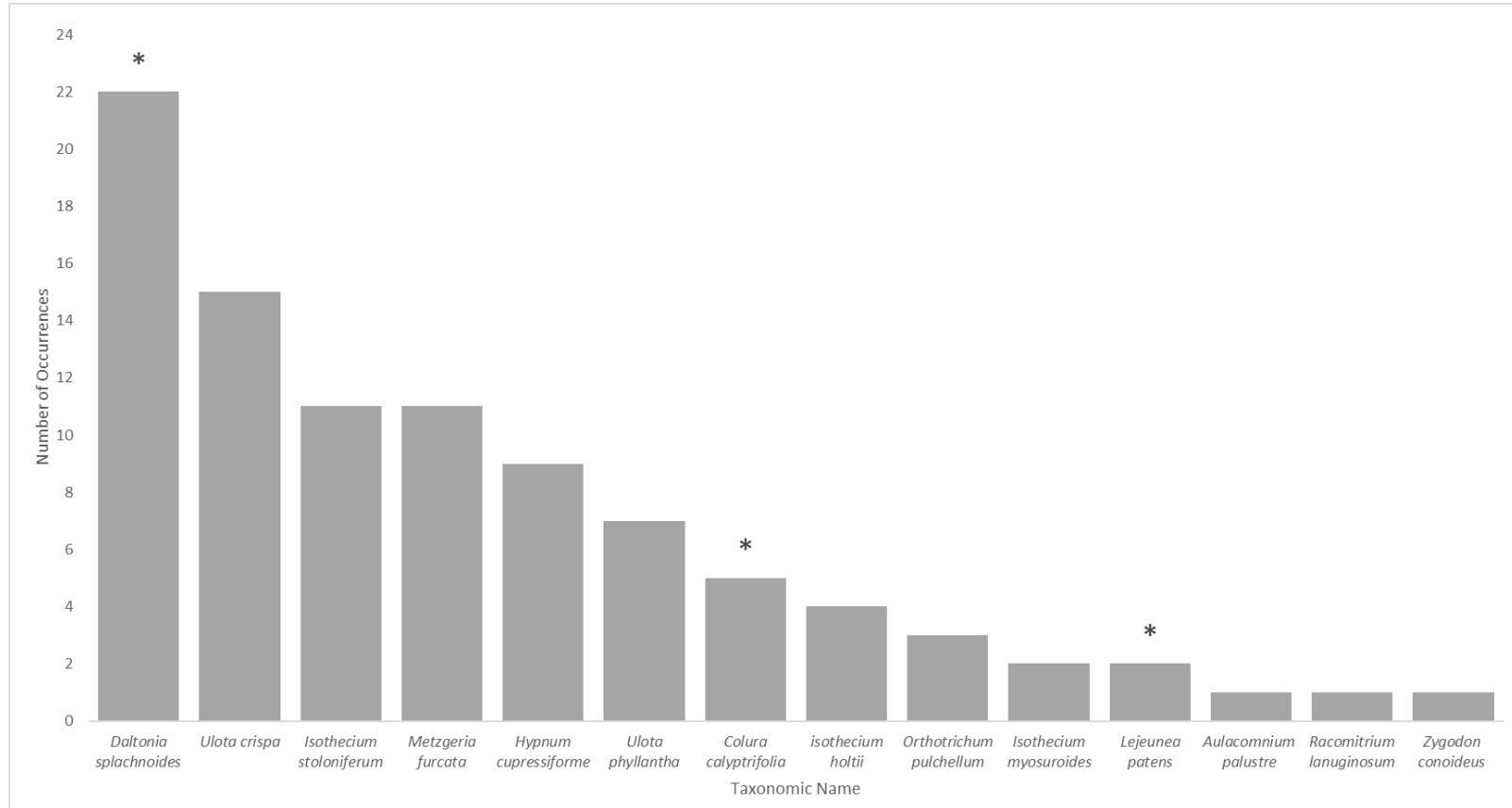


Figure 1: Total number of occurrences of each species identified during the course of the study across 52 samples within the three study sites. Asterix indicate hyperoceanic bryophyte

