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Ballynahone Bog SAC Wind Data Analysis October 2021 to March 2022

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Title	Ballynahone Bog SAC Wind Data Analysis October 2021 to March 2022
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1 Introduction / background

Local prevailing wind patterns play a key role in atmospheric nitrogen (N) input to designated sites, in terms of local ammonia (NH_3) concentrations and N deposition originating from local, regional and transboundary sources. The aim of this study is to investigate local wind patterns and their temporal variability using locally measured weather data. These data were analysed in conjunction with NH_3 measurements within and surrounding Ballynahone Bog SAC.

This report is part of a series that started to analyse data from month-year, with the period investigated in the current report being 1st October 2021 to 31st March 2022. Previous reports can be found via DAERAs public webpages[1] (Thomas et al. 2020, Williams et al. 2021, Williams et al. 2022a).

This report aims to:

- Assess local wind patterns for the period October 2021 to March 2022
- Establish how local wind patterns influence NH_3 concentrations

[1] https://www.daera-ni.gov.uk/topics/protect-environment/air-pollution-and-natural-environment

2 Wind measurements on Ballynahone Bog (October 2021 – March 2022)

2.1 Background

A new Campbell Automatic Weather Station (AWS, greenhouse gas flux tower) was installed at NH_3 monitoring site BB9 (Figure 3 & Table 1) and has been operational since 26th May 2021. The old met station, installed 1st October 2020 at BB3, has been working well for the most part, however on further inspection had a faulty bearing and uses a cup anemometer which has a sensitivity of >0.5 m/s so is unable to record wind speeds below this accurately (this became apparent in April 2021 Williams et.al 2022a). The new Campbell AWS has a 3D sonic which has a higher sensitivity for recording lower wind speeds (<0.5 m/s). The greater precision of the new Campbell AWS compared to the older Campbell AWS met station (installed in September 2020) results in a more complete time series of low wind speed conditions at the site. This report focuses on analysing the wind conditions at Ballynahone Bog SAC and interpreting their influence on NH_3 concentrations using the new Campbell AWS. Wind speed and wind direction are recorded at 30-minute intervals and measurements can be downloaded remotely which enables periods of low data capture to be identified very rapidly.

2.2. Wind data

The new Campbell AWS was installed on the bog as part of the greenhouse gas flux tower (Table 1), about 400m to the east of the existing Campbell met station and began recording on 26th May 2021. An additional ALPHA® sampler was placed at the new flux tower site, to record NH_3 concentrations (BB9, Figure 3).

This report covers the period between 1st October 2021 (00:00) and 31st March 2022 (23:30). During this period the Campbell AWS made 152 half hourly measurements where wind speed was not recorded, representing ~1.7 % of all records for the period. The weather station is not recording any other meteorological variables during these periods, so is assumed to be either not operational or being serviced at these points.

Overall, the wind patterns on Ballynahone Bog for the period October 2021 to the end of March 2022, is that of a prevailing SW wind direction which is similar to that reported for previous years. The highest wind speeds (>6 m s^{-1}) were from a north-westerly direction, with some high winds also from the SW and SE (Figure 1). The majority of the wind recorded on the bog is from the southern half of the wind rose (Figure 1). Wind speeds on the bog are mostly <4 m s^{-1} (~75% of measurements). February shows the strongest wind speeds with ~53% of measurements >4 m s^{-1}, and a maximum of ~13 m s^{-1} (Figure 2).