Appendix 10: Raw Data

Table 1: Raw data from field sampling. Each row remains the same across the continued images of the raw data.

| Sample Identifier | G1 | G2 | G3 | G4 | G5 | G6 | G7 |
|-------------------------------|-----------------------|-----------------------|-------------|----------------|----------------|------------------------|-------------------|
| Location | Glyncorwrg | Glyncorwrg | Glyncorwrg | Glyncorwrg | Glyncorwrg | Glyncorwrg | Glyncorwrg |
| Grid Reference | SS 85693 97750 | SS85669774 | SS85609772 | SS 85223 97590 | SS 84592 97155 | SS 84580 97137 | SS 84592 97182 |
| Wind speed (m/s) | | | 0 | 0 | 0 | 0 | 0 |
| Relative Humidity | | | 0.61 | 0.63 | 0.54 | 0.62 | 0.64 |
| Temperature (°C) | | | 19.7 | 19.4 | 19.8 | 15.9 | 15.7 |
| Zeta (R:FR) | | | 0.91 | 0.93 | 1 | 0.81 | 0.83 |
| DBH (cm) | | | 9.867606472 | 10.82253613 | 18.4619734 | 12.5 | 5.5 |
| Tree Description | Willow | Willow | Willow | Sitka spruce | Willow | Oak | Willow |
| Above Water (Y/N?) | | 1 | 0 | 0 | 0 | 0 | 0 |
| Above Potential Stream (Y/N?) | | 1 | 0 | 0 | 0 | 0 | 0 |
| D | | | 0 | 0 | 0 | | |
| A | | | 0 | 0 | 0 | Isothecium myosuroides | Isothecium holtii |
| F | | | 0 | 0 | 0 | | Ulotia crisa |
| O | | | 0 | 0 | 0 | Metzgeria furcata | Metzgeria furcata |
| R | Daltonia splachnoides | Daltonia splachnoides | Daltonia | | 0 | | Isothecium holtii |
| Tree height (m) | | | 3.6 | 2.8 | 6.79 | 4.4 | 2.6 |

| G8 | G9 | G10 | R1 | R2 | R3 | R4 | R5 |
|-------------------|------------------------|------------------------|---------------|---------------|---------------|---------------|--------------|
| Glyncorwrg | Glyncorwrg | Glyncorwrg | Rheola | Rheola | Rheola | Rheola | Rheola |
| SS 84610 97121 | SS 84584 97115 | SS 85000 97000 | SN83555 05870 | SN83486 06424 | SN83500 06416 | SN83492 06063 | SN8348906071 |
| 0 | | 0 | 2.1 | | | | |
| 0.65 | | 0.73 | 0.82 | 0.72 | 0.84 | 0.54 | 0.57 |
| 13.6 | | 12.3 | 20.1 | 10 | 6.4 | 11.8 | 12 |
| 0.87 | | 0.91 | 0.78 | | | | |
| 10.4 | | 21.32 | 7.002817496 | | | | |
| Rowan | Rowan | Willow | | | | | |
| 0 | | 0 | 0 | | | | |
| 0 | | 0 | 0 | | | | |
| | | | 0 | | | | |
| | | | 0 | | | | |
| | | | 0 | | | | |
| | | | 0 | | | | |
| Ulotia phyllantha | Orthotrichum puchellum | Orthotrichum puchellum | | | | | |
| | | Colura calyptriifolia | | | | | |
| 3.61 | | 3.81 | 3.6 | | | | |