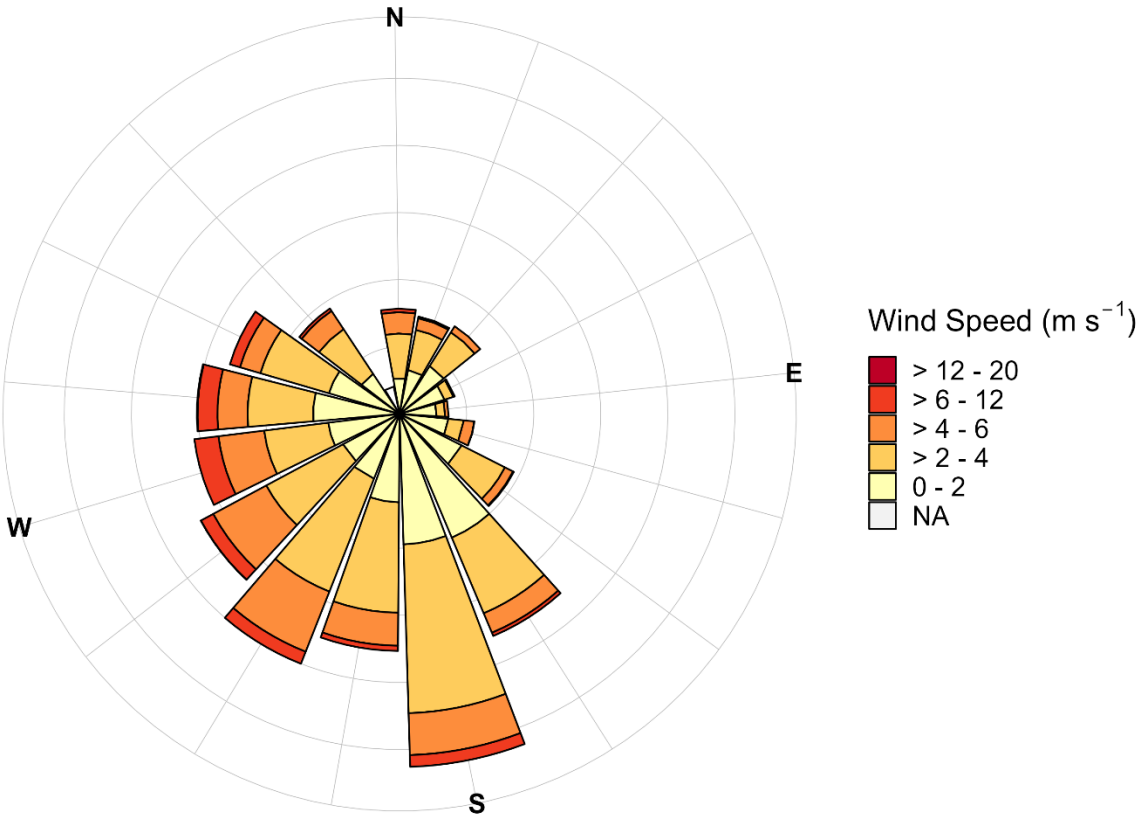

Figure 1: Wind rose for Ballynahone Bog met station between 1st October 2021 to 31st March 2022, showing wind speed and direction.