| R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 |
|-----------------------|-----------------------|-------------------------|-------------------------|-------------------|-------------------------|-----------------------|----------------|
| Rheola | Rheola | Rheola | Rheola | Rheola | Rheola | Rheola | Rheola |
| SN83600 05757 | SN83548 05892 | SN83719 05849 | SN83619 05849 | SN8354105855 | SN8353105901 | SN840050 | SN 83878 05134 |
| 0 | 0 | 0 | 0 | 0 | 2.5 | 0 | 0.4 |
| 0.68 | 0.74 | 0.71 | 0.6 | 0.56 | 0.52 | 0.75 | 0.75 |
| 16.9 | 15.8 | 15.8 | 17.7 | 15.1 | 16.7 | 22.2 | 22.2 |
| 0.96 | 0.96 | 0.95 | 0.6 | 0.52 | 0.95 | 0.87 | 0.86 |
| | | | | | | 3.183098862 | 3.819718634 |
| Willow | Willow | Willow | Sitka spruce | Sitka spruce | Willow | Willow | Willow |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 0 | 0 | Hypnum cupressiforme | isothecium stoloniferum | 0 | 0 | 0 | 0 |
| 0 | Ulotia crisa | Orthotrichum pulchellum | Hypnum cupressiforme | isothecium holtii | Isothecium stoloniferum | 0 | 0 |
| Hypnum cupressiforme | Metzgeria furcata | Ulotia crisa | Ulotia crisa | Metzgeria furcata | 0 | 0 | 0 |
| Daltonia splachnoides | Daltonia splachnoides | Metzgeria furcata | Ulotia phyllantha | Ulotia crisa | Ulotia crisa | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | Daltonia splachnoides | Daltonia |
| 0.27 | 0.6 | 5.2 | 8.96 | 6.98 | 7.76 | 2.16 | 3.1 |

| R14 | R15 | R16 | R17 | R18 | R19 | R20 | R21 |
|-------------------------|-------------------------|-----------------------|-----------------------|-------------------------|-------------------------|-----------------------|------------------------|
| Rheola | Rheola | Rheola | Rheola | Rheola | Rheola | Rheola | Rheola |
| SN8351005964 | SN8350505971 | SN8350105990 | SN8348906059 | SN8347806081 | SN8347306104 | SN8345606158 | SN8340206253 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.72 | 0.75 | 0.76 | 0.83 | 0.88 | 0.87 | 0.92 | 0.92 |
| 17.8 | 17.2 | 17.4 | 16.5 | 17.2 | 17 | 15.2 | 14.9 |
| 1.15 | 0.98 | 0.93 | 0.79 | 0.67 | 0.79 | 0.78 | 0.82 |
| 36.60563691 | 22.28169203 | 15.59718442 | 11.77746579 | 12 | 14.32394488 | 12.41408556 | 17.18873385 |
| Willow | Willow | Willow | Willow | Willow | Willow | Willow | Willow |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| Isothecium stoloniferum | Isothecium stoloniferum | Ulota crispa | 0 Isothecium holtii | Isothecium stoloniferum | Isothecium holtii | Metzgeria furcata | Metzgeria furcata |
| Hypnum cupressiforme | Hypnum cupressiforme | 0 | Isothecium holtii | Isothecium holtii | Isothecium stoloniferum | Ulota crispa | Isothecium myosuroides |
| Zygodon conoideus | Ulota phyllantha | Metzgeria furcata | Metzgeria furcata | Ulota phyllantha | Ulota crispa | 0 | Hypnum cupressiforme |
| Ulota crispa | 0 | Hypnum cupressiforme | 0 | Metzgeria furcata | 0 | Hypnum cupressiforme | Ulota phyllantha |
| Daltonia splachnoides | Daltonia splachnoides | Daltonia splachnoides | Daltonia splachnoides | Daltonia splachnoides | Daltonia splachnoides | Daltonia splachnoides | Daltonia splachnoides |
| 8.8 | 11.68 | 6.7 | 6.7 | 5.7 | 5.5 | 3.3 | 7.4 |