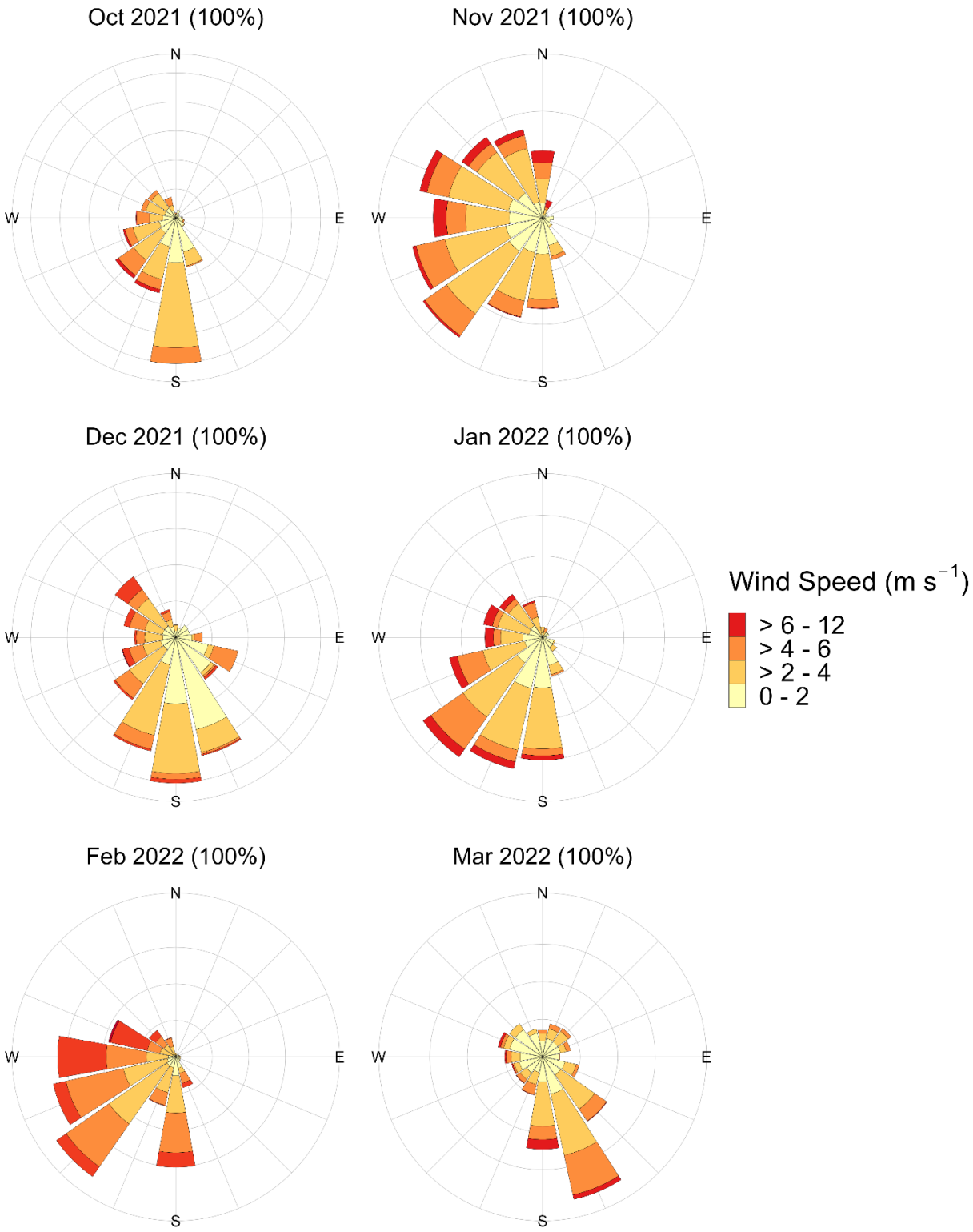

Figure 2: Monthly wind roses for Ballynahone Bog met station between 1st October 2021 and 31st March 2022. During this period the met station was switched off for 1.7% of the total time period due to instrument servicing. The full data coverage (100%) shown here are for the time when the met station was not undergoing servicing.

3 NH_3 concentrations on Ballynahone Bog SAC

3.1 Background

Ammonia concentrations have been recorded on Ballynahone Bog at monthly intervals since 2014, providing a near complete time series for over 8 years using ALPHA® samplers (Tang et al., 2001) which are exchanged at monthly intervals. Full details of the NH_3 concentration measurements can be found in Tang et al. (2022 forthcoming). Ammonia concentrations are measured at 9 locations across the bog (Figure 3). Site BB9 was added in May 2021, with the installation of the new greenhouse gas flux tower (Table 1). This report focuses on the period October 2021 to March 2022.

Figure 3: Location of the 9 samplers on Ballynahone Bog SAC.

Table 1: Details of met stations on Ballynahone Bog

Name	Campbell AWS (original)	Campbell AWS (new)
Recording start date	1st October 2020	26th May 2021
Location	BB3	BB9
Precision	>0.5 m s-1	<0.5 m s-1

3.2 Results

October 2021 – March 2022 Overview

Ammonia concentrations on the bog ranged from ~1 µg NH_3 m^{-3} to ~10.8 µg NH_3 m^{-3} over the period October 2021 to March 2022 (Figure 4). Only two NH_3 concentration measurements (~4% of measurements during this period) were below the 1 µg NH_3 critical level for lichens, mosses and bryophytes. These measurements < 1 µg NH_3 were recorded at Site 8, on the south eastern edge of the site.

October – December 2021

During the period October to December 2021, NH_3 concentrations were relatively low compared to comparable measurements made in the rest of the year. When compared to 2020 measurements, they were similar values or slightly reduced apart from Site 7 which was significantly higher in October 2021. This winter period corresponds with the closed period (where landspreading is not permitted under Nitrate Action Plan (NAP) Regulations) and where lower concentrations are expected across the wider landscape. This is consistent with the two measurements <1 µg NH_3 m^{-3} recorded at Site 8 which is the "background" site on the bog expected to show the lowest concentrations.

The high prevalence of stronger south westerly and south easterly winds in October to December 2021 appears to correspond with lower concentrations on the site transect (apart from Site 6, 3.3 - 5 µg NH_3 m^{-3}), likely reflecting more dispersal and dilution of the ammonia plumes. The samplers at Sites 5 and 7 were unsuccessful in reliably recording NH_3 concentrations due to mislabelling and damage and therefore, are shown as N/A in October and November 2021, respectively.

January – March 2022

Some of the highest monthly NH_3 concentrations (>3 µg NH_3 m^{-3}) for the year were recorded across several measurement sites in February to March 2022 (Figure 4). High concentrations were recorded on the south west edge of the bog, with concentrations declining away from the site boundary. Very high concentrations (>6 µg NH_3 m^{-3}) were recorded in March at several sample locations (1-4, 6, 7 & 9).

High NH_3 concentrations (>4 µg NH_3 m^{-3}) were also recorded at Site 8 in March 2022, which normally has NH_3 concentrations <2 µg NH_3 m^{-3} for most of the year (Figure 4). High concentrations are common in February and March, as these months are typically associated with the open season under the NI Nutrients Action Programme (NAP) Regulations when manure spreading, and synthetic fertiliser application commonly occurs across the region. Landspreading activities are the likely reason why all sites including Site 8 experienced high NH_3 concentrations during March.

N.B. Monthly met data are summarised for calendar months (e.g. 31 days in January), whereas monthly exposure periods for the measured NH_3 concentrations are generally one calendar month +/- 5 days. This difference of a few days is not expected to change the wind rose profile for comparison with NH_3 data.

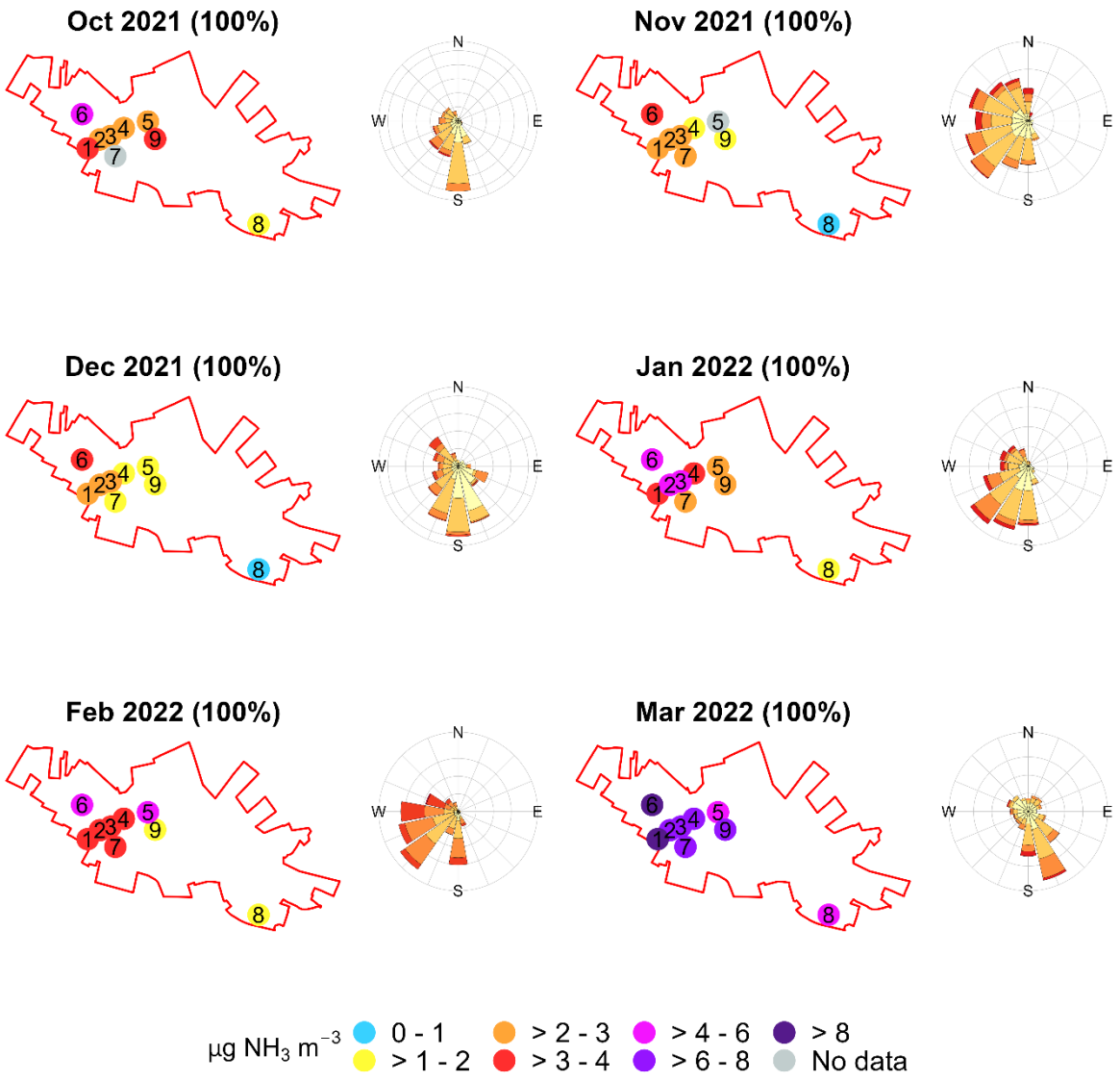

Figure 4: Monthly NH3 concentrations at measurement sites on Ballynahone Bog for the period 1st October 2021 to 31st March 2022. Wind roses from the Ballynahone Bog met station, with data capture of ~100% between October 2021 and March 2022.

4 NH_3 concentrations surrounding Ballynahone Bog SAC