| R22 | P1 | P2 | P3 | P4 | P5 | P6 | P7 |
|------------------------|-------------------------|-------------------------|---------------|-------------------------|-------------------------|-------------------------|---------------|
| Rheola | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd |
| SN8336706299 | SN8802702829 | SN8643200730 | SN91801 02345 | SN91549 02268 | SN91364 02350 | SN91235 02437 | SN91049 02278 |
| 0 | 0 | 0.4 | 1.4 | 3.5 | 0 | 1.6 | 4.6 |
| 0.94 | 0.62 | 0.53 | 0.51 | 0.54 | 0.67 | 0.58 | 0.46 |
| 14.5 | 20.6 | 22.9 | 14.6 | 14.7 | 14.1 | 14.5 | 16.1 |
| 0.64 | 0.97 | 0.94 | 1 | 1.05 | 1.08 | 1.06 | 1.03 |
| 17.82535363 | 34.37746771 | 42.01690498 | | | | | |
| Willow | Willow | Willow | Sitka spruce | Willow | Willow | Willow | Willow |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Isothecium holtii | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Isothecium myosuroides | Isothecium stoloniferum | 0 | 0 | 0 | 0 | 0 | 0 |
| Ulota crispa | Ulota crispa | Orthotrichum pulchellum | 0 | 0 | 0 | 0 | 0 |
| Daltonia splachnoides | Ulota phyllantha | Ulota crispa | 0 | Campyllum chrysophyllum | Campyllum chrysophyllum | Campyllum chrysophyllum | 0 |
| 0 | Daltonia splachnoides | Daltonia splachnoides | 0 | 0 | 0 | 0 | 0 |
| 6.9 | | | 2.2 | 1.9 | 1.39 | 1.75 | 0.98 |

| P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 |
|-------------------------|---------------|-------------------|-----------------|---------------------------|-------------------------|-----------------------------|---------------|
| Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd |
| SN90878 02342 | SN90765 02278 | SN912033 | SN918031 | SN900020 | SN9076402279 | SN9175102761 | SN9158402911 |
| 2.5 | 3.8 | 0.8 | 4.4 | 0 | 2 | 2.2 | 4.4 |
| 0.5 | 0.44 | 0.62 | 0.57 | 0.61 | 0.46 | 0.43 | 0.42 |
| 15.7 | 17.1 | 17.5 | 18 | 17.6 | 16.5 | 17.7 | 17.1 |
| 1.06 | 1.04 | 0.74 | 0.95 | 0.86 | 0.95 | 1 | 1 |
| | | 7.957747155 | 22.91831181 | 35.65070725 | 1.591549431 | 3.819718634 | 4.456338407 |
| Willow | Willow | Sitka spruce | Sitka spruce | Willow | Sitka spruce | Sitka spruce (knocked over) | Sitka spruce |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 Isothecium stoloniferum | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 Hypnum cupressiforme | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 Ulota phyllantha | Isothecium stoloniferum | 0 | 0 |
| Campyllum chrysophyllum | 0 | 0 | 0 | 0 Ulota crispa | 0 | 0 | 0 |
| 0 | 0 | 0 Lejeunea patens | Lejeunea patens | Colura calyptrifolia | 0 | 0 | 0 |
| 2.27 | 3.41 | 2.32 | 4.1 | 4.4 | 1.22 | 3.05 | 2.69 |

| P16 | P17 | P18 | P19 | P20 |
|-------------------------|---------------|-------------------------|------------------------|----------------------|
| Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd | Pen-y-cymoedd |
| SN9158302983 | SN91936 02451 | SN 92000 02000 | SN 93000 02000 | SN 94000 00000 |
| 0 | 3.5 | 2.3 | 0 | 0 |
| 0.45 | 0.48 | 0.88 | 0.84 | 0.87 |
| 16.3 | 15.1 | 14.9 | 14.3 | 14.3 |
| 0.62 | 0.98 | 1.07 | 0.96 | 1.08 |
| 4.456338407 | | 4.45 | 35.969 | 3.18 |
| Willow | Sitka spruce | Willow | Sitka spruce | Sitka spruce |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| Metzgeria furcata | 0 | Aulacomnium palustre | 0 | 0 |
| Ulota crispa | 0 | Racomitrium lanuginosum | Isothecium myosuroides | 0 |
| Ulota phyllantha | 0 | 0 | Isothecium holtii | 0 |
| White lichen | 0 | 0 | Zygodon conoideus | 0 |
| Isothecium stoloniferum | 0 | Colura calyptrifolia | Colura calyptrifolia | Colura calyptrifolia |
| | | 2.4 | 18.83 | 1.69 |