4.1 Background

Ammonia concentration data have been collected by nine ALPHA® samplers surrounding Ballynahone Bog since February 2019 (Figure 5). The ammonia monitoring network surrounding Ballynahone Bog was established to better understand ammonia emission sources (and subsequent elevated concentrations and deposition) in the area surrounding the site.

4.2 Results

October - December 2021

Ammonia concentrations of 1 to 6 µg m^{-3} NH_3 were recorded at several measurement sites in October 2021, coinciding with the autumn landspreading period. Low ammonia concentrations (1-3 µg m^{-3}) were recorded between November and December 2021 apart from at Site 6 (>4 µg m^{-3}) in November. The low ammonia concentrations during this period align with the closed season under the NAP Regulations, when no slurry spreading is permitted across Northern Ireland. The samplers at Site 4 were unsuccessful in recording reliably for NH_3 concentrations for November and December 2021, therefore the data are shown as N/A in the maps.

January – March 2022

Measured ammonia concentrations were slightly higher in January (1 to 4 µg m^{-3}) than concentrations recorded in November and December 2021. This was followed by very low ammonia concentrations in February (majority between 0-4 µg m^{-3}) which could be due to the high rainfall and low temperatures seen throughout the month which may have restricted slurry spreading. Another period of elevated concentrations was then recorded in March 2022 (2 to 8 µg m^{-3} NH_3). This spring increase is seen every year and coincides with local landspreading activity following the end of the closed period.

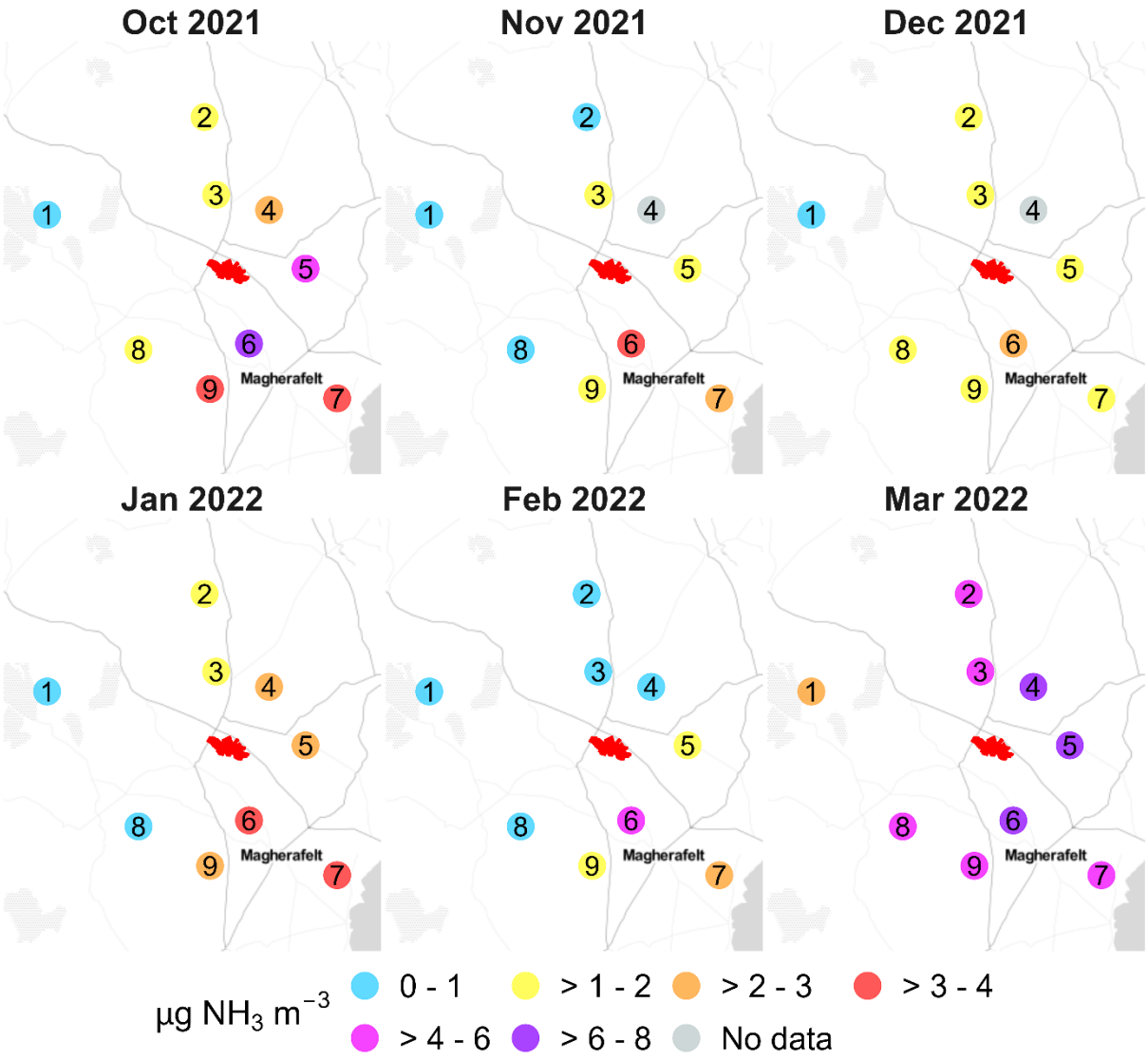

Figure 5: Monthly NH3 concentrations at measurement sites around Ballynahone Bog between 2021 and 2022.

5 Discussion and conclusions

Wind direction and wind speed data can provide a valuable insight for inferring the sources of high ammonia concentrations measured at a site. This is the second year that a whole cycle of relevant emissions sources and events could be captured in the interpretation of the NH_3 concentration data, with more reliable met data recorded on the bog. The new Campbell AWS has a 3D sonic which has a higher sensitivity for recording lower wind speeds (<0.5 m/s) than the older Campbell AWS which had a cup anemometer (>0.5 m/s), and no issues with faulty bearings. Therefore, the new Campbell AWS met station was used in this report as it has greater precision and a more complete time series of wind speed conditions on the site. Overall, the use of the new weather station has increased the reliability and accessibility of the wind data allowing data to be accessed remotely and any potential malfunctions quickly found.

Met data have been recorded over the period from 00:00 1st October 2021 to 23:30 31st March 2022 with ~98% temporal coverage. Some of the lower ammonia concentrations on the bog during this period have been recorded between October and December 2021with a prevailing S/SW wind (Figure 4). This winter period corresponds with the closed period (where landspreading of slurries and manures is not permitted under NAP rules) and where lower concentrations are normally expected across the wider landscape. Site 1 and Site 6 have higher ammonia concentrations (>4 µg NH_3) compared with the other sites on the bog during this period.

February normally indicates the start of the landspreading season for farmers (open period under NAP rules) and is often associated with increased ammonia emissions (due to land spreading of slurries and manures) in the wider area. The high NH_3 concentrations that were recorded in February and March are likely associated with the application of manures, slurries and synthetic fertiliser across the region. The majority of sites recorded concentrations between 3 – 8 µg NH_3 m^{-3} (Figure 4). Site 8 recorded the lowest concentrations of all the sites in March 2022 as expected, but even so these concentrations (>4 µg NH_3 m^{-3}) are high for this site. Site 8 normally has the lowest NH_3 concentrations (<2 µg NH_3 m^{-3}) and is used to estimated background concentrations across the bog.

The monthly monitoring of wind and ammonia concentration values across Ballynahone Bog highlights the importance of events, such as land spreading, in influencing high NH_3 concentrations in the spring months as opposed to lower concentrations in the closed season, during the winter months. Williams et al. (2022b) further investigated how other meteorological parameters, such as rainfall, temperature, and humidity, could be used in combination with wind patterns in future reports to gain a more complete picture of how monthly ammonia concentrations are influenced by local sources and weather patterns across the bog.

